Rehabilitation principles for motor dysfunctions according to the Kozyavkin Method

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The proposed book is devoted to theoretical principles of motor dysfunction rehabilitation according to Prof. Kozyavkin’s Method and reflects 17 years of experience by the staff at the Institute of Medical Rehabilitation and the International Clinic of Rehabilitation.

Readers will be informed about fundamentals related to the organization of human movement systems and rehabilitation principles for disorders of function caused by brain lesions and, in particular, cerebral palsy. They will come to understand how this idea evolved into a fundamentally new tendency in medical treatments and will learn about the effectiveness and application of the given system of rehabilitation.

The book will be useful to child neurologists, pediatricians, specialists in medical and physical rehabilitation and students attending related academic institutions.


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Introduction

Motor dysfunctions are one of the main causes of child disabilities and rank the problem of cerebral palsies together with the most important tasks which social pediatrics, child neurology and medical rehabilitation face.

For many years, the history of the development of medical treatments for CP was based on attempts to eliminate the most obvious disorders of movement and posture. Countless rehabilitation methods were developed, including methods of physical therapy, drug, and surgical treatments. However, it has become more and more evident that fundamentally new approaches are needed for rehabilitating patients with cerebral palsy. These seem to be real and tangible if based on combinations of practical experience and scientific research.

Prof. Kozyavkin’s Method is an example of such harmonious interaction between science and practice in the field of medical rehabilitation - The System of Intensive Neurophysiological Rehabilitation.

Scientific research of the mid-80ies threw a new light on cerebral palsy by revealing the role of vertebral components in the etiopathogenesis of this illness. The interdependence of the spinal column and brain functions were taken into account and an integral system of rehabilitation was created based on Prof. Kozyavkin’s methodology of biomechanical spinal correction.

By combining spinal corrections with an entire system of medical acts, a new functional state takes shape in the child’s organism. It is accompanied by normalization in muscle tone, an increase in microcirculation and an activation of tissue trophism; it ensures quicker motor and mental developments in the child and, thus, contributes to raising his quality of life.

The normalization of spinal functions constitutes a condition for rehabilitating body symmetry and neural and muscular interaction. By removing functional obstacles, the flow of proprioceptive information is activated, which, in turn, stimulates compensatory and plastic possibilities in the brain and the entire organism.

The methodological principles of the given system were attained by contemporary integrative anthropology and medicine which consider the organism as an integral system with close connections to the external environment. Its success is based on both manifest disorders and the normalization of body structures and functions as a whole.

Creating a program for biodynamic movement correction became a significant step in developing and improving Prof. Kozyavkin’s Method. For the first time in the history of medical rehabilitation, the problem of restoring body activities was determined by basing analyses on functional muscular coordination. Universal principles of spiral connections of body muscles led to further development of the
system of rehabilitating body symmetry, posture and movements. This involves using both functional possibilities of a patient’s body muscles as well as external efforts which complement muscle pull. “Spiral”, our self-developed suit for correcting movements has been highly effective in our work as it enables redressing spastic tissues, sustaining body symmetry, strengthening pulls by body and abdominal flexor muscles and bringing the positions of the body and extremities back to normal.

The proposed book is devoted to theoretical principles of motor dysfunction rehabilitation according to Prof. Kozyavkin Method and reflects 17 years of experience by the staff at the Institute of Medical Rehabilitation and the International Clinic of Rehabilitation.

Readers will be informed about fundamentals related to the organization of human movement systems and rehabilitation principles for disorders of functions caused by organic lesions of the nervous system. They will come to understand how this idea evolved into a fundamentally new tendency in medical treatments and will learn more about the main results of the given system of rehabilitation.
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Cerebral palsy viewed as a medical and social problem
1.1. General information about Cerebral Palsy

The History of Cerebral Palsy

The actual term “cerebral palsy” (CP) has existed for more than a century. It is likely that the illness has existed without being actually named since the dawn of human history. Nevertheless, in spite of its long history, there has been no unity of opinion in regard to this problem to this very day.

The general term CP is sometimes called Little’s illness, in honor of William John Little, a British surgeon and orthopedist. In the mid-XIXth century, he first established connections between childbirth complications and infant disorders related to mental and physical developments [Little W.J., 1843]¹. These ideas were set forth in an article, “On the influence of abnormal parturition, difficult labors, premature birth and asphyxia neonatorum on the mental and physical conditions of the child, especially in relation to deformities” [Little W.J., 1862]². This article was addressed to the British Royal College of Midwives and has been often quoted in publications dedicated to cerebral palsy.

Little’s work attracted the attention of his contemporaries. As a result, several critical comments appeared immediately after the article was published [Kavcic A., 2005]³. Little answered the critics and did not try to prove his precedence in affirming and describing neurological consequences of pathological childbirth. As he was not able to find support for his theses in English medical records, he decided to quote William Shakespeare [Shakespeare W., 2003]⁴. In Little’s opinion, Shakespeare portrays a moving picture of Richard III, where readers can guess at deformities attributed to premature birth or, possibly, childbirth complications:

“I, that am curtailed, of this fair proportion,
Cheated by features by dissembling Nature,
Deformed, unfinished, sent before my time
Into this breathing world, scarce half made-up,
And that so lamely and unfashionable
That dogs bark at me as I halt by them…”

Similar movement disorders continued to be referred to as “Little’s illness” until 1889, when William Osler, a Canadian physician suggested using the term “cerebral palsy”. [Osler W., 1889]. In his monograph, “Cerebral Palsies in Children”, Osler noted the connection between difficult labor and brain lesions in children.

Sigmund Freud, the famous Viennese neuropathist, prominent psychiatrist and psychologist first referred to cerebral palsy as a separate nosological form which combines diverse motor dysfunctions of cerebral origin [Freud S., 1897].

In all other XIXth century publications dedicated to motor dysfunctions in children, the term “cerebral palsy” was used only in relation to other terms (for example, cerebral birth palsy”). And yet, daily clinical work and practice of the second half of the XIXth century required more concrete terminology. In his monograph, Freud writes that the term “cerebral palsy” combines “pathological conditions which have been long since known and where rigidity muscle or spontaneous muscle twitching predominate over paralysis”.

Freudian classification and interpretation of cerebral palsy were much wider than succeeding formulations by other authors. He even suggested applying this term to
cases of complete absence of paralysis, for example, epilepsy or mental retardation. Such interpretations of CP were closer to concepts of early “brain damage”, which was formulated much later [Amiel-Tison C, 1994].

It is likely that Freud could not find another way of arranging this sphere of child neurology and so, suggested including all motor disorders in children into one single nosological group. At first, Freud explored cerebral hemiplegia. Subsequently, he included all motor lesions into one group which he named cerebral dyplegia, thus, naming and taking into account both sides of the body. He then proceeded to enumerate four kinds of lesions: 1) general cerebral rigidity; 2) paraplegic rigidity; 3) bilateral hemiplegia and 4) general chorea and bilateral athetosis [Freud S., 1983]. Later, Freud again included all these motor disorders into one nosological unit - cerebral palsy.

In the XXth century, the absence of a unified notion that might determine its nosology led to further complications in conducting scientific research. Specialists became more and more convinced that the creation of a general view regarding CP was greatly needed. Some researchers interpreted CP as a single clinical nosology, others saw it as a list of similar syndromes [Phelps W.M., 1947].

One of the initiatives directed towards generalization and further development of contemporary views on cerebral palsy was worked out in the Little Club in 1957 by Ronald McKeith and Paul Polani. After two years of research, they published “The memorandum on terminology and classification of cerebral palsy”. According to the members of the Little Club, cerebral palsy is defined as a non-progressive brain lesion which manifests itself through movement disorders and body postures during the early years. Clinical presentations which arise as a result of a neurodevelopmental disorder are non-progressive, but variable [MacKeith R.C., 1959].

Other scholars of different scientific schools set forth their own views. Thus, Prof. K. A. Semenova, a leading Russian specialist in problems related to cerebral palsy and manager of the biggest treatment center for CP patients in Moscow suggested the following definition: “CP embraces a group of different clinical syndromes which appear as a result of brain underdevelopment or brain damage during different stages of ontogenesis and are characterized by the patient’s inability to maintain normal posture and perform arbitrary movements” [Semenova K.A., 1972].
A concordant definition was suggested by the academician, Levon Badalyan. In his opinion, the term cerebral palsy embraces a group of syndromes which appeared as a result of brain underdevelopment or brain damage in prenatal, intranatal and early postnatal periods. Brain lesions manifest themselves by muscle tone disorders and movement coordination dysfunctions, and the inability to maintain normal posture and perform arbitrary movements. Movement disorders are often accompanied by sensitive disturbances, mental and speech delays and spasms [Badalyan L.O., 1980].

In spite of the polymorphic clinical picture, most existing classifications of CP take into consideration only muscle tone conditions and the localization of movement disorders. Very often, a diagnosis includes patients with absolutely different motor possibilities and does not take into account the dynamics of the patient’s motor status in regard to long-lasting rehabilitation treatments. Rehabilitation classifications of CP were suggested and effectively put into practice by the rehabilitation school in Truskavets [Kozyavkin V.I., 1999]. Besides the generally accepted parameters, this classification also includes characteristics related to the patient’s locomotor and posture possibilities.

The immediate aim of rehabilitation treatment of CP patients is to raise the quality of life, which had been prearranged to a large extent by the limited conditions of movement functions. Many years of experience in practical work and scientific research were conducted under Prof. Kozyavkin’s supervision and led to elaborating a new idea of cerebral palsy and, in particular, the significance of vertebrogenic components and etiopathogenesis in this illness [Kozyavkin V.I., 1996]. A new multi-modular system of rehabilitation was built up on this principle, which emphasizes biomechanical corrections of the spinal column. Applying integral influences on different levels of the nervous system creates a new functional condition in the child’s organism. This is accompanied by a normalization in muscle tone, an amelioration in microcirculation and metabolism, an activation of plastic possibilities of the nervous system and contributes to the child’s motor and mental developments. A more detailed description of rehabilitation systems is set forth in the second chapter.

A major milestone regarding a consensus on cerebral palsy was reached at the International Seminar on definition and classification of cerebral palsy in Maryland (USA) in July, 2004. The participants confirmed the importance of acknowledging this nosological form and emphasized that CP is not an etiological diagnosis, but a clinical and descriptive term. The results of seminar work groups were published in the article, “Proposed definition and classification of cerebral palsy” [Bax M., 2005]. The authors suggested the following definition: Cerebral palsy (CP) describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behavior, and/or by a seizure disorder.
CP Epidemiology

Cerebral palsy often leads to serious neurological disabilities, which, in turn, disturb the patient’s social adaptation and his quality of life. According to statistics of the World Health Organization, 10% of the world population is made up of people with limited health possibilities, and more than 100 million of the fore-mentioned are children under 16 years.

According to statistics, more than 150,000 such children and teenagers have been counted in Ukraine. Mental disturbances, illnesses of the nervous system and sense organs (vision, hearing impairments, etc.) are the leading forms of disease. Up to 60 - 70% of the causes of child disabilities are due to perinatal pathologies.

In general, the number of child disabilities has increased considerably in the past few years. In 1992, the general index for child disabilities showed 95.7 per 1,000, whereas in 2004, it reached 170.4 per 1,000, that is, the index increased by 78% [Martyniuk V. Y., 2006].

Index fluctuations regarding the rate of CP in Ukraine from 1996 to 2004 are shown in the graph below (illustration 1.1.1).

Similar indices have been registered in other countries. According to statistics of the United Cerebral Palsy Association, close to 764,000 children and adults in the USA show symptoms of cerebral palsy [www.ucp.org, 2006]. Today, this diagnosis is established yearly for eight thousand newborns and children. Moreover, 1200 - 1500 preschoolers are diagnosed annually with this illness.

In Great Britain, 2.1 cases of cerebral palsy per 1000 newborns have been registered [Pharoah P., 1998]. In Denmark, in the course of the past 40 years (from 1965 to 2004), CP illnesses exceeded 2 cases per 1000 newborns [Odding E., 2006].
Authors have remarked on the increase in premature infants with low and extremely low birth weight. The clinical picture of the illness shows a decrease in the number of patients suffering from dyplegia and an increase in the number of patients with hemiplegic forms of CP. Cerebral palsy is more often encountered in countries with a low standard of social and economic developments. Spastic forms of CP are the most widely-spread, among which the lowest numbers can be attributed to patients with dyplegia. 25 - 80% of the children have other associated syndromes, depending on the degree of motor deficiencies. A large number of these children suffer from cognitive disorders, the extent of which depends on the various forms of CP and the presence of epilepsy. Epilepsy is observed in 20 - 40% of CP cases, mainly in children suffering from hemi and tetraplegias.

Computer tomography shows structural brain disorders in 70% of the children suffering from spastic forms of CP. According to neurosonography results, organic brain lesions are more distinctly associated with hemiplegia, whereas normal neurosonographic results are more frequently observed in patients with dyplegia. The most significant risk factors are perceived in infants with low birth weight, multiple pregnancies and intrauterine infections. These cases should be strictly controlled by the doctor.

**Causes of CP and risk factors**

As long ago as 1862, William Little, a British surgeon and orthopedist advanced a hypothesis that cerebral palsy is predominantly caused by premature births, newborn asphyxia and childbirth traumas.

Understanding cerebral palsy onsets has increased significantly in the last 30 years. Epidemiological studies have shown that the quality of obstetrical and neonatal assistance has risen in the past twenty years, but this has not contributed to decreasing the incidence of cerebral palsy [Nelson K. B., 1986]20.

These observations were continued in N. Badawi’s research. She confirmed that asphyxia during childbirth causes encephalopathy in newborn infants only in individual cases [Badawi N., 1998]21. These results have refuted ideas about childbirth complications being the main cause for encephalopathy in newborn infants (illustration 1.1.2).

In 2003, common work groups at the American Academy of Pediatrics and the Academy of Obstetrics and Gynecology studied neonatal encephalopathy and cerebral palsy and selected several indispensable criteria affirming that the most severe hypoxic and ischemic brain injuries during childbirth cause neonatal encephalopathy, which can lead to future development of cerebral palsy [Hankins G. D. V., 2003]22. These criteria are as follows:

1) the presence of metabolic acidosis in fetal blood circulating in umbilical arteries during childbirth;
2) early beginnings of neonatal encephalopathy in children with a gestation period of 34 weeks and more;
3) the development of cerebral palsy as spastic tetraplegia or dyskinetic lesions;
4) the exclusion of other possible causes (trauma, blood coagulation disorders, genetic dysfunctions and others).

A. MacLennan’s research also confirmed that 75% - 80% of cases showing CP development were caused by prenatal factors, whereas only 10% were connected with birth traumas and asphyxia [MacLennan А., 1999].

Prenatal factors are the most frequent causes for CP onset and thus, can contribute to developmental disorders of the brain at any period of intrauterine growth. They may depend on genetic changes, inadequate blood circulation or toxic or infectious injuries to the brain structure.

The nervous system goes through a series of periods during its developmental process, namely: primary neurulation, prosencephalic development, neuron proliferation, neuron migration, organization and myelinization [Volpe J.J., 2001] (diagram 1.1.3).

The human brain is most sensitive in certain critical periods when its complex organization and developmental features are duly taken into consideration. One single factor during different periods of brain development can lead to various changes. Thus, cerebral ischemia prior to the 20th week of gestation can lead to disorders of neuron migration; during the 26th and 34th week gestation period, it may cause periventricular leukomalacia and between 34th and 40th week period - focal or multifocal brain damage.

Brain damage provoked by an inadequate blood supply depends on many factors: disorders of anlage and development of the brain’s vascular system, efficiency
decrease of cerebral blood flow and its regulator mechanisms and reaction levels of brain tissues to low oxygenation.

**Premature births and low weight at childbirth** are the two most important risk factors of CP, especially in developed countries with a sufficiently high level of medical assistance. Cerebral palsy develops in 10 - 18% of newborn infants with a birth weight of 500 - 999 gr. [Michael E.M., 2004].

A premature child with immature brain structures and cerebral blood supply has lower potentials to bear physical and other stresses. Embryonic types of blood circulation in the brain predominate in these children, which determine the inadequacy of blood supply in periventricular substances. This, in turn, can lead to hemorrhage in the brain marrow and periventricular leukomalacia. It can further be revealed as a clinical picture of spastic dyplegia.

Brain tissues of lateral ventricles are the most sensitive between 26 and 34 months of gestation. Descending corticospinal fibers responsible for the motor control of lower extremities make their way through this zone and so, damage can generate spastic dyplegia. Both upper and lower extremities suffer even more when more severe lesions occur, thus damaging movement centers and tracts (centrum semiovale, corona radiata).

Periventricular leukomalacia is usually symmetrical. It is supposed that it is caused by ischemic lesions of white brain substance in premature infants. Capillaries of
the germinal matrix in periventricular areas are especially sensitive to hypoxic and ischemic lesions as they are located on the fringes of blood supply zones between the striatal and thalamic arteries. Clinical pictures of asymmetrical lesions show clearer lesions of one part of the body and resemble spastic hemiplegia even though a more correct term in such a case would be “asymmetric and spastic dyplegia”.

The blood supply to the brain in children born full term is sufficient and comes close to the adult’s. Hypoperfusion can be mainly observed in “water parting” areas of principal cerebral arteries. Formations of spastic hemiparesis may be identified by vascular lesions located in the blood supply area of the central brain artery.

Damage to basal ganglions lead to extrapyramidal manifestations in the form of hyperkinetic or distonic types of CP.

V. I. Kozyavkin’s research deserves great attention; it is directed towards studying special structural and functional features of the brain and spinal column in children suffering from cerebral palsy [Kozyavkin V. I., 1996]. The author explored spinal pathologies when determining the etiopathogenesis of cerebral palsy and so, drew attention to the vertebrogenic factor. Analyses were used from magnetic resonance imaging records for 120 children suffering from various forms of CP. 72% of the patients displayed consequences due to childbirth traumas of the spinal cord (cysts, dilatation of the central canal, local adhesions) and the spinal column (dislocation, vertebrae fractures, appearance of degenerative and dystrophic lesions), more often manifested in the cervical section of the spinal column. These research studies showed that cerebral palsies are direct, if not mediated lesions of cerebral and spinal structures.

In 10 – 20% of the cases, CP takes shape at the expense of postnatal brain lesions. They may be brought on by meningitis, viral encephalitis, hyperbilirubinemia, cerebral cranium traumas and others [Taylor F., 2006].

In most cases, it is very difficult to establish an accurate cause of CP as lesions are very often connected with other factors. Thus, the concept of “risk factors” is commonly employed when complexities involved in naming causes of CP are taken into account. The risk factor does not refer to the causes of the illness, but to variables which increase risks in regard to the origin of the illness. Main risk factors which increase probabilities of development of cerebral palsy are presented in diagram 1.1.4. The occurrence of risk factors does not necessarily mean that cerebral palsy is taking shape in a child, but their absence does not exclude the onset of the illness.

Detecting causes of brain lesions and risk factors of CP development can without doubt facilitate early diagnosis and prophylactic measures for this illness. One of the methods for early diagnosis, early treatment and prophylactics of developing CP is the new component program according to the Kozyavkin’s Method - “Early rehabilitation”, which is described in greater detail in the second chapter.
## General information about Cerebral Palsy

### Diagram 1.1.4. Risk factors involved in CP development

<table>
<thead>
<tr>
<th>Prenatal</th>
<th>Perinatal</th>
<th>Postnatal (0-2 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prematurity (gestation age is less than 36 weeks)</td>
<td>Premature rupture of fetal membranes and breaking of waters</td>
<td>Infections of the brain (encephalitis, meningitis)</td>
</tr>
<tr>
<td>Low (less than 2500 gm.) or very low weight (less than 1500 gm.) at birth</td>
<td>Prolonged and protracted labor, application of obstetric assistance</td>
<td>Postnatal hypoxia</td>
</tr>
<tr>
<td>Mother’s condition or illness: epilepsy, hyperthyrea, TORCH-infections, trauma, harmful habits</td>
<td>Anomalies of fetus presentation</td>
<td>Seizures syndrome</td>
</tr>
<tr>
<td>Infectious and toxic influences on fetus</td>
<td>Vaginal hemorrhage during labor</td>
<td>Coagulopathy</td>
</tr>
<tr>
<td>Pregnancy complications: gestosis, bleeding in third trimester, insufficiency of uterine neck, placenta insufficiency, multiple pregnancy</td>
<td>Bradycardia, hypoxia of fetus</td>
<td>Neonatal bilirubinemia</td>
</tr>
<tr>
<td>Newborn asphyxia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth traumas of the brain and spinal cord, traumas of the spinal column</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.2. Clinical forms of CP

Clinical manifestations of CP may vary from negligible symptoms to apparent disorders. The severity of illness is connected with the character, level and localization of damage to the brain. Early manifestations are often visible immediately following the child’s birth, whereas explicit signs of CP become evident in infancy.

1.2.1. Pathology of motor systems in CP

Various clinical forms of cerebral palsy may appear as a result of developmental disorders or damage to brain centers and conduction pathways at the early stage of ontogenetic development. The fundamental motor systems which ensure control of human posture and movements are as follows:

1. The **terminal motor pathway** (the lower motoneuron composed of cranial and spinal nerves) - brings about stimulation of muscle contractions and movements.

2. The **pathway for direct activation of movements** (the upper motoneuron, corticobulbar and corticospinal tracts) - executes movements, which are controlled consciously. The path is connected with conscious movement skills.

3. The **pathway for indirect activation of movements** (the upper motoneuron, the extrapyramidal system: corticorubral and corticoreticular pathways, rubrospinal, reticulospinal, vestibulospinal pathways and analogous pathways to cranial nerves) - ensures subconscious and automatic muscle activity which is directed towards posture, maintaining muscle tone and realization of movements, which are concomitant to conscious movements.

4. **Control circuits** on different levels of the nervous system directed towards the integration and coordination of sensory information, stimulation of direct and indirect pathways of movement activation for controlling movement activity. Included in control circles - the subcortical and cerebellar.

The **Subcortical control circuit** includes basal ganglia and the extrapyramidal system. It produces programs for postural control, ensures supportive and servicing components of motor activity.

The **Cerebellar control circuit** includes the cerebellum, the pons cerebella, reticular formation, red nuclei, inferior olive, thalamus and cortex. The circuit ensures the integration and coordination of movement executions of smooth and skeletal musculatures.

The **pyramidal system** includes corticospinal and corticonuclear pathways. They begin at the pyramidal cells of the motor zone of the telencephalon (anterior central gyrus) where the upper motoneuron is situated. Movement pathways make their way from this point to the lower neuron, which, in turn transmits cortex signals
Clinical forms of CP
to skeletal muscles. The corticospinal pathway proceeds to motor neurons of the anterior horns, whereas the corticonuclear pathway makes its way to motor nuclei of brainstem cranial nerves. The corticospinal pathway controls body and limb movements, whereas the corticonuclear pathway - face and neck muscles (illustration 1.2.1).

Illustration 1.2.1. Diagram of corticospinal (pyramidal) pathways

Lesions of the central motor neuron contribute to the development of central (spastic) palsies. This is manifested by muscle hypertension, like spasticity,
hyperreflexia with extended thones of tendon reflexes, clonus, pathological and withdrawal reflexes as well as pathological movement synkinesie.

Lesions of the lower motor neuron in the pyramidal system contribute to peripheral (flaccid) palsies located on the affected side. They are observed on the faces when the nuclei of brainstem cranial nerves are affected; in the body and limbs when the nuclei of anterior horns of the spinal cord are affected. Peripheral palsies are not included in the CP group.

**The extrapyramidal system** is more ancient in phylogenesis. Its parts are located in different layers of the cortex, subcortex and brainstem. The system is formed by basal nuclei (paleostriatum and neostriatum) and the cerebellum. The **Paleostriatum** includes the pale globe and the substantia nigra of cerebral peduncle; the **neostriatum** - the tegmentum and caudate nucleus (illustration 1.2.2). Pathways for indirect activation of movements begin at the structures of extrapyramidal systems. They also go to the lower motor neuron which is thus doubly controlled by both the pyramidal and extrapyramidal systems.

![Illustration 1.2.2. Basal ganglia of the brain](image)

The influence of the paleostriatal system on motor activity is especially evident in infants. Children under 6 months show characteristically high muscle tone, which slowly decreases in neck, arm and leg muscles. Neostriatal systems in motor
ontogenesis are most active in children aged 2 to 7 years. These children are often emotional, restless; they talk a lot and they gesticulate energetically.

Yielding to movement priorities of the pyramidal system, the more ancient extrapyramidal system leaves behind the following important functions: sequence regulation, strength and duration of muscle contractions, automatic activation of an entire complex of muscle groups, which are indispensable for executing a conscious and conceived movement. This system is responsible for automated acts, coordinated work of the skeletal musculature, timely start and termination of movements and their accurate execution. The basal ganglia are a central link in the extrapyramidal system. They allow for realizing positions of body links for executing movements, controlling synergies related to complex movement acts (walking, running and so on) and ensuring movement flow. Basal ganglia cause inhibitions of movement links in conditioned and unconditioned reflexes. As they do not have direct connections to alpha motor neurons of the spinal cord, they mediate their influence through the reticulospinal pathway to gamma motor neurons of the spinal cord. The latter regulate the flow of proprioceptive and afferent impulses which enter the spinal cord from muscle spindles. These impulses influence the excitability of alpha motor neurons and thus, determine the operating condition of skeletal muscles.

Two diametrically opposite syndromes may arise when the functions of basal ganglia are not executed. A hypertonic and hypokinetic syndrome (like Parkinson’s disease) develops when the pallidum segment is affected. A hypotonic and hyperkinetic syndrome (athetosis and other forms of hyperkinesis) develops when the striatal segment is affected.

Lesions of the **palliostriatal system** are manifested by general body stiffness, muscle supertension in both flexor and extensor muscles, which tests confirm as a symptom of “cogwheel” rigidity. Patients display movement slowness, weak movement expressions in reactivity, sluggish mimicry, mask-like faces, absence of arm and leg coordination when walking. This condition in clinical pictures of diseases of the nervous system is called hypokinesis.

Children affected by lesions of the **striatal system** show excess movements - hyperkinesis in different locations. They can be observed in the body (axial, torsional hyperkinesis), in limbs (chorea disease, athetosis, ballism, myoclonia and tremor), in facial and neck muscles (tics, spasmodic torticollis) and in vocal chords (vocal hyperkinesis). Hyperkinesis usually appears when children try to maintain a certain position or perform a delicate act. Hyperkinesis is absent when children are completely relaxed or asleep. These lesions are manifested by a decrease in muscle tone from hypo- to atonia. Dystonia often progresses and is apparent in joint overextension, especially when attempts are made to move around. Typical cases of dystonic muscles show foot flexures, arm extensions, back overextension, neck extension and rotation, all of which are manifestations of the hypotonic and hyperkinetic syndromes.
The **cerebellum** takes part in organizing movement activities, constructing ballistic movements as well as regulating the organism’s autonomic functions. Cerebellum nuclei carry out movement corrections and ensure their accuracy, all of which are needed in connection with the constant activity of inertial strength appearing when movements are called for.

The cerebellum is composed of two hemispheres and the vermis. The neuron bodies form the cerebellum cortex and nuclei layers in the white substance matter of the hemispheres and vermis - cogwheel, suberose, globular and fastigial nuclei. Various zones of the cerebellum are responsible for controlling movement accuracy. The most ancient section of the cerebellum is the flocculonodular lobe which controls body balance and maintains muscle tone. Median sections of the cerebellum near the vermis coordinate body movements and thoracic and pelvic girdles. Intermediate sections coordinate fine motor arm activities, whereas lateral sections of the cerebellar hemisphere take part in planning movements (illustration 1.2.3).

![Illustration 1.2.3. Cerebellum: a) sagittal section of the brainstem, b) somatotopical representation of body parts in the cerebellum](image-url)
The cerebellum has an important function, namely, ensuring mutual coordination of postural and conscious movements as well as correcting their accuracy and conformity. Such movement coordination is realized by the cerebellum according to the comparison principle, that is, comparative signals equipped with an activity program which flow from the motor cortex and proprioceptors (illustration 1.2.4).

Clinical forms of CP

When active and conscious movements are performed, impulses from the cerebral motor cortex descend to the spinal cord and transmit instructions to muscles through lower motor neurons. At the same time, information about movement intentions from this same cortex zone is transmitted to the cerebellum. At this time, action potentials from proprioceptive neurons, which innervate joints and limb tendons, ascend to the cerebellum and transmit information about actual positions of limbs and the entire body. The cerebellum juxtaposes impulses from the cerebral motor cortex and proprioceptors of the extremities (signal comparison) and so can compare planned movements with executed movements. When a discrepancy is detected, the cerebellum sends signals to the motor cortex and the spinal cord to have it removed. Free-flowing and coordinated movements are results of this work in the cerebellum.

The clinical picture of cerebellum lesions is manifested by the ataxic hypotonic syndrome. Low muscle tone (hypotonia or atonia) is observed and displays an ataxic gait, difficulties in equilibrium and movement coordination, asynergy with static
and locomotor function disorders. Ataxia manifests itself by disorders related to equilibrium, movement coordination and sequence of arbitrary movement acts.

Any parts of the body may be included in ataxia depending on the location of the brain lesion. Paravertebral musculature suffers when the cerebellar vermis is affected; ataxia progresses in the body; speech disorders are observed; speech becomes indistinct and staccato-like. Ataxia related to eyeball movements is manifested by nystagmus. Dysmetria - difficulties performing finger-nose and heel-knee tests as well as many others. When the patient attempts to correct dysmetria, he is seized by ataxic intention tremors with trembling of the limbs when terminating movements and adiadochokinesia with difficulties in alternating supinator and pronator arm movements.

Cerebellar ataxia is observed in patients attempting to keep their balance when walking. They must place their legs wide apart so that the support area ensures better body stability. Thus, the patient is “thrown about” by lesions in the cerebellar hemisphere. When a child is affected to a light degree by ataxia, he cannot follow a straight line by walking heel and toe or jump on one leg. When rotating, he is “pulled” sideways and cannot follow movement trajectories.

The cerebellar vermis, brainstem and spinal cord are all directly associated with the development of such important movements as walking, running and swimming. The cerebellar cortex together with pontine tracts plays an important role in ensuring manipulative movements and motor speech functions. The cerebellum and premotor cortex also preserve reflexive memory which is connected with developing such skills as bicycle riding and piano playing.

1.2.2. Forms of CP

As a rule, the actual classification of CP is based on muscle tone condition and lesion location. According to this principle, all forms of CP may be divided into two groups - pyramidal and extrapyramidal (illustration 1.2.5).

Pyramidal forms of CP are mainly connected with lesions of the corticospinal pathway; they are characterized by spastic disorders of muscle tone. Spastic tetraparesis (tetraplegia), spastic diparesis (diplegia) and spastic hemiparesis (hemiplegia) can be distinguished depending on dominating lesion areas.

Extrapyramidal forms are divided into athetoid (dystonic, hyperkinetic) and ataxic (cerebellar, hypotonic) forms.

There are also mixed forms of CP with different combinations of pyramidal and extrapyramidal systems.
Clinical forms of CP

Illustration 1.2.5. Clinical forms of CP

Pyramidal (spastic) forms
- Tetraparesis
- Diparesis

Extrapyramidal forms
- Athetoid
- Ataxic

Hemiparesis
Mixed

Spastic diparesis

Dominating lesions of the lower limbs lead to the development of spastic diparesis (diplegia). This form of CP is called Little’s disease. It is quite common and numbers between 10 to 33% of all patients.

Lesions occur gradually as the child’s movements are developed. Spastic palsies can occur in legs and arms during the first months. In future, arm movements may be renewed and the clinical picture may show predominating leg paralysis.

Versions of triplegia with leg and single arm lesions are referred to as transitional forms of CP. Such children have a higher muscle tone, continually maintain tonic labyrinthine and neck reflexes and show delays in motor development. During medical testing, increased tendon reflexes, foot clonus and pathological reflexes can be observed. Contractures of hip muscles and foot deformities develop quickly; leg movements are abruptly restricted [Sussman M.D., 1992]27. Sensitivity and pelvic organ functions may be preserved.

Speech and mental disorders are sometimes moderate, but they often appear against the background of microcephaly, hydrocephaly and epileptic symptoms, which tends to complicate prognosis [Zucker M. B., 1986]28.

Spastic diparesis shows predominant movement disorders of the lower limbs, but should be differentiated from spinal paraplegia which may be a consequence of childbirth trauma or a deficiency in the development of the nervous system. In such cases, sphincter functions suffer and autonomic disorders are observed. In contrast to cerebral diparesis, there are no spasms and no retardation in mental development [Badalyan L.O., 1980]29.
Spastic tetraparesis

Depending on brain lesion localization, spastic tetraparesis (tetraplegia) may cause paralysis to extend to all four extremities. This is the most severe form of CP; its frequency rate fluctuates between 9 to 43% among all forms of CP.

Hypertension may occur in both the upper and lower extremities and muscles, or it may only predominate in the arm muscles. Contractures and bone deformations are formed very early. Mimetic and mastication muscles suffer, oral synkinesis appears and pseudobulbar disorders progress. Spastic dysarthria affects speech articulation and there are severe delays in motor and mental developments. There is a possible development of double hemiplegia with asymmetric lesions of the right and left sides of the body.

Spastic hemiparesis

Spastic hemiparesis (hemiplegia) is observed in 25 - 40% of the children suffering from CP. This form is characterized by one-sided lesions of the extremities and especially their distal sections. Right-sided hemiplegia is twice as common as left-sided. Simultaneously, lesions of homolateral nuclei VII and XII pair of cranial nerves can be observed to various degrees.

As the patient grows older, the muscle tone in affected extremities increases; they fall behind in growth and development compared to the healthy side. There is a possibility of an insignificant decrease in unilateral sensitivity, but this is very difficult to define in children. Contrary to adults, children gradually develop hemiatrophy, which occurs only in early brain lesions. Simple muscle atrophy without qualitative electroexcitability disorders is observed. Focal or general seizures are observed in 30 - 49% of the patients. This reduces the probability of normal mental development.

Athetoid form of CP

Extrapyramidal cerebral palsy has many names - hyperkinetic form of CP, athetoid or dystonic paralysis. The frequency rate among patients suffering from CP is between 9 to 22%. This form of palsy manifests itself as hypotonia during the child’s first two months; dystonic attacks appear at 3 - 4 months; these attacks are due to sudden muscle hypertension and are conditioned by an increased activity in reduced tonic reflexes.

In older children, extrapyramidal forms of CP are manifested as forced movements (choreoathetosis, tics, torsions) and muscle dystonia. Muscle rigidity sets in as soon
as energetic movements are attempted, hyperkinesis intensifies in the body and extremities. Mental development does not suffer very much, but apparent speech and movement disorders hamper the patient’s learning and his social adaptation.

Besides severe hyperkinesis such as double athetosis or choreoathetosis, and with the presence of nuclear icterus on the basis of immunological incompatibility of blood groups or the Rhesus factor, patients develop growing hearing difficulties or even complete deafness together with delays in speech development.

Ataxic form of CP

The ataxic cerebellar form of CP is represented by balance and movement coordination disorders. Even if the patient is able to walk, his gait is uncertain and unstable. Patients suffering from this lesion have problems executing rapid movements and movements which require fine control, such as writing. Tendon reflexes are usually overactive. Slow and gradual improvements of motor and mental functions are observed during the course of treatment. This form of CP occurs in 5 to 10% of CP cases.

Besides cerebellar lesions, areas of the frontal “pole” cortex may also suffer. Here, there are centers which manage the cerebellum through cerebellar frontal pons pathways. In such cases, patients develop Forster’s atonic-astatic form of CP, whereby static functions suffer sharply and deeply. Patients cannot maintain their heads; they are not able to sit, stand or walk while keeping their balance. Apart from apparent cerebellar pathology, there is predominant and severe mental retardation, lack of motivation and apparent delays in speech development.

In 9 - 25% of CP patients, mixed forms of the illness are observed. These are combinations of different forms of cerebral palsy. Combination of spastic forms with athetoid or atactic forms is widespread.

1.2.3. Fundamentals for diagnosis and rehabilitation classification of CP

CP diagnosis is based on the following key factors: the availability of reliable signs of early organic brain lesions and the evidence of a nonprogressive course of the illness; manifestation of pathological operations at a determined stage of brain development, delays in further maturity of the brain and formation of its functions; the availability of clinical symptoms in regard to centrally controlled lesions of movement functions; symptoms of motor deficiency.

Children with developing cerebral palsy noticeably lag behind other children of the same age in regard to motor development. Delayed motor development (DMD) and the inability to align the body are the first and fundamental syndromes of CP.
Manifestations of normal motor development may be conveniently evaluated (especially by parents) in the “motor ladder” shown below. Each step corresponds to one single stage of motor development. Each stage lasts 2 months (plus or minus 1 - 2 weeks according to individual variations).

Evidence for diagnosing delayed motor development can be justified when motor development drops below average parameters. Delayed motor development corresponding to one to two motor stages is considered as light, three to four stages as average severity. The consequences of II degree DMD depends on a timely diagnosis and rehabilitation measures. A child stands a good chance of restoring further normal rates of motor development if there is early rehabilitation treatment.

Delayed motor development corresponding to the fifth and sixth stages can be considered as lesions of severe degree. In such cases, a child’s body alignment and locomotion are seriously affected, which confirms a CP diagnosis.

Delayed motor development is connected with lesions of the nervous system and should be differentiated from other forms of DMD, which are conditioned by other causes, for example, severe somatic state or infectious illnesses. In these cases, delayed motor development has unspecific characteristics. As the child gets better,
his somatic and immune conditions are restored and the child gradually catches up with children of the same age.

Classifications of CP are based on topical diagnostics of lesions of the nervous system. However, the clinical picture of CP can change into another form during the first two years of a child’s life and in regard to motor function development [Badalyan L.O., 1988].

The following observations are important for normal motor development and body alignment during the child’s first year:

a) independent movements of all body parts with regard to one another;

b) the rotation of the upper part of the body with regard to the lower part;

c) the ability to maintain the body and all body parts in the terrestrial gravitational field (lying, sitting and subsequently, standing positions);

d) the capacity to relocate the body in regard to gravity force;

e) the gradual reduction of support areas as the body aligns itself for sitting, standing and walking.

These principles concerning the biomechanics of movements together with combinations of genetic factors determine potential possibilities of a child’s motor development [Cook R., 1996].

The formation of pathological motor patterns in CP is connected with the cerebral brainstem structures being released from controls by the endbrain cortex and cerebellum. Released from hierarchical subordination to higher motor centers, brainstem structures and cervical sections of the spinal cord begin to activate tonic reflexes (LTE, tonic neck reflexes, the grasp reflex, head-body righting reflex, pelvis-body righting reflex and others). In CP, these reflexes are not reduced by a determined date; on the contrary, they become more intensive. Their pathological activities prevent the development of spontaneous motor activity, expressions of congenital movement reflexes, such as support reflexes, the infant’s step movements and body rotations from supine to prone positions and back.

CP does not allow for the development of the cervical chain righting reflex, which is controlled by the midbrain, and subsequently, by the striate body and parietal segments of the brain cortex. Normally, this reflex allows the child up to 8 -10 months to increase the tone of dorsal muscle flexors, lower limbs and so, prepare the child for standing up.

The development of the cervical asymmetrical chain righting reflex enables the 6 - 8 month child to sit and maintain balance when in sitting and standing positions. At first, this reflex is controlled by the midbrain, labyrinth, cerebellum, subcortical nuclei, later, by cortical centers of frontal, parietal and temporal lobes in the brain. Lesions of sensory motor zones in pre- and postcentral gyri delay the formation of kinesthetic sensations, which, in turn, affects the development of movement patterns and formation of motoric automatisms and praxis [Semenova K.A., 1990].

Clinical forms of CP
In the clinical picture of a patient with CP, delays in reducing tonic reflexes determine different versions of muscle tone disorders. Continuous persistence of tonic reflexes and muscle hypertension creates flows of pathological proprioceptive impulsations. The child’s brain receives impulses from kinematic links with pathological patterns. As a result, there is no possibility of formation of normal movement stereotypes. Pathological patterns remain in the upper and lower limb joints; in time, this determines formations of myogenic and arthrogenic contractures, the development of persistent deformations of the limbs and the spinal column. Pathological movement habits are formed, which are then used by the child for further motor development. In connection with muscle tone pathologies in patients with CP, other body functions are also affected, namely, breathing, articulation, mastication, swallowing, functions of the internal organs and many other vital and important functions.

Depending on the localization of brain lesions, a CP clinical picture may show such forms of motor deficiency as paralysis, hyperkinesis, ataxia and dysmetria.

Apart from primary symptoms of motor function lesions, compensatory movement patterns develop, which patients employ to overcome muscle spasticity. Early motor ontogenetic disorders lead to formations of one of the following versions of pathological movement development – spastic, atonic or dystonic types.

Rehabilitation classification of CP

During primary diagnostics of CP, neurologists traditionally assess the degree of intensity of the following three fundamental neurological manifestations:

1) the degree of movement disorders: paresis, plegias;
2) the localization of motor deficiencies: mono-, hemi-, para-, tri-, or tetraplegia;
3) muscle tone condition: spasticity, rigidity, hypotonia, atonia, dystonia.

This practice in regard to current classifications does not reflect the course of movement disorders in CP when used in rehabilitation treatments.

And so, when a diagnosis “CP, spastic tetraparesis” is established for a 1-year old patient, it is hardly ever changed during the rest of his life. Nevertheless, all patients with such diagnoses will not be similar to each other. A patient suffering from CP finds himself in one medical institution and then another; he goes through repeated rehabilitation therapies; he receives a diagnosis when he is admitted to and discharged from hospital. His clinical history will show to what extent improvements were made in the patient’s rehabilitation treatments; however, this will by no means be reflected in his diagnosis.

In our rehabilitation clinics in Lviv and Truskavets, a straightforward and practical rehabilitation classification of CP has been worked out and introduced in order to
clearly define the degree of the child’s motor development [Kozyavkin V. I., 1995].

In addition to the three diagnostic criteria, it is expected that obligatory diagnoses in regard to alignment and motor development stages will be established for each patient (illustration 1.2.7).

And so, we indicate in the patient’s diagnosis the alignment phase in order to describe opposition to gravity force: a) a lying position with no head control; b) a lying position with head control; c) sitting independently; d) rising with support devices; e) rising independently.

We define the following locomotor stages which describe his motor development: a) an absence of locomotion; b) locomotion by rolling over; c) crawling on the stomach and chest; d) non- alternating crawling (rabbit jump type); e) alternating crawling (reciprocal); f) walking on the knees; g) walking with support devices; h) pathological and independent walking.

The diagnosis necessarily includes concomitant disorders: a) the patient’s psychology; b) cognitive development; c) speech development; d) somatovegetative sphere.

In such a way, the assessment of motor development in each patient in regard to our classification is carried out by using syndromological, topical and functional diagnoses.

Complex approaches to diagnostics, treatment and active follow-up of all cases enables an interactive evaluation of the patient’s condition. This is particularly important for analyzing the effectiveness of rehabilitation.

<table>
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<tr>
<th>Muscle tone</th>
<th>Localization</th>
<th>Verticalization phase</th>
<th>Locomotor stage</th>
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</table>
| Spastic     | Tetraparesis with dominating lesions:  
- on the right.  
- on the left  
- upper limbs  
- lower limbs | in a lying position with no head control | absence of locomotion  
locomotion by rolling over  
crawling on the stomach  
non- alternating crawling  
alternating crawling  
walking on the knees  
walking with support devices  
pathological and independent walking |
| Dystonic    |             |                      |                 |
| Hypotonic   |             |                      |                 |
| Diparesis   |             |                      |                 |
| Hemiparesis | - right side  
- left side  | sitting independently  
rising with support devices  
rising independently |                 |
| Triparesis  |             |                      |                 |
1.3. Cerebral Palsy treatments

Cerebral palsy is a serious illness connected with perinatal lesions of the nervous system. If there is a timely diagnosis and progressive rehabilitation treatments, the severity of the illness may be considerably reduced. However, there is no unique standardized method for treating this illness. One method may be beneficial to one child, but will not necessarily be able to help another child. Parents and rehabilitation specialists should work together in order to define the child’s needs first, define apparent functional disorders and finally, work out an individual program for progressive rehabilitation.

Rehabilitation treatments for children with CP should be directed towards developing motor activity, speech, practical skills and expanding the patient’s social contacts. The child’s needs should be taken into account; these needs change as the child grows older. A two-year old child’s habits, which are indispensable for getting to know the surrounding world are considerably different from a schoolchild’s habits or from a teenagers needs, who longs for independence and freedom.

So-called “authors’ treatment methods” deserve special attention in this extensive sphere of rehabilitation. Today, the most widespread methods are: the Bobath method, Vojta method, dynamic proprioceptive correction, conductive education and intensive neurophysiological rehabilitation (illustration 1.3.1).

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<td>Illustration 1.3.1. Most widespread methods for CP rehabilitation</td>
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<td>1</td>
<td>Neurodevelopmental treatment (Karel and Berta Bobath)</td>
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<td>2</td>
<td>Reflex locomotor method (Vaclav Vojta)</td>
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<td>3</td>
<td>Conductive education (Andreas Peto)</td>
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<td>4</td>
<td>Dynamic proprioceptive correction method (Kseniya Semenova)</td>
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<tr>
<td>5</td>
<td>Intensive neurophysiological rehabilitation system (Volodymyr Kozyavkin)</td>
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</table>

Principles for CP treatment according to the first four methods will be described in this chapter. Treatments using the intensive neurophysiological rehabilitation system will be set forth more in detail in the second chapter of the book.

One of the most important methods for treating CP is physical rehabilitation, which should be started during the child’s first months, after the diagnosis has been established. Physical rehabilitation is only one element of the child’s developmental program and should ensure a stimulating and interesting environment for the child in order to be successful.
Physical rehabilitation is an important component of the rehabilitation process. It should be supplemented by other effective methods and techniques. Children suffering from cerebral palsy, like other children, constantly require new experiences and interaction related to the surrounding environment in order to develop, grow and learn. Sensory stimulation programs may provide such experience for these children, who do not have many opportunities of communicating with the outside world because of their motor restrictions.

For many children with delayed motor development and communicative difficulties, speech therapy classes should be directed towards detecting and determining specific speech disorders and then, overcoming them by systematic execution of programs dealing with special corrective exercises.

Psychological help is a most important branch for increasing the patient’s abilities and can complement physical rehabilitation, just like lessons with a speech therapist. This help is also indispensable for the child’s family. Psychological consultations are important for patients of all ages, but especially for teenage patients. This is a most critical period for individual growth and maturity, during which physical rehabilitation and professional preparations can be jointly used for working out social programs and specialized educational programs.

Medical treatment is applied during the newborn’s critical period of brain lesions, mainly during the first six months. Medical treatment is essentially prescribed for CP patients with concomitant seizures or is sometimes used to reduce muscle spasticity and the intensity of involuntary movements.

Complex treatments of cerebral palsy may also include surgical interventions. Orthopedic interventions are fairly widespread; they are aimed at removing joint contractures and bone deformities.

Regardless of the patient’s age and adapted rehabilitation programs, treatments should not come to an end when the patient leaves the doctor’s office or is discharged from a rehabilitation center. Medical specialists should act as coaches who provide parents and patients with rehabilitation strategies and teach them indispensable skills for improving the patient’s lifestyle at home, at school and in the surrounding environment.

1.3.1. Physical rehabilitation of CP

Physical rehabilitation represents one of the most important methods of treating CP. During the first months of a child’s life, exercise programs are directed towards executing two main tasks: muscle atrophy must not be allowed to set in as a result of insufficient practice and use and also, the development of myogenic contractures must be prevented as muscle spasticity or rigidity fix the limbs in pathological positions.
Contractures are one of the most frequent and serious complications of cerebral palsy. A healthy child’s muscles and tendons stretch regularly when he walks, runs and performs daily movement activities. This ensures interdependent bone and muscle growth. In children with cerebral palsy, spasticity hampers muscle stretching. As a result, muscles do not develop adequately and rapidly enough, muscle length does not keep up with skeletal growth and subsequently, bone growth is also restricted.

Contracture formations in CP patients may lead to equilibrium disorders and loss of acquired movement skills. Physical rehabilitation programs should be directed towards prophylactic measures for these unwanted complications by means of a gradual stretching of spastic muscles.

Contributing to the child’s motor development is the most important task facing physical rehabilitation. Countless concepts are offered and a great number of rehabilitation plans have been developed all over the world to carry out this task.

As the CP patient gets older and reaches school age, treatment programs change from ensuring early motor development to placing more emphasis on the child’s adaptation to society. At this stage, physical rehabilitation efforts should be directed towards learning and shaping everyday skills, developing communicative faculties and preparing the child for collective social life. Physical rehabilitation should be directed towards developing the child’s independent locomotion, with the assistance of canes or wheelchairs, as well as developing fine motor activity of the hand for mastering such complex techniques as writing. The child should also be taught to perform tasks independently, such as eating, getting dressed and using bathroom and toilet facilities. By mastering these daily skills, children with CP will make life and work easier for people who look after them and will enhance their own self-confidence and self-esteem.

1.3.1.1. Neurodevelopmental treatment (the Bobath method)

Berta and Karel Bobath, a man-and-wife team, made a significant contribution to developing principles of physical rehabilitation. As long ago as the 1940s, they began to develop their own approach founded on Berta Bobath’s clinical observations.

Owing to their active work, publications, lessons and training courses, the Bobath concept of “neurodevelopmental therapy” spread throughout the whole world. After the Second World War, it made a significant contribution to developing principles for rehabilitating patients with CP.

The essence of their method can be explained by the hierarchical maturity theory in the nervous system, which was largely prevalent in those days. Consequently, the founders considered ontogenetic sequences in motor development as one of the main theoretical postulates for treatment.
According to the Bobath concept, motor problems in cerebral palsy appear as a result of brain structure lesions, which are responsible for antigravitational and postural mechanisms. These, in turn, decelerate and deform normal motor development. Therefore, neurodevelopmental treatments were aimed at rehabilitating systems which are most likely to be affected in CNS disorders. Special attention was paid to the sensomotor control of muscle work, muscle tone, movement memory and mechanisms for postural control. Practical tasks included reducing muscle spasticity, contractures and deformation prophylactics, suppressing pathological reflex activity and eliminating nonphysiological movement patterns. Various sensory stimuli were employed to stimulate the child’s motor development and form normal balancing reactions and physiological movement patterns. This system made the child a comparatively passive recipient of neurodevelopmental treatments.

With time and owing to their own experience and new achievements in neurophysiology, the Bobaths changed their approach somewhat and began to place more emphasis on other aspects of treatment. In their last publication in 1984, they described how key theoretical positions of their concept had been transformed [Bobath K., 1984]34. At first, they defended their position, arguing for the necessity of placing the child in special “conditions which would suppress pathological reflexes”. Although these conditions did indeed lead to reduced spasticity, the founders later came to the conclusion that this lowered muscle tone was only temporary and was not maintained when the child attempted other movements.

With so many years of experience in rehabilitating patients with CP behind them, the Bobaths focused on the important influence of “key control points”. Thus, physiotherapy work was conducted during the child’s movement activities and was directed towards suppressing pathological movement patterns and stimulating development of more accurate movements.

In the end, the Bobaths came to the conclusion that it is not necessary to strictly control development of automatic straightening reactions as the child cannot spontaneously transfer these skills into conscious independent movements. It is more effective and reasonable to develop the child’s faculties for independently controlling his balance and managing his movements. They concluded that it was not important or necessary to stimulate the child by adhering strictly to standard ontogenetic sequences of motor development.
1.3.1.2. The reflex locomotion method (Vojta therapy)

Vojta’s therapy, also known as the reflex locomotion method was elaborated at the beginning of the 1950s by Vaclav Vojta, a Czech doctor.

The method was created empirically when Vojta was studying motor reactions to specific stimulation, which was applied when a child assumed a specific position. As long ago as 1964, Doctor Vojta stated that such stimulation causes “global dynamic muscle activity”, which can be observed during all forms of human locomotion [www.vojta.com, 2005]35.

These same “global patterns” constitute the theoretical basis for the reflex locomotion method. The term “global locomotion” means motor responses which appear during applications of the reflex locomotion method. Skeletal muscles are activated in a coordinated fashion, impulses arrive at all movement centers of the brain, all of which contributes to the formation of new reflex connections. This process includes not only body and limb muscles, facial and respiratory muscles, but also swallowing muscles, intestinal peristalsis and urinary bladder functions. “Global patterns” are also an essential part of other human movement activities, such as, grasping, turning over, crawling and walking. Doctor Vojta revealed that reflex reactions which occur in patients with movement disorders are similar to the reactions of healthy children. This meant that formations of important movement patterns can be stimulated during a child’s early years and thus, create “building blocks”, which are necessary for motor development.

Therefore, such motor reactions lay the basis for rehabilitating movements in patients with CP. They are provoked by applying measured pressure on specific body parts of a patient who is lying on his stomach or reclining on his side.

The reflex locomotion method aims at developing limb support functions, the child’s skills in controlling body positions and movement coordination. These skills are affected to a various extent in all patients with brain lesions, as well as patients with musculoskeletal system disorders of other etiology. In such cases, pathological movement patterns can be corrected with the assistance of the reflex locomotion method.
Applications of two coordinating complexes - crawling reflex and turning reflex are core components of the reflex locomotion method. Vojta studied both reflexes in patients with spastic paralyses, in healthy newborns and in infants.

Vojta’s therapy becomes effective when exercises are repeated often and for a longer period of time. Exercise procedures consist in maintaining the child in a specific reflex position and applying hand pressure to the selected zone. Influence zones are selected individually and depend on movement disorders and the intensity of appropriate reactions. When there is a responding reflex movement, this exercise should be repeated during the whole course of treatment.

Parents are essential partners in the treatment process. Assisted by specialists, they should study Vojta’s method and then, continue rehabilitation procedures at home.

Attention should be drawn to the fact that the reflex locomotion method is not aimed at practicing a specific movement, but at creating work patterns of muscle coordination, which can be used for building up further chains of movements.
1.3.1.3. The conductive education method (the Peto method)

Conductive education was elaborated after the Second World War by Andreas Peto, a Hungarian doctor and teacher. At first, this method was applied only at the Institute for Conductive Education in Budapest, which is named after the founder. With time, the method gained popularity and began to be used in many other countries.

According to Professor Peto, motor disorders are not only due to damage in brain movement centers, but are also the result of integration process disorders, which lead to inadequate interaction of different brain sections. Integrating abilities of the nervous system should be mobilized with the assistance of an active teaching process [www.peto.hu, 2006].

In Hungary, traditional programs of conductive education are directed by conductive specialists (conductors) who have a four year university education in specialized training programs. They plan and carry out their program individually, both as teachers and medical specialists. Group work is conducted according to pre-arranged programs including blocks, which are composed of exercise complexes and educational occupations. Activities are presented as games in specialized groups numbering between 10 and 25 children who are all affected with the same type of cerebral palsy. Conductors manage the group while ensuring motivational surroundings and providing emotional support.

Programs involve several years of prolonged work with the child. Exercise complexes are chosen according to pathological characteristics and the child’s movement and mental possibilities. Various objects and sport equipment are used in these complexes, for example, ball exercises, steps, gymnastic benches and poles; these are supplemented by walking exercises and practice on wall bars. Specialized equipment is used during the exercises, namely, ladders, tables and boxes made of rounded lacquered wooden planks.

All exercises are based on physiological movements. “Rhythmical intention” is widely used during these activities; these include rhythmical movements, dancing, singing and reciting poems. Rhythmical treatment also refers to rhythmical oral instructions, which are delivered during the performance of these exercises.
Rhythmical backgrounds heighten motivation and draw attention to required movements, thus contributing to the child’s learning process.

Motivation is a key factor of the child’s participation in this rehabilitation process. As a rule, children with cerebral palsy not only act and move more passively, but also express their wishes more passively, too. The conductive education method requires the child to play an active role in overcoming his motor deficiencies. If the aims are set out clearly, the child will become interested and so, will express appropriate motivation for further activities. Programs are designed to activate the child’s continuous participation in different sorts of activities, which teach children to think and act in different situations. Motivation is most significant as it shows the children how to strive for success and, finally, achieve the proposed goals. Therefore, even the most insignificant success should get positive support and encouragement from conductors. This will definitely increase the child’s self-esteem.

1.3.1.4. Dynamic proprioceptive correction method (Semenova method)

The dynamic proprioceptive correction method was worked out under the supervision of K. A. Semenova, honored scientist of Russia, in the rehabilitation department for children with cerebral palsy at the Science and Research Pediatric Institute of the Russian Academy of Medical Sciences. K. A. Semenova believes that motor rehabilitation in cerebral palsy and brain trauma can be realized by correcting afferent proprioceptive flow in patients. This flow has an immediate influence on the basic structures of the central nervous system, which control motor activity and the functional antigravitation system as well as monitoring muscle synergies responsible for locomotion and the erect alignment of the body.

K. A. Semenova based her studies on the abilities of the functional antigravitation system in patients suffering from CP. In 1991, she suggested using “Pingvin” (Penguin), a modified space suit for rehabilitation treatments.

The “Penguin” loading device was designed in the 1970s in the laboratory of space medicine as a measure to counter the effects of long-term weightlessness on the body while in space [Barer A. S., 1972]37. It is an established fact that muscle hypotrophy occurs as a result of the absence of loading pressure on bones and muscles in zero gravity conditions. The “Penguin” device imitates gravity...
pull on a cosmonaut’s organism using a 40 kilo power load directed length wise along the cephalocaudal axis and so, reduces the negative influence of zero gravity. The invention of the loading suit resolved the problem of a person’s long-term stay in anti-gravity conditions and so, caused a revolution in biological aspects of space travel. The “Penguin” device was then adapted to children and named “Adeli-92”. Utilization and experience of the “Adeli-92” led to the elaboration of a next-generation medical suit, especially intended for the rehabilitation of patients with CP; it also took into account movement specifications of each patient. At the expense of available resources, each patient builds up his own defective system to help him to overcome gravitational force. The medical suit influences tonic reflexes which are essential for forming pathological muscle interaction.

As the suit was directed towards stimulating afferent proprioceptive flow, this new method of treatment was called “dynamic proprioceptive correction” [Semenova K.A., 1999]38.

The reflex-loading device “Gravistat” was developed in 1997; it allows a functional correction of a patient’s posture (illustration 1.3.3). “Gravistat” consists of elastics tension bands which are fixed and counterbalance each other. Tension regulation in these bands allows strictly measured doses of loading pressure to travel along the cephalocaudal axis, thus exerting activity in body muscles and the lower limbs. Rotational elastic pressure corrects the positions of body movement sections. This enhances information flow from receptors of muscles, joints and tendons, and stimulates the central nervous system where movement patterns are shaped.

Neurophysiological research (EEG (electroencephalography), ENG (electroneurography), EMG (electromyography), SSEP (somatosensory evoked potentials) was conducted in 580 patients aged 4 to 25 years suffering from cerebral palsy and 68 patients suffering from consequences of brain trauma with different severity of disease. 55 - 70% of the cases showed substantial improvements in motor activity regardless of illness duration and intensity of brain lesions.
1.3.1.5. The intensive neurophysiological rehabilitation system (The Kozyavkin Method)

The intensive neurophysiological rehabilitation system, widely known as the Kozyavkin Method was invented in the 1980s and has become an important landmark in the developing field of medical rehabilitation. The principles for this rehabilitation treatment were based on research which established a new approach to cerebral palsy and stressed the vertebrogenic component in the etiopathogenesis of this illness. The Kozyavkin Method represents an integral rehabilitation complex, the basis of which is biomechanical correction of the spinal column. This unique method of correcting spinal movements is aimed at eliminating functional blocks of spinal movement segments, improving activities of autochthonic body muscles and directing the flow of proprioceptive information to nerve centers.

Spinal correction using this system is combined with a multimodal complex of treatments, which complete and potentiate each other mutually. The result is a durable normalization in muscle tone, an increase of microcirculation in tissues and bradytrophic structures and a normalization of tissue trophism. This contributes to the formation of a new functional condition, which ensures activation of brain plasticity and compensatory possibilities of the organism.

This new approach to rehabilitating patients with CP takes into account peripheral structures in the etiopathogenesis of lesions and thus, leads to more positive and durable results. Professor Kozyavkin’s method is described more in detail in the second chapter.

1.3.2. Medicamental treatment of CP

Medicamental treatment is applied by neonatologists and pediatricians during a newborn’s critical period of brain lesions, mainly during the first six months. Combating brain oedema and hypoxia constitutes the main aim of this treatment. Later, medicamental treatment is prescribed when seizure syndromes appear, or sometimes, for reducing muscle spasticity and involuntary movements.
On the whole, two groups of medication are used to combat seizures in CP. On the one hand, there is a wide range of anticonvulsants, which rapidly put an end to seizure activity and prevent further repeated outbreaks. Benzodiazepine type preparations constitute the other group of medication. Diazepam is the most widely known. This drug is used in emergency cases of epileptic convulsions.

All antiepileptic drugs should be selected and prescribed according to electroencephalography results, the patient’s individual characteristics and the general clinical picture. Neither medication can be used effectively in all types of seizures. It is often recommended to use two or more antiepileptic drugs during a resistant course of epilepsy.

Medicamental treatments are also prescribed to reduce muscle spasticity in CP, especially after orthopedic interventions. The following drugs are often prescribed: diazepam, which acts as a relaxant; baclofen (lioresal), which blocks motor neuron signals to muscles; dantrolene that has an effect on muscle contraction. Taking drugs in tablet form results in short-term reduction of muscle tone; long-term use of these drugs causes side effects, such as drowsiness and allergic reactions.

Hyperkinetic forms of CP sometimes call for the prescription of medication which can reduce the strength and intensity of involuntary movements. This refers to dopaminergic or anticholinergic agents.

Drugs belonging to the dopaminergic group are widely prescribed in treating Parkinson’s disease; they raise the dopamine level in the brain, which ensures muscle tone reduction and arrests pathological and involuntary movements. Anticholinergic drugs reduce acetylcholine activity, a neurotransmitter, which is responsible for the transmission of nervous impulses in the synaptic gap.

Botulinum toxin type A, sold commercially as Botox and Dysport, is also a medication used in treating CP. Botulinum toxin is a neurotoxic protein produced by the bacterium Clostridium botulinum and one of the most natural toxic substances in the world. Despite its high toxicity, it is used mainly in minute doses to treat muscle spasms and cosmetic defects.

Justinus Kerner (1786-1862), a German physician and poet described this toxin, calling it a “sausage poison” as this bacterium often caused severe poisoning by growing in improperly prepared meat products. J. Kerner first conceived a possible therapeutic use for botulinium toxin.

In the 1950s, it was discovered that minute doses of botulinium toxin type A reduce muscle hyperactivity by blocking the release of acetylcholine at the neuromuscular junction, thus preventing muscles from contracting for a 4-5 month period (Illustration 1.3.4). In time, the excitation transfer to the muscle is restored by means of compensatory sprouting of axon terminal portions. [Park E.S., 2006]39. This effect is used to treat spastic forms of cerebral palsy, thus reducing muscle spasticity in the limbs and increasing the range for joint movements. Today, there
is no common viewpoint in regard to the effectiveness and rationality of using botulinum toxin in cerebral palsy treatments.

It is important to emphasize that all the various methods for medicamental treatment of CP are symptomatic and can only be complementary in general rehabilitation programs for patients with cerebral palsy.

1.3.3. Surgical methods for treating CP

Surgery is usually performed in order to remove bone deformities, lengthen muscle tendons, ligaments and fasciae. The operations should improve motor activities of patients who have potential possibilities of being able to walk independently. For children who have no perspective of walking without assistance, surgical interventions are aimed at removing painful syndromes and increasing their abilities for self-help.

The most widely spread operations are directed towards correcting scoliotic deformities of the spinal column, removing dislocations in hip joints, relocating tendon attachments, reducing imbalance of spastic muscles and so on. Osteotomy may be practiced in individual cases in order to correct the biomechanical axis of kinematic links. Today, there is no common viewpoint in regard to optimal periods for conducting surgical treatments. According to existing recommendations, it is necessary to take into consideration the maturity of the nervous system, potentials for developing independent gait as well as the tempo of deformation processes when making a decision about expedient surgery [Murphy N.A., 2006].

The effectiveness of surgical interventions on CP patients remains a controversial subject. During a scientific program of the American Academy for Cerebral Palsy dealing with the effectiveness of various methods of treatment, analyses were conducted in regard to using adductomy as a prophylactic measure for hip subluxation in CP patients [Stott N.S., 2004]. Following an adductomy, a positive effect on hip subluxation was observed in X-rays among 32% of the cases only.
(168 per 530 observations). It was also established that there is no reliable research on actual results of adductomy, which might provide more conclusive information about improving the range of joint movements or bettering the patient’s lifestyle.

Recently, functional neurosurgical procedures have been used more widely together with traditional orthopedic surgery on bones, muscles, joints and tendons. In the USA, **selective dorsal rhizotomy** has been introduced. During this surgery 70 – 90% of posterior nerve roots L2 - S1 levels are severed [Peacock W.J., 1982]. In some patients with CP, rhizotomy procedures help to reduce muscle spasticity and increase abilities to sit, stand or walk. However, this operation requires careful assessment when applied to patients as complications may arise, namely, weak muscles may decrease a patient’s daily skills and independence.

**The baclofen intrathecal pump method**, which allows medication to be delivered continuously, also deserves our attention. Baclofen is a derivative of gamma-aminobutyric acid; it connects with gamma-aminobutyric acid receptors and reduces the effects of excitative neurotransmitters.

Baclofen is administered into the subarachnoid space of the spinal cord by an infusion system which includes a pump implanted under the skin covering of anterior abdominal muscles and a catheter placed in the subarachnoid space, but lower than the cone of the spinal cord (Illustration 1.3.5). The pump ensures continuous delivery of medication into spinal cord fluid. Dosage control is carried out by an exterior programmed device. The pump reservoir can be refilled every 3 months by means of a subcutaneous injection. There are many advantages to this method owing to effects of evenly-dosed medication flowing into the spinal cord. However, baclofen intrathecal administration and selective dorsal rhizotomy are sometimes thought to be the most effective only when treating wandering reflex contractures (these appear as a result of hypervasitactivity and imbalance of synergetic muscles when

Illustration 1.3.5. The baclofen pump allows medication to be administered directly into the subarachnoid space of the spinal cord
the patient is in an erect position) and the least effective when treating fixed limb deformities [Lilin E. T., 1999]43.

Current surgical methods for treating cerebral palsy need further research so that evidence and contraindications can be defined more precisely in regard to age and clinical forms of CP. When choosing therapeutic method for children with CP, we should remember the epigraph in the book written by Eugene Bleck, the famous American orthopedist and specialist in surgical treatments for people suffering from CP: “Decision is more important than incision” [Bleck E., 1987]44.

**Literature:**

33. Kozyavkin V. I. Principles of Intensive Neuropsychological Rehabilitation System for Patients with Cerebral Palsy (CP) [in Ukrainian], Козявкин В.І. Основи системи інтенсивної нейропсихологічної реабілітації пацієнтів з дитячим церебральним паралічем (ДЦП) // Український вісник психоневрології.- 1995.-Т.№3.- Вип.2 (6).- С.376-378.