EU-Russia Cooperation Programme (formerly known as Tacis)

The Establishment of International Rehabilitation Center for 7-14 Year-Old Children with Disabilities
2007/132-594

Rehabilitation programmes for children and adolescents with bad posture, vertebral column curvatures and pelvis deformities

This project is funded by the European Union

The project is implemented by the Federal State Institution Pediatric Orthopedic Sanatorium "Pionersk" of the Federal Agency for Healthcare and Social Development (Pionersky, Kaliningrad Region, Russia) and the Voivodeship rehabilitation clinic for children in Ameryka settlement (Warmia-Mazury Voivodeship, Poland)

REHABILITATION PROGRAMMES FOR CHILDREN AND ADOLESCENTS WITH BAD POSTURE, VERTEBRAL COLUMN CURVATURES AND PELVIS DEFORMITIES

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ISBN 978-83-916179-7-7

The publication was financed by the European Union and the Federal State Institution Pediatric Orthopedic Sanatorium "Pionersk" of the Federal Agency for Healthcare and Social Development in the framework of **"The Establishment of International Rehabilitation Center for 7-14 Year-Old Children with Disabilities"** project as implemented under part of Lithuania–Poland–Kaliningrad region of the Russian Federation Neighbourhood Programme.

CONTENT

EPIDEMIOLOGY

Frequency of postural defects, defects of thoracic and pelvic girdles in children and adolescents is 50 to 70% depending on the region of Europe. This difference in frequency of postural defects appearance in different regions could be explained by continuously changing influence of industrial and other factors of civilization on common state of health of population. Such difference in defining frequency of child and adolescent postural defects in different regions might indicate differences in interpretation of certain deformities identification. In addition, different methods of examination are used and standardized diagnostic criterions of present postural abnormalities are absent.

The most apparent (primary) deformities of the body are changes in the vertebral column itself make only 2 to 14% (Wejsflog signs of I range) among children and adolescents. Frequency of the secondary changes of skeletal structures associated with the vertebral column (thoracic cage, pelvis, i.e. signs of the II range) together with abnormalities of other locomotorium elements (upper and lower limbs, i.e. signs of the III range) in total is about 45 – 55 %.

ETIOPATHOGENESIS

In prenatal period (fetal period before 28 weeks) new organism is developing out of three germ layers: ectoderm, endoderm and mesoderm. Due to this fact, forming of different systems of a fetus depends on favourable prenatal conditions, first of all, on general well-being of a mother. Normal gestation course is an essential condition for normal development of a fetus. Environment surrounding a waiting mother plays a significant role in this period. Chemical, radioactive, industrial pollution and all the environmental factors in general as well as tobacco smoke, stress, improper diet, alcohol and drugs abuse undoubtedly influence negatively and destructively fetal development. Apart from that, mother's contagious diseases, the most dangerous in the first trimester of pregnancy, such as German measles, cytomegalic inclusion disease, herpes (TORH – infections), AIDS, influenza, smallpox, can not only lead to miscarriage but also cause further congenital abnormalities of development. Bacillary diseases, especially lues, or diseases induced by protozoons like toxoplasmosis, listerellosis also jeopardize normal prenatal development. Other factors threatening fetal development are mother's extragenital diseases such as diabetes mellitus, anaemia, hypertension, obesity and other endocrinopathy associated with significant metabolic changes. In general any pregnancy pathology, especially gestosis of the first or second halves of pregnancy, as well as placenta or umbilical cord deficiency threatens fetal functional systems development, including locomotor apparatus.

In perinatal period (period between 28 weeks of fetal development to 7 days after birth) the main threat for normal development is abnormal labor (intranatal period). Intranatal asphyxia (oxygen deprivation and increase of CO_2 concentration) leads to further hypoxia and tissue ischemia of a fetus and newborn. Lack of oxygen can cause subscleral or cerebral hemorrhage which can result in further postnatal motor and sensory disorders and developmental disorders in general. One more problem in prenatal period is disorders due to prematurity of a fetus (a newborn of less than 2500 g of weight and gestational age of less than 37 weeks), its postmaturity (gestational age of more than 40 weeks) or hyperbilirubinemia. These states lead frequently to central nervous system damage and other developmental diseases.

In postnatal period the main threat is viral and bacillary diseases of a newborn leading to viremia or bacillemia – to sepsis. Their complications in the form of brain fever (meningitis and encephalitis) influence significantly further child development causing motormental retardation and secondary deformities of locomotor apparatus.

Motormental state of a newborn is considered to be the key point for further child development which is not continuous and gradual but steplike, approximately taking three months for each activity (critical periods of development). This development process is inseparably associated with formation of body posture, physiologic curvatures of the vertebral column as well as forming normal motor reflexes. A child undergoes all stages of ontogenetic development (stages of verticalization) changing lying position to on-all-fours position and then to a vertical standing position. While vertical position is forming, central nervous system is not mature enough, thus, developmental process becomes possible only as a result of functioning first unconditioned and then conditioned reflex mechanisms.

Nowadays there are various theories of postural defects appearance, authors of which consider main pathogenetic factors to be prior influence of growth, genetic, metabolic, mechanic, rachitic factors. Nevertheless, the most numerous are disciples of the theory of disbalance of muscle tonus.

In addition to these theories, new theories and hypotheses are being developed on the basis of clinical observations and experimental research; those are trying to explain etiopathogenesis mechanisms of the most severe postural defects - idiopathic scoliosis (IS), and which were reviewed historically by Kasperczyk [53] and Tylman [103].

The theory of congenital postural changes is proposed and discussed more often, which highlights a great role of fetal abnormalities of spine initiation and segmentation – disontogenesis predetermined by prenatal development pathology. The most remarkable disciples of this theory are Bremer, Engelmann, Kogan, Wierzejewski.

According to so called theory of physiologic curvatures some authors demonstrated that lateral curvatures of the body appear in connection with keeping irregular asymmetric posture and asymmetry of arising or produced workload (Bichat, Hass, Lovette).

According to the theory of rachitic changes scoliosis is formed while sitting position is acquired, so called "sitting hump" by Frejka, Grucy, Hanglund and Schede.

Dolega's osteoplastic theory proposes that IS is caused by extreme susceptibility of growing vertebrae to deformation which is explained by genetic determination of metabolic peculiarities in osseous tissue.

Anatomo-functional theory of Farkas combined elements of all the theories mentioned above.

The author of mechanic static-dynamic theory, Pusch, assumes that unilateral section of vertebral ligamentous apparatus leads to its curvature laterally.

Heuer, the author of growth disorders theory gives an explanation of IS appearance through faster growth of vertebral body than the growth of vertebral arch.

Some authors propose a hypothesis that scoliosis might be caused by mucopolysaccharide metabolic disorders (Farkas, Duriez, Ponsetii), others draw attention to their genetic determination (Faber, Kleinberg, Miodonski [85] and Mitroszewska [87]).

According to the theory of muscular tonus disbalance disorders vertebra abnormalities could be caused by damage of reflex arch at the spinal medulla segment or damaged axis control disorders (pyramidal, extrapyramidal, cerebellar systems). Muscle tonus disorders occurred are connected with disfunction of gamma motoneuron system. Intrafusal muscle fibers situated in neuromuscular spindle are innervated by gamma motoneurons and do not participate directly in muscle contraction but control degree of stimulation of neuromuscular spindle receptor. In case of pyramidal, extrapyramidal, cerebellar functional disorders efferent impulses through reticulospinal, Monakow's tracts, dorsal longitudinal fascicles actualize disregulating impulses to gamma motoneurons leading to contraction of intrafusal fibers and stimulation of muscular receptors increasing muscle tonus. Muscle tonus changes lead to imbalance of neuro-muscular coordination and to asymmetric dorsal muscle tension and result into its distonic curvature. Thus, primary idiopathic curvature occurs. Further muscular changes

have secondary nature and appear as a result of unbalanced axial stress of the spine.

In Poland the first followers of the theory of muscular tonus disbalance disorders were Gruca, Wejsflog, Zuk [43-45]. In the 50s of the last century namely they paid their attention to abnormalities of integration of neuromuscular system and influence of the above said abnormalities to the secondary changes in osseous-articular-ligamentous apparatus. Conceptualization that dorsal muscles asymmetry resulting from the muscular distony leads to disorders of static and dynamic vertebral functions is viewed by the aforementioned authors as the main reason of IS.

On the basis of observations of scoliosis associated with neurological diseases poliomyelitis and myelosyringosis in 1961 Liszka advanced an opinion that postural defects are connected with breakage of reflex arch and afferent pathways leading to axis. In case of viral infections like poliomyelitis inflammatory process damages mainly large and small alpha-motoneurons of anterior horns causing asymmetric damage and necrocytosis. Further atrophic changes of muscles attached to the spine and resulting scoliosis are considered as secondary events of this process. The scientist, having cut dorsal and ventral roots from the same side in several adjacent spinal segments of a rabbit, found that lateral spinal curvature appeared at the place. Thus, he proved that unilateral incision of sensory roots on the one hand causes greater spinal curvature than simultaneous damage of afferent and efferent pathways, on the other hand, he concluded that switching off sensory impulses damaged vertebral statics more than disorders of efferent regulation of muscles.

Some time later Tabjan [99] not only confirmed that cutting sensory pathways alone lead to secondary changes in muscular fibres at the damaged side, but he also added to Liszka's experience. Having cut dorsal roots of cats contralateral to the curvature, he corrected scoliosis induced earlier. Degree of correction was inversely proportional to damage intensity caused by the first procedure and time of setting.

Data obtained during experimental study of animals were proved in Zuk's works [43, 45], who used electromyography (EMG) of dorsal and abdominal muscles of children with idiopathic scoliosis (IS) being treated conservatively and surgically, found that 55% of patients had apparent or low-grade signs of protoneuron damage at the both sides of the curvature, but it was more significant from convexity, where higher potential amplitude was also registered. The researcher came to conclusion that this fact does not witness functional integrity of the muscle studied but indicates mobilization of greater number of undamaged motor units at the opposite side in order to balance muscle tension. That is, overbalance of muscular functional activity from the covex side according to electromyography does not cause IS but accompanies its development reflecting the whole range of pathogenetic mechanisms determined by nervous system dysfunction.

During other experimental studies [102] of rabbits it was established that in case of scoliosis caused by unilateral damage of vertebral ligaments and costotransverse joints as well as spinal extensor, changes occur in juxtaspinal muscle tension from both sides proved by asymmetric bioelectric activity. Muscle contracture formed from concave side of curvature, evident through decreasing potential time duration of motor units, is secondary. Strained muscles from convexity, according to myotatic reflex data, are characterized by higher bioelectric activity. Changes intensity prevails from convexity.

In 1993 – 1994 Machida and co-authors obtained experimental scoliosis as a result of experiments on chickens which involved excision of pineal body. They advanced a hypothesis that progressing asymmetry of body is caused by central nervous system dysfunction and the lesion might be located between mesencephalon and cerebral cortex.

In 1997 Kowalski [61] in his experiments on rabbits as a result of electrostimulation of vertebral muscles by LESS method obtained experimental scoliosis, occurred from the opposite side of the one having been stimulated. In that case vertebral deformities had fixed form, impossible to be corrected manually.

In earlier works influence of electrostimulation on static function of rabbit's spine was studied by Bobechko [3] and Herbert who who first implemented this method in clinic treatment in 1974.

Other researchers, studying influence of electrostimulation on ape organism, demonstrated growth of respiratory enzymes in spinal muscles under LESS influence (Bigard and Grimby [11]).

In some other works influence of electrostimulation to the ratio of fast and slow muscular fibres was studied. Thus, Joe [16] in his experiments on rats, carrying out electrostimulation of dorsal muscles for three weeks, found growth of fibres of the first type in relation to the second on the stimulated side. After the following three weeks of the experiment without electrostimulation, normalization of the ratio of fibers was observed, at this experimentally formed scoliosis was maintained.

Wright, applying electrostimulation of spinal muscles of children for a long period of time, did not find any pathological muscular changes. However, he also disclosed increase of the ratio of the first type fibres in relation to the second on the stimulated side.

Carrying out morphologic studies of the material taken from children spinal muscles biopsy, Hsu described appearance of small atrophic fibres of the first type from both sides of the curvature. The greatest changes were evident from curvature convexity. These changes existed independently from period of LESS application.

Three months after carrying out LESS Grimby, studying children's biopsy samples from stimulated side and the opposite one, stated growth of fibres of the first and second type from convexity, i.e. side of stimulation. However, after three months' application of LESS the author also notes occurence of muscular fibre atrophy.

Summarizing results of experimental, clinical and hystologic studies, it could be stated that all of the authors agrees that present atrophic and degenerate changes in muscular and connective tissues in case of IS are secondary and occur due to damage of afferent part of reflex arch of spinal medulla.

It was also proven that postural abnormalities are formed not only as a result of motor apparatus disorders (e.g., deformities of vertebrae in case of Scheuermann-Mau disease, rachitis, contractures), but can also result from diseases of other organs (vision deficiency, nervous system diseases, inflammatory changes in pleural and abdominal cavities). And vice versa, postural abnormalities can lead to visceral organs diseases, their extrusion, atelectasis and emphysema, to forming pulmonary heart, neurological diseases due to spinal medulla compression.

Postural abnormalities could result from insufficient physical activity of children and adolescents. In addition, as one of the reasons of its occurrence is considered to be deviance of rational diet which leads to insufficient supply of organism with full-

value protein, vitamins, macro and micro elements, particularly needed at rapid growth stage in critical periods of development. Particularly important is lack of rational rest and insufficient time spent in the sun rays as well as alcohol and drug abuse among children and youth, which eventually leads to the lack of essential positive osseous balance and as a consequence to abnormal stimulation of skeletal development.

Recently a problem xenobiotics present in the environment country-wide became very acute, they are able to invade food from the environment and consequently get into human body. Many xenobiotics, such as chlorohydrocarbon composing plastics influence estrogens, which leads to breakage of mechanisms regulating forming and development of bones.

Postural defects can also be determined by length difference of upper and lower extremities, misfunctioning of muscle groups as well as functional state of joints, their anchilosis, contractures, restricted joint rotation.

Thus, sources of postural defects could lie in prenatal, perinatal or postnatal periods of development. In those cases when postural abnormalities are associated with fixed tortcollis, unstable hip, equinovarus, brachial plexus abnormalities being defects of the same developmental stages, it proves congenital genesis of the disease.

GOOD POSTURE

Vertebral column is an osseous column which consists of many vertebrae and which executes two main functions, which are very different: static and dynamic. Static function is sustained as the spinal column keeps the body in vertical position as well as muscles and organs. Performing dynamic function, vertebral column as an apparatus allows movements in different planes, including amortization function.

Vertebrae are connected to each other with chondral, ligamentous elements and muscles. Present physiological curvatures make vertebral column load resistant, its elasticity helps absorbing shock.

Leading role in maintaining vertebral balance is played by torso muscles and especially **deep muscles of back**: long and short.

Long muscles of back (vertebral extensor, rising ribs, spinal muscle) keep position of vertebral column and performs balance function in posterior and anterior planes.

Short muscles of back (intertransverse, interspinal, transversospinal) have one of the most important functions as they stabilize vertebral column providing vertebral rotation.

Deep muscles are of the lowest weight in thoracic region of the spine at Th3 segment.

Abdominal muscles (abdominal rectus muscles) fix vertebral column and execute its bending in posterior plane. Abdominal oblique muscles provide rotation in lumbar region and torso. Abdominal muscles and flexor muscles of neck are antagonists of muscles of back in posterior plane, but jointly maintain vertical fixation of a vertebral column.

Gluteus muscles also contribute to maintaining vertical position. Extensors and flexors of hips jointly participate in keeping vertical position of body fixing pelvis and changing its bending angle while moving.

In picture 2 of Addendum 2 vertebral column is presented in lateral and anterio-posterior projections.

Good posture is considered to be a habitual position taken by human freely without extra muscular tension in standing position, characterized by symmetric location of parts of body in relation to spinal column. Free position is a habitual position of a person and it can change under influence of muscular tension. Free position is a real static characteristic of vertical position of a person, thus, being subject of medical examination. At the same time body posture is a dynamic notion undergoing changes in child and adolescent ages.

Good posture means that position of parts of body as well as keeping optimal balance and stability requires minimal muscular tension, but maintains best static-dynamic performance efficiency, creates favourable conditions for correct location and optimal functioning of visceral organs. At that, body centre of gravity (weight centre) and vertical line coincides with support centre formed with quadrangle of feet put together (support quadrangle).

What does good posture depend on?

Spinal column is the main support skeletal structure, it does not only balance body position, but also represents locomotor apparatus due to the fact that it consists of

many parts (vertebrae). These two functions seem to be contradictory as support function requires stability and movement function requires significant mobility. Healthy and well performing vertebral column has physiological curves which increase its load and shock resistance by 17 times.

Body posture is an individual feature of every person, determines his silhouette which is recognizable from the distance (habitual posture). Posture can be good and correct or abnormal and unpleasant. When we feel tired we most often keep passive posture which worsens our posture (head and body bent forward, relaxed abdomen, slouched shoulders), when we feel well our posture is better (upright body, free motion and walking).

In different age periods human posture is changing. Habitual posture, characteristic of different age groups are presented in picture 3 of Addendum 2.

POSTURAL DEFECTS

Postural defects determined by functional changes in locomotor apparatus declare themselves through abnormalities of vertical body position, mainly in frontal plane which apparently differs from typical physiological norm among this population.

Postural defects resulting from pathologic changes, as a rule, become evident in all three planes: anterior, posterior and lateral planes. Not only vertebral column is characterized by changes but also the part directly attached to it.

More often postural abnormalities become evident in childhood and adolescence. The following are the most frequent.

Humpback – thoracic hyperkyphosis with lumbar lordosis almost absent, depending on localization it could be high, low or total.

Congenital humpback is a thoracic hyperkyphosis diagnosed at birth. Often observed as a family abnormality, it is also formed due to congenital abnormality of vertebrae (cuneiform) development or their fusion.

Acquired humpback is, as a rule, a secondary defect resulting from rachitis, tuberculosis, metabolic disorders and blood supply disorders (e.g., Scheuermann-Mau disease), inflammatory development of stiffness of vertebral joints (ankylosis) or their posttraumatic changes, it can also form as a secondary psychogenetic changes. In the course of these diseases dorsal muscles are strained and pectoral muscles are supertensed leadings to shoulders going forward and forming scapula alata.

Hunchback is a kind of abnormal physiological thoracic and lumbar curvatures of vertebral column at which all the vertebral curvatures are exaggerated, greater pelvic angulation. Back is concave and flat. Head, neck, shoulders are bent forward, stomach comes forward.

Pathologic thoracic or lumbar-thoracic kyphosis (hyperkyphosis) is often a sign of deformities caused by Scheuermann disease at certain levels.

Deepened lordosis is an acquired lumbar lordosis, characterized by extreme physiologic lumbar curvature. It is often associated with increased pelvic anterior angulation. Muscle tonus disorders in this case is characterized by weakening and strain of gluteus muscles, posterior group of thigh muscles (biceps muscle of thigh) and calf muscles as well as lower part of abdominal rectus muscles. Simultaneously supertension (spasticity) and elasticity reduction occur (contractures are possible) in iliopsoas muscle and rectus muscle of thigh, vertebral lumbar extensor and lumbar quadrate muscle as well.

Deepened congenial lumbar lordosis is often associated with pathologic kyphotic lumbar curvature. Most frequently diagnosed together with various congenital vertebral lumbar-sacral abnormalities, especially with myelomeningocele and meningocele.

RIB CAGE DEFORMITIES

Koilosternia ("cobbler's chest") is a thoracic cage and rib deformity when sternum and ribs are dislocated back to the vertebral column (sunken breastbone).

Chicken breast is a deformity when sternum and parasternal ribs are dislocated forth; chest circumference is often smaller than normal.

Postrachitic chest has a characteristic feature – Harrison sulcus formed by rib attenuation resulting from their introvolution by diaphragm and secondary dislocation costal arches forward.

Contracted thorax means no advance of rib cage in relation to abdominal plane. Secondary changes of this rib cage deformity are often blood circulation and breathing disorders.

LIMB DEFORMITIES

Genus varum is a deformity characterized by outward bowing of lower limbs, when knees can not be joined with a distance between them of more than 5 cm.

Genu valgum is a deformity characterized by impossibility to touch feet together while simultaneously straightening both legs with knees kept together, distance between medial malleoluses huckelebone joints is more than 5 cm.

Clubfoot (inward clubfoot) means dislocation of heel bone inward from vertical line more than 5º.

Talipes valgus (outward clubfoot) means dislocation of heel bone from vertical line more than 5º.

Flat talipes valgus result from functional inefficiency of muscular ligamentous system and appear through dislocation of heel bone from vertical line outward more than 5º with simultaneous lowering arch of foot.

Hyposthenic foot is an inversive form of flat talipes valgus.

Longitudinal platypodia is a state when longitudinal arch of foot is lowered which leads to its dynamic and static disfunction.

Transverse platypodia is a state when transverse arch of foot is lowered which leads to its dynamic and static dysfunction.

Strephopodia is a fixed pathologic position of a foot in plantar flexion state.

Heel foot is a fixed pathologic position of a foot in dorsiflexion state.

Pes cavus is a fixed pathologic longitudinal and transverse position of arch of foot often with hammer toes.

Hallux valgus is a deformity based on a leaning great toe outward more than 5º. It is often a secondary deformation associated with transverse platypodia.

SPINAL CURVATURES

Spinal abnormal curvature is a complex of deformities of a vertebral column and attached thoracic cage as well as other elements of locomotor apparatus which often lead to dislocation of viscera. The following abnormalities could be distinguished.

Functional curvatures mean, as a rule, lateral vertebral curvatures, first seen only in anterior projection and being secondary with regard to the reason causing them, e.g. different length of lower limbs, their adduction or abduction, pelvic joints contractures, severe pain syndrome. Functional abnormal curvatures straighten after the reason is eliminated.

Structural changes (organic) are regularly multiplanar vertebral curvatures, they are stable and fixed changes (stable lateralization, rotation or torsion). These changes are actual deformities of vertebral column.

Classification of abnormal curvatures of spinal column is given below.

Cobb's classification of abnormal curvatures of vertebral column

I. Functional scoliosis.

1. Static scoliosis is formed due to different length of lower limbs or oblique pelvic curvature.
2. Reflex scoliosis occurs due to severe pain syndrome.

II. Structural (organic) scoliosis.

1. Scoliosis of osseous origin:
    a) congenital scoliosis occurs due to congenital abnormalities of vertebrae (cuneiform vertebrae, hemivertebrae, vertebrae adhesion);
    b) thoracogenic scoliosis occurs due to rib union
    c) systemic scoliosis occurs due to ossification disorders (arachnodactylia, pathologic bones fragility, osteogenesis imperfecta).
2. Scoliosis of neurogenic origin:
    a) congenital scoiosis – determined by Recklinghausen disease (phacomatosis), a genesis of spinal medulla (myelodysplasia);
    b) scoliosis determined by flaccid paralysis – poliomyelitis, amyotrophia (curvature forwarded to damaged side);
    c) scoliosis determined by spastic paralysis – spastic forms of cerebral palsy, most often hemiparetic form (curvature forwarded to undamaged side);
    d) others – Friedrich disease, vertebral tumor, myelosyringosis, multiple sclerosis.
3. Scoliosis of muscular origin:
    a) congenital scoliosis – due to cicatrical fetal muscle changes, muscle aplasia (hypoplasia);

b) muscular dystrophy;

c) others – birth vertebral traumas.

4. Mixed type of scoliosis – when abnormalities have osseo-neuro-muscular origin (myelocele and meningocele);
5. Idiopathic scoliosis (IS).

Idiopathic scoliosis makes 90% of all abnormal curvatures of vertebral column. It is a multiplanar curvature occurring only in children and adolescents in the period of intensive growth. More frequent among girls, often dextral.

Ideopathic scoliosis are classified according to deformity localization (cervical-thoracic, thoracic – 44% (Th7 – Th9), thoracic-lumbar and their combination), as well as patient's age. In accordance with patient's age the following four groups of IS are distinguished.

1. Infant (0 – 3 years of age) – diagnosed mainly in boys, have sinistral dislocation, progressing nature, deformation angle often exceeds 100°;
2. Child (3 – 10 years of age) – diagnosed mainly in girls, have dextral dislocation, often lead to great worsening of health;
3. Adolescent (10 – 18 years of age) – also diagnosed mainly in girls, have dextral curvature;
4. Adult (after 18 years of age).

Classification of abnormal curvature of vertebral column according to deformation angle

I° - deformation angle up to 30°;

II° - deformation angle from 31° to 60°;

III° - deformation angle from 61° to 90°;

IV° - deformation angle more than 90°.

Classification of abnormal curvature of vertebral column according to kind of curvature

1. Cervical (C).
2. Thoracic (Th).
3. Lumbar (L).

Classification of abnormal curvature of vertebral column according to type of curvature

1. Dextral.
2. Sinistral.
3. Primary S-shaped.

Classification of abnormal curvature of vertebral column according to clinical course

1. Progressing.
2. Non-progressing.
3. Regressing.

Classification of abnormal curvature of vertebral column according to the period of curvature onset

4. In infancy.
5. In childhood.
6. In youth.
7. In adulthood.

Orthostatic reflex and compensation

Orthostatic reflex is a reflex causing tension in muscles located higher and lower the damaged region and it is aimed at straightening the curvature. As a result compensation mechanisms are formed in order to straighten mechanical axis of spinal column.

Compensation (substitution of a lost function by the other one) does not only involve straightening of a vertebral curvature in frontal plane but also straightening of pelvic angularity including its axial angle reduction at the side of its primary curve as well as reduction of degree of lower limb flexion in posterior plane. Compensation may have positive effect (reduction of body lateralization) or negative, due to pathologic setting of thoracic and pelvic girdles and fixed contractures of muscles.

In case of full compensation development equality of angular sum of primary and straightening curvatures (countercurvature) is registered.

A natural mechanism of vertebral curvature compensation is forming a mechanism in order to balance secondary changes formation leading to straightening mechanical vertebral axis. This phenomenon is described as a linear compensation meaning that mechanical vertebral axis straightening results into balancing angular degree of the primary curvature with angular degree of straightening curvatures (Cobb). At that, thoracic cage is situated exactly above pelvis and vertical line of acanthi of VII cervical vertebra is projected on the support centre through gluteal fold (Wejsflog). Linear compensation is developed in approximately 30% of cases of abnormal vertebral curvatures [103].

Nonlinear compensation develops in 70% of cases of abnormal vertebral curvatures and is formed due to tendency of finding a position of body balance while moving centre of gravity in frontal projection. This mechanism is based on the secondary changes (modifications) of lower limbs setting and/ or pelvis setting in such a way that centre of gravity fall within the support centre of a quadrangle formed by the patient due to weight and balance changes of location of body centre of gravity in anterior projection. At that, flexion of a lower limb in hip and knee joint as well as pelvic angularity, as a reflexion of non-linear compensation, occurs mainly at the curvature side. This state of nonlinear compensation persistent for a long time leads to secondary pathologic symptoms, i.e. flexion contracture in lower limb joints and fixation of oblique pelvis position.

Pelvic deformities are formed generally in fixed set deformities of vertebral column (70%) as a presentation of nonlinear compensation which does not occur in case of rapidly progressing curvatures.

Pelvic deformities consist in:

- asymmetry of sinistral and dextral coxal bones (Rtg);
- lowering and advancing spina iliaca anterior superior (according to clinical research data);
- asymmetry of a waist and Bryant's triangle (according to clinical research data).

Pelvic deformity can occur at simultaneous:

- co-existence of equal absolute length of lower extremities,
- co-existence of parallel line between coxal cavities and floor.

Pelvic deformities further lead to sacral bone position changes and anterior dislocation of innominate bone from convexity of vertebral curvature.

In common pelvic deformities occur more often in case of paralytic and idiopathic curvatures, being rather an exception in case of congenial genesis of the disease, and also in case of III° and II° vertebral curvatures, being a rare case at I° vertebral curvature, when non-linear compensation is persistent for a long period of time.

Compensation pelvic deformities are most frequent in cases of lumbar scoliosis, less often – thoracic-lumbar scoliosis and most rare – thoracic scoliosis.

The most severe pelvic deformities are formed in case of primary long-lasting paralytic scoliosis.

Objective examination in infancy

I. Static reflexes (inconditioned reflexes which influence posture formation) are integrated at spinal medulla and spinal bulb, afficient in baby's first six months.

Reflexes attended by limbs movements – withdrawal reflex with triple flexion of lower limb and crossed reflex of extensors and also righting reflex appear by the end of the second month. In this period a child lifts his head from prone position. The first physiological curvature of vertebral column starts to form – cervical lordosis.

Positive support reflex – tonic increase of muscle tonus and body straightening with flexion of lower limbs when a child is kept under his arms and his feet bounce on the flat surfaceas well as Moro's reflex are efficient up to the age of 4 months. In this period a child must be able te keep his head withing body axis when his upper limbs are pulled up (test for traction) from dorsal position, turn to lateral position, in prone position keep support on his lower arms, forming and fixing cervical lordosis.

Tonic labyrinthine reflex, tonic cervical assymetric and symmetric reflexes efficient from 6 to 8 months. In this period a child in prone position can lift, keep his head and turn it, can turn to prone position easily and back, sits if he is seated and starts getting into sitting position without help.

Tonic labyrinthine reflex and innervation of trunk responses do not appear as a rule in healthy infants after 8-10 months of age.

In this period thoracic kyphosis is formed.

II. Statokinetic reflexes (righting reflexes) are integrated at cervical region, spinal bulb and midbrain, appear and influence vertebral curves forming from 6th to eighth months of age.

Cervical righting reflex of head, trunk righting reflex, forming rotation elements as well as upper and lower Landau's reflexes appear and start to disappear at the age of 6-8 months. In this period an infant can stand on all fours, take sitting position himself. Defense reflexes (defense turn of head, defense extension of arms), reflex of readiness to jump or so called parachute response are efficient till the age of 8 – 9 months. In this period a child can crawl well, standing on all fours, it supported he can keep vertical position for a short time, alternating flexing and extending his knees.

In this period thoracic kyphotic curve is fixed.

III. Reflexes of balance automatism (complex balance reflexes) are integrated at subcortical and cortical levels of motor contral of central nervous system and reticular formation of brainstem. They appear at the age of 9 to 24 months. This group consists of complex reflexes including proprioceptive, labyrinthine and visual reflexes. New integrative relations are formed as auditory-motor links, visual-tactile-kinaesthetic links, visual-tactile-motor links and coordinations complementory to each other. Integration and mutial coordination is executed with participation of subcortex nuclei and tentorium. In this period a child starts taking standing position independently, walks if supported with one arm, then walks independently. He/ she can easily change positions, from lying position to standing

position. In this period the last physiological vertebral curve is formed – lumbar lordosis.

Picture 1 of Addendum 2 illustrates forming of physiological curves of vertebral column at the age of 1, 2, 3, 4, 6 and 12 months.

Objective examination in infancy

In objective examination it is necessary to consider all three planes investigating posture from front, from above or from below, from rare or laterally and at bending forward position.

Investigating posture from front we check if head and neck are set vertically, if space between thoracic limbs and trunk (waist triangles) are symmertic as well as knee and foot setting. From rare we evaluate symmetry of shoulder level, shoulder blades, hips, gluteal fold and politeal spaces, ankles, heels. Doublecheck waist triangles from rare. Then we measure vertical line checking if it deviates.

Investigating anterior plane unlike classic projection of a vertical line from an inion we suggest projecting vertical line from acantha of 7 cervical vertebra, which allows avoid mistakes in vertical deviations conditioned by head movement. Correct prjection line should coincide with the line joining acanthae of vertebrae and also the line between glutes and falls down within the centre of support quadrangle made with free feet setting. In anterior position any assymetry and vertical deviation is considered to be a postural abnormality (See Picture 4 of Addendum 2).

In posterior view (anterior-posterior) vertical line falls down from processes of temporal bones, goes through the centre of head of humerus, trochanter and condyle of femur to cuboid metatarsus. In posterior position postural defects are detected associated with physiologic curves abnormalities (kyphosis and lordosis – cervical and lumbar), pathologic deviations from vertical line as well as abnormal pelvic position (anterior or posterior deviation).

In lateral position (lateral plane of spine) significant dorsal assymetry could be detected during estimation of topview. Arrangements of girdle of superior extremity, thoracic cage and pelvic are estimated. Investigation of bend forward position is very important as it creates an opportunity to detect asymmetric convexity in case of posterior rib hump or lumbar levator cushion.

Objective investigation measurements we carry out with Haglund frame.

Other investigation methods are also wide spread.

Phototypographic Moiré's method uses concentric shadows projected on the patient's body (See Picture 4 of Addendum 2).

Investigation of growth coefficient. This measurement we carry out with the help of defining ratio of petient's height and length of his vertebral column. It is proven that scoliosis frequency is directly proportional to high growth coefficient, i.e. tall stout children and children of asthenic build.

X-ray in standing position.

a) In X-ray photographs angles of vertebral curves can be measured with the help of Kobb, Grucy and Fergusson's method. The most wide spread method is Kobb's angle measurement. It is based measuring the angle between two lines, drawn perpendicular to the upper endplate of the uppermost vertebrae involved and the lower endplate of the lowest vertebrae involved, as well as direct

perpendiculars of these lines. The perpendicular angles shows curve angle characterizing curveature severity in degrees. Pragmatically not an actual angle is considered but so called additional angle dgree of which grows pro rata curvature deformity increase. In Picture 5 of Addendum 2 Cobb's method of measuring curvature of spinal column is presented.

b) F. Harrington's coefficient requires measuring quotient Kobb's and defining number of vertebrae involved. This factor has a prognostic value:

- F smaller than 3 means scoliosis which can be eliminated
- F > 3 – scoliosis subject to progression
- F > 5 – progressing scoliosis

Growing F. Harrington's prognostic value indicates increase of vertebral curvature.

c) Rotation degree is defined by movement of the acantha of this vertebra from (+) to (++++) or from 0 to 4 according to Nash and Moe in the direction rotated laterally in relation to the next vartebrae (See Picture 6 of Addendum 2). Growing rotation degree indicates increasing rotation deviation of the vertebra in relation to the length of vertebral axis in lateral plane and charecterises scoliosis severity.

d) Oblique rotation (torsion) of a vertebra is a deformity of a separate disk in form of its torsion.

e) Raisser's test Risser is an estimation of femoral bone, pelvis ossification and indirectly characterizing vertebral ossification, i.e. a test which allows judging if growth of spinal column is completed. Osseus maturity is estimated through the degree of ossification of femur gristle withing the scale from 0 to 5. Here a phenomenon of parallel development of pelvis and vertebral column was used, they complete their growth at the same time (See Picture 7 of Addendum 2).

Modern diagnostic methods

a) Three dimension estimation of spinal column – through parallel x-ray photography in posterior and anterior views using scanner trigonometric diagrams are processed, which lay the basis for three dimensional estimation of curvature of vertebral column.

Three-dimensional computer tomography (KT-3D) is a sterioscopic picture of computer tomography which undergoes mathematic processing and creates opportunity for detailed analysis of quantitative changes of individual vertebrae. Vertebral column can be shown from any view and computer mathematic opportunities of external view drawing allows seeing osseus structures from inside, even inside spinal canal.

b) Magnetic Resonance Imaging (MRI) allows estimation of nervous structures and spinal canal shape without opaque injection. This technique is often used in diagnostic and therapeutic process as preoperative assesment.

c) Integrated surface-imaging system (ISIS) – can be used for population-based studies. It is based on optical Moiré method. Computer system allows full measurement of dorsal surface. Acanthae and transverse processes are marked with black marker froming three points on the surface under investigation. In the picture obtained, markers indicate central line of processes and paracentral lines from both sides of spinal column. This method allows assesment of vertebral column in three dimentions – posterior, lateral and horizontal views.

Assessment of strength and endurance.

In separate tests muscle strength is estimated with the help of static tests and muscle endurance is estimated with the help of dynamic tests.

Abdominal muscles testing

It is presented in Picture 8 of Addendum 2.

Starting position: dorsal position, lower limbs bent in hip and knee joints.

- Static test finds out time of keeping this position with lifted head and limbs. Arms are crossed on the chest, breathing freely.
- Dynamic test registers number of repetitions of assuming position of lifted head and lower limbs and touching knees with fingers and returning into starting position in a certain tempo.

Dorsal muscles testing

It is presented in Picture 9 of Addendum 2.

Starting position: prone position, upper limbs stretched above head.

- Static test means time of keeping this position with the head lifted and stretching and lifting upper and lower limbs.
- Dynamic test means number of repetitions of assuming position with lifted head and stretching and lifting upper limbs with lower limbs fixed.

Gluteal muscles testing

It is presented in Picture 10 of Addendum 2.

Starting position: torso on the table, body fixed up to the hips, upper limbs are extended and grabbing the table.

- Static test means time of keeping this position with lower limbs lifted to the table level.
- Dynamic test means number of repetitions of assuming position with lower limbs lifted to the table level.

REHABILITATION TREATMENT

Rehabilitation treatment is aimed at elimination of deformities or reduction of its severity and fixing correction obtained or containment of disease progression if stabilization is impossible.

Prevention

Prevntion commonly means preventive measures aimed at making the body healthier – rational diet, sufficient motion activity, keeping right posture in different positions (standing, sitting, lying), forming healthy lifestyle. Apart from that, prevention includes health care system organization, which allows detecting the disease at early stages, e.g. in health units of kindergardens and schools. Prevention measures also include a special complex of prevensive exercises.

We recommend to arrange your lifestyle, work and rest in such a way as to avoid irrational stress for your spine. Thus, we can avoid widely spread spine diseases associated with severe, sometimes unbearable pains in future. It is essential to train habits of correct performance of various activities (housework, weight lifting, sitting work at the desk), using right and safe body positions.

All kinds of movement are essential. They balance sitting lifestyle (hyperkineasis), which became characteristic of our civilization. Except for muscle strengthening, muscular activity improves functional capabilities of circulation and respiratory systems. Together with them mental stability is improved. You should choose such activities which you enjoy: for instance, skiing, downhill skiing, skating, swimming, cycling, walking, etc.

Stress reduction is achieved with the help of daytime relaxation, sleeping on flat surface, avoiding assymetric load on the back. Symmetric load distribution is achieved with the help of backpacks, knapsacks or doing exercises in lying position.

Reason elimination in case of functional scoliosis and vertebral curvatures could be achieved through correction of the short limb using special orthodaedic footwear or eliminating contractures.

Correcting excercises are an essential part of non-surgical treatment of diseases and curvatures of spinal column. All the training is planned in such a way as to make the patient interested in systematic and often durable treatment. Training plan could be modified depending on the kind of disease, its progression or alteration of orthpaedic rehabilitation objectives including possibility of operative treatment.

Application of a certain correction method, namely assymetric exercises, is conditioned by the detailed analysis of functional abnormalities of thoracic cage, spinal column and pelvis joints. Primary diagnostics and analysis of the results are carried out in three dimensions: posterior, anterior and lateral.

The main objective of exercising is training of **the feeling of the right posture,** for instance, doing self-correction and elongation exercises in front of a mirror or reducing contractures severity with the help of stretching exercises or postisometric relaxation.

The most popular and most frequently prescribed is **corrigent gymnastics** aimed at improving body motor functioning through correcting assymetry of motor apparatus and normalization of location of visceral organs. Correcting exercises

develop and form muscle coat keeping right posture in any position. This is achieved through muscle tone improvement and muscle strenght while doing **symmetric and anti-gravity** exercises. Development of muscles stabilizing vertebral column – deep and short dorsal muscles - is of especial importance.

A significant part of corrigent gymnastics is exercises training **gluteal and abdominal muscles** with gradual load increase in rehabilitation period. Except for that, exercises correcting **pelvis position** are compulsory, they are used to teach a patient to keep his pelvis in right position while moving upper and lower limbs, including feet. These exercises serve to keeping the right posture while doing various actions. The most efficient method used after first detailed analysis of movements is **PNF method** (proprio-neuromuscular-fascilitation). This method is based on usage of special exercises (movement patterns) forming through stimulation of proprioreceptors and feedback mechanisms (periphery – center – periphery) facilitating conditions for patient movements corresponding to more physiologic movement patterns.

The excercises described above can be added with **respiratory and conditioning** excercises, which are done in groups. It is necessary to make the training sessions interesting, if possible add musical accompaniment. It is important to form groups with regard to patients' age and functional abilities, if group games are conducted it is necessary to set a clear instructions sequencing actions.

Neuro-motor interaction development

In individual kynesiotherapy of infants exercises stimulating psychomotor appratus according to Voita's method and PNF therapy are widely and successfully used.

Self-correction

In this programme children are taught in front of a mirror to control the right posture using his/her feelings with the help of a vertical line. The right posture is assumed if feet, knees, hips, waist triangles, shoulderblades and head are set correctly. The child is demonstrated his or her postural errors in order he could correct them exercising consciously. The aim of such exercises is froming conscious control of correct posture and development the feeling of his/ her own body position.

Contractures correction

In the course of contractures correction stretching exersises are used, which are selected with regard to individual particularities of child's deformities. Isometric stretching is used most frequently, when stretching of a homogenious intensity is alternated with relaxation of 10-15 seconds' interval, and increasing stretching when stretching intensity is rising withing 10-30 seconds followed by postisometric relaxation. Thus, motor capacity of joints and muscle elasticity are achieved as well as normalization of neuro-muscular activities and conscious control of positioning of own parts of body.

Stabilization

Stabilization includes a group of excercises in different positions aimed at strenthening muscle coat and involving deep muscles. Isometric, isolating exercises in lying position prevail. Nowadays rehabilitation fitballs are used. Fitball exercises involve many muscle groups, posture is possible to be controlled consciously. Such exercises involve weak muscles and assist reduction of contractures severity.

Visual-motor coordination

Visual-motor coordination is based on doing isometric exercises, duration of which is from 10 to 60 seconds, controlled visually. Moreover, exercises for posture control training can be done without visual control, when they are reproduced grounding on the memory as the correct postural patterns have been trained before. Exercises on reproduction of the right postural pattern are done with the patient's eyes closed using muscle memory and his own feelings.

Swimming

Swimming is an integral part of corrigent exercises. This element relieves stress naturally and makes it easier to do all the movements at full extent. Keeping the body on water surface is the main exercise for training „right posture feeling". In this case we deal with both dynamic and **isometric** exercises training deep dorsal muscles, which are chief stabilizers (fixators) of a vertebral column.

Hippotherapy

Hippotherapy (from Greek hippos – horse) means using horse riding in a rehabilitation process of disabled people. Striding horse serves as a therapeutic mean of reproduction of motor activity. A patient sitting on horseback improves his posture due to specific horse movements, furthermore, skills of keeping balance and compensatory muscle contractions are developed and trained with the help of slight coordination reflexes. Effect of proprioceptive sensor-motor stimulation arising improves patient's posture since it facilitates finding and fixing most natural motor reflexes. At the same time this motor correction trains muscles, reducing their disproportion, and controls muscle tonus, making it possible to increase the amount of motor activity of spinal column and joints.

Exercising in self-correction device

Exercises with self-correction device include elements of isometric exercises with simultaneous usage of directed pressure effect gained when exercise machines are used. All the exercises must be done in two steps.

At the first stage intensity of training is the centre of attention, they can be used:

- in hospital departments in pre-operative period – for about 6 weeks;
- in correction groups in hospital;
- in rehabilitation centres;
- in rehabilitation health care institutions (sanatoriums).

At the second stage it is necessary to retain skills developed earlier through training, doing exercises regularly independently:

- at home twice a day for 30 minutes;
- in correction groups in local sport clubs;
- in school correction (special) groups.

Electrostimulation LESS

Electrostimulation LESS is illustrated in Picture 12 of Addendum 2. This method helps avoiding forming asymmetric muscle tension and increase muscle receptors sensitivity. It is used in cases of ideopathic scoliosis of I^{o} degree for 2 hours a day taking into consideration collateral effects (sleeping problems, etc.) and imperfection of the method itself (electrodes going loose, rubbing of fibres, wires

damaged). Some time earlier this procedure was recommended to conduct for the whole night. Muscles are stimulated from the convex side of the curvature, starting from the vertebral column to posterior median line. Surface electrodes are placed 6 – 12 cm from eac other. As a result correction makes up about 10-20% a year. Modern medical studies using criteria of evidentiary medicine proved that reduction of electorostimulation LESS to 2 hours a day if it is carried out daily gives the same correction results as if stimulation was carried out for the whole night, however significant reduction of side effects was achieved.

Traction

The following kinds of traction are carried out:

- night passive traction in lying position using Glisson scull traction tongs;
- active traction - Cotrel traction using self-elongation;
- gravitational traction;
- Weiss gravitational auxiliary traction.

Except for correction action gravitation traction provides increasing lungs volume if respiratory exercises for thoracic cage are done and also improves circulation system functioning, which is of great significance in rehabilitation period in case of further surgery.

In gravitation traction hangs are used which prepare patients for operations or conservative orthopaedic correction using plaster jackets. Correction plaster jackets (classic) guarantee fast correction and are ideal for non-surgical treatment. After prior relaxation of a vertebral column in gravitation position the jacket is put on a so called Cotrel frame. Moreover, plaster jackets are compulsory after operation for the period when orthopaedic spinal spport is being produced.

Orthopedic brace is used if curvature angle is:

- from 20º to 30º in case of uncontrollable scoliosis;
- from 20º to 50º in case of controlled scoliosis.

The most wide-spread braces became:

Milwaukee brace (Blount, Schmidt) – is a waist belt in which vertical supports with cervical rim, chin holder and hinthead stopper are mounted. In Poland this brace has been used since 70s mainly in cases of thoracic and lumbar scoliosis.

Boston brace is an elongated waist belt made of polymeric discs. It is used in tratment of thoracic and lumbar scoliosis.

Cheneau brace is a modern local support used in treatment of thoracic and lumbar scoliosis.

Spine-cor support is a brand new model of dynamic orthosis for wide use in cases of plastic (elastic) scoliosis or incipient development of it.

Orthopedic bracing is prescribed and put on the patient after prior relaxation of the spinal column and intensive corrigent gymnastics. A support is necessary to adjust in hospital taking into consideration changes of its form in the initial period of wear and patient's acquired tolerance, it is also essential to explain a patient the necessity to wear this support. Support is worn 23 hours a day. The rest is devoted to private hygiene and exercising. RTG is done while wearing support. Ufter support usage, improvements are registered in 50% of patient suffering vertebral

curvatures. Orthopedic brace usage does not cause complications in form of decalcification of vertebral column and pelvis comparing to plaster jackets and does not cause muscle atrophy. Gymnastic exercises can be done in orthopedic support or without it depending on kynesitherapy method.

Operative therapy

Operative therapy is considered to be a consituent of rehabilitation program, it is one of the stages preceded and followed by conservative treatment. Operative treatment of scoliosis is an operative correction aimed at fixing joints with spondylosyndesis and/or arthrodesis using special instruments to fix them to bone fixtures.

The main operative methods are used:

- Grucy's method means placing a spring from the side of convexity of the curvature. This method has become traditional (Picture 12 of Addendum 2);
- Harrington's method means placing a distractor – brace from the concave side of the curvature, distractor is fixed with hooks; this is the most frequently used method in the world (Picture 12 of Addendum 2);
- Cotrel-Dubousset method (C-D Instrumentarium) – they proposed placing modelled rods from both sides of the dorsal side of the vertebral column with correction in anterior position; the rods are fixed with the help of special screws; this method was used in Poland in 80s. (Picture 13 of Addendum 2);
- Zielke method is a method similar to Cotrel-Dubousset method except for the fact that access to vertebral column is carried out through thoracic cage and/or abdominal space;
- Lukue method was developed in Mexico, it allowed to minimize usage of postoperative brace, it uses L-shaped transverse rod fixed with a wire (Picture 14 of Addendum 2).

In Galveston method a rod fixed in pelvis (Picture 14 of Addendum 2).

Combined techniques and improves aforesaid methods are used depending on the disease nature, e.g. Moe technique.

In Poland Grucy, Wierusz, Skwarcza's techniques and more modern - DERO (Zarzycki, Ciupik) found wide application.

Main indications for operative therapy:

a) progressing of scoliosis of 10° or more degrees in a year;

b) when curvature angle is more than 40°;

c) when scoliosis is elastic.

The best age for operation is 12-15 years old. However, regarding fast development of science and technics in this field, operative treatment is possible in preschool age, and considering improvements of respiratory and circulation systems functioning during the child's growth in older age as well.

ADDENDUM 1. SOME REHABILITATION PROGRAMMES AIMED AT VERTEBRAL DEFORMITIES CORRECTIONS

PROGRAMME 1

Rehabilitation of congenital abnormalities of vertebral column development, severe postural abnormalities and lateral curvatures of vertebral column

1. Patient group

M 40 Kyphosis and lordosis.

M 41 Lateral curvatures of the spinal column (scoliosis).

Q 76 Congenital abnormalities of development of vertebral column and thoracic cage.

Indications for rehabilitation according to this programme are presence of any of the above mentioned diseases.

2. Programme aims

The aim of the programme is to provide special rehabilitation aid to the patients suffering severe congenital vertebral abnormalities, postural abnormalities and evident curvatures. It is characterized by local interventions, it requires carrying out accurate analyses, diagnostics and dynamic observation as well as systematic rehabilitation measures in conditions of a specialized department of hospital. It is also targeted at the patients undergoing operative treatment in preparation and postoperative periods.

3. Rehabilitation plan

A) Average time spent by the patient in hospital is 3 – 4 weeks.

B) Diagnostic measures include:

- computer investigation of vertebral abnormalities;
- RTG;
- muscle endurance assesment;
- assesment of reserves of respiratory function according to spirometric data;

C) Pharmacotherapy includes:

- analgetics in postoperative period;
- medications improving functioning of blood circulation and respiratory systems;

D) In the course of treatment it is necessary to:

- observe patient continuously (monitoring) and assist him, as well as to take care of him at the initial stage of wearing brace;
- provide postoperative care itself.

E) General health improvement plan includes:

- kynesitherapy

ICD 9	Name of procedure
93.13	Symmetric and assymetric gymnastics method
93.13	Exercises on muscle stretching to eliminate contractures in pectoral and pelvic girdles
93.13	Conditioning exercises
93.09	Power training (endurance) – static and dynamic
93.14	Training of power (endurance) and speed (rate)
93.14	Endurance training
93.19	Group exercises using symmetric exercises method (static training)
93.19	Anti-gravitational exercises
93.19	Figure exercises
93.14	Respiration exercises
93.19	Individual exercises according to PNF-method
93.19	Teaching right posture feeling
93.18	Gravitational traction
93.18	Traction on special table in the course of preoperative preparation
	Exercises in self-corrector
93.15	Stimulation LESS with «scol» apparatus
93.22	Dynamic currents, interferential currents (in localization area of pain syndrome)
93.22	TES currents
93.21	Classic massage
93.27	Hydrotherapy

F) Orthopedic observation includes:

- prescription of orthopedic brace (Boston, high Boston, Milwaukee–Blount, Cheneau, dynamic Spine-cor).

G) Patient and care-taker training.

Training is arranged in the form of lectures, presentations, exercises, film demonstrations. Participants of educational sessions receive specially selected and prepared materials. Training is divided into the following topics:

- preoperative preparation training;

- postoperative observation and care training;
- instructions on wearing brace round-the-clock;
- training on maintenance of «scol» device in order to carry out electrostimulation Less;
- instructions on maintenance of orthopedic brace;
- teaching patient's care-taker (relatives, friends) to carry out treatment at home at the support stage of complex rehabilitation of lateral curvatures of the vertebral column;
- handing out patient's care-takers selected practical and theoretic materials informing on postural abnormalities and vertebral deformities.

PROGRAMME 2

Rehabilitation for children with necrosteosis (osteochondropathy)

1. Group of patients

M 42 Osteochondropathy of vertebral column.

M 91 Legg-Calve-Parthes disease, avascular necrosis of coxofemoral joint and pelvis.

M 92 Other child disease.

Indications for rehabilitation under this programme is detection of one of the abovementioned diseases.

2. Aims of rehabilitation treatment

Considering long-lasting course of these diseases, different aims are made at different stages:

- at exacerbation it is necessary to reduce load (pressure) on damaged parts of the skeleton;
- further reduction of pressure on the skeleton using fixing rods;
- keeping and increasing muscle bulk and power of muscles using various exercises complexes;
- training (gaining) manner of walking and everyday actions (self-care, production activities), concerning that the course of disease is long-term and treatment lasts for months and years;
- providing patients and their relatives' with information and knowledge about course of the disease, possible exacebration and ways to avoid it;
- providing appripriate orthopedic equipment.

3. Rehabilitation plan

A) Average time spent in-hospital is from 3 weeks to 3 months.

B) Diagnostics includes:

- RTG;
- MRI;
- densimetric analysis;
- assessment of muscle strength with computer dynamometric test data;
- functional assessment of motor apparatus.

C) Pharmacotherapy.

The course of pharmacotherapy includes:

- analgetics;
- medications reducing muscle tone;
- medications contributing to mineral resources of the body.

D) Care

The aim of the proper care is:

- prevention of vesical calcification and urinary tracts infections;
- prevention of contractures development in recumbent patients.

E) Plan of improvement of patient's general health. The plan includes:

- kynesitherapy;
- physical therapy.

ICD 9	Name of procedure
93.23	Kinesitherapy
93.11	Respiration exercises
93.17	Passive exercises
93.12	Exercises aimed at increasing joint movement amplitude
93.12	Auxiliary exercises
93.13	Active-passive exercises
93.14	Loading (power) exercises in lying position or with support on special exercising devices
93.13	Water exercises
93.13	Optional exercises on various actions
93.11	Support stretching exercises
93.13	Exercises reducing pressure on joints
93.14	Isometric exercises based on computer analysis
93.16	Training to walk in the swimming pool under gravitation relief
93.16	Training to walk in parachute type equipment
93.16	Training to walk using crutches

93.14	Independent walking training
93.21	Hydrotherapy
93.21	Massage
93.21	Underwater massage
	Using gels
93.21	Massage
93.21	Relaxing massage
	Stimulating massage
93.22	Physical therapy
93.20	Electromagnetic fields
93.24	Cryotherapy
93.24	Polirized light (Biopton lamp)
93.22	Laser therapy
93.22	TES currents
93.23	Russian currents

F) Orthopedic equipment

Prescribed:

- lumbar splint devices stabilizing, correcting and relieving pressure;
- orthopedic braces;
- crutches;
- walking frame;
- orthopedic trolley.

G) Patient and care-taker training.

Training is arranged in the form of lectures, presentations, exercises, film demonstrations. Participants of educational sessions receive specially selected and prepared materials on the following topics:

- self-care training for the period of long-term immobolisation;
- prevention issues: avoiding everyday actions causing patient's health deterioration and negative sensations, ways to avoid them;
- training on how to use orthopedic equipment correctly.

PROGRAMME 3

Rehabilitation for children with osteoporosis

1. Patient groups

M 80 Osteoporosis with associated pathologic fracture.

M 81 Osteoporosis without pathologic fracture.

Patient's referral to rehabilitation under this programme is issued if one of these diseases were detected. This programme is targeted at children and adoloscents suffering local and general presentation of osteoporosis of primary and secondary genesis.

2. Aims of the programme

The programme aims at the following:

- acceleration of bones union, their regeneration and consolidation;
- prevention of secondary sceletal deformities after pathologic (osteoporotic) fractures;
- patient's training for full and safe functioning in everyday activities.

3. Rehabilitation plan

A) Average time spent in-hospital is from 4 to 6 weeks.

B) Diagnostics includes:

- RTG;
- densimetric analysis;
- assessment of muscle strength;
- application of Lovette test;
- dynamometric computer test;
- complex assessment of motor function;
- endurance assessment;
- laboratory test of calcium phosphoric metabolism.

C) Pharmacotherapy.

The following medications are prescribed:

- analgetics;
- medications containing calcium (calcitonins);
- medications containing limestone (chalk);
- vitamin D.

D) Care.

First of all, care includes prevention measures to avoid pathologic fractures

E) General mobility improvement plan:

Rehabilitation plan comprises:

- kynesitherapy;
- Physical therapy.

ICD 9	Name of procedure
	Kynesitherapy
93.11	Passive exercises
93.13	Active exercises to relieve pressure on vertebral column
93.13	Optional exercises
93.13	Exercises with support
93.19	Manual therapy
	Physical therapy
93.23	Magnetic field
93.20	Cryotherapy
93.24	Polarized light
93.24	Biostimulating laser
	Hydrotherapy
93.27	Exercising in water
93.16	Training to walk
93.13	Active exercising

F) Diet.

Diet is compulsory, eating food rich in phosphorus.

G) Orthopedic equipment.

The following equipment is applied:

- orthopedic training devices;
- orthopedic devices;
- crutches;
- walking frame;
- orthopedic trolley;
- orthopedic brace.

H) Patient and care-taker training.

Training is arranged in the form of lectures, presentations, exercises, film demonstrations. Participants of educational sessions receive specially selected and prepared materials. The following events are conducted:

- teaching rules of a rational diet;
- training care-taker's skills, conducting classes with a child while he/she is in-hospital;
- providing parents with information (booklets about osteoporosis);
- lections for parents on nutritional therapy;

- training on safe movements and functioning in everyday life.

I) Cooperation with consultants in rheumatology and orthopeadics is essetial.

PROGRAMME 4

Rehabilitation for patients with rheumatic diseases

1. Patient groups

M 02 Acquired diseases of joints, including infectious and responsive arthropathy.

M 03 Others.

M 06 Other rheumatic diseases of joints.

M 07 arthritis associated with bowel diseases.

M 08 Child arthropathies.

M 09 Other child arthropathies associated with diagnosed disease.

M 10 Lithic diathesis.

M 11 Other arthrites caused by tophus.

M 12 Other known arthrites.

M 13 Other arthrites.

M 14 Arthrites associated with other diseases in the course of diagnosed disease.

Indications for patient's referral to rehabilitation treatment under this programme are detection of one of the above listed diseases.

2. Aims of rehabilitation

Rehabilitation treatment aims comprise:

- reduction of pain severity;
- prevention of bones and joints deformities as well as muscle atrophy;
- maintaining general functional motor abilities;
- providing necessary orthopedic equipment (materials).

3. Rehabilitation plan

A) Average time spent by the patient in-hospital varies from 4 to 6 weeks.

B) Diagnostics.

Diagnostics includes:

- assessment of motor state;
- assessment of routine functioning;
- carrying out tests on self-care;
- estimation of biochemical indexes of inflammatory processes severity;

- RTG;
- assessment of stomach functioning;
- assessment of kidneys functioning;
- computer assessment of muscle strength;
- performance capability assessment;
- densinometric analysis.

C) Pharmacotherapy.

Systematic taking antipyretic medications and analgetics of local or general action are prescribed depending on the disease after prescription or correction by rheumatologist.

D) Care.

Care is directed on prevention of secondary contractures.

E) Functional health state improvement plan includes:

- carrying out physical therapy and hydrotherapy before kinesitherapy;
- irradiation with Sollux lamp and Biopton lamp;
- using direct galvanic currents;
- using ionophoresis;
- using diadynamic currents;
- using electromagnetic field;
- prescription of cryotherapy;
- prescription of a hot bath;
- application of hydrogels;
- consulting in rheumatology and orthopaedia;
- kinesitherapy.

Programme aimed at increasing joint movement include:

ICD 9	Name of procedure
93.11	Application of manual technique for unblocking joints and encreasing amount of passive movements
93.11	Using stretching
93.11	Improvement of passive movement with the help of training devices and CPM splint
93.17	Exercises for improvement of local motor activity
93.27	Whirlpool massage
93.21	Underwater massage
93.21	Air massage
93.27	Application of hydrogels

Programme aimed at increasing muscle strength includes:

ICD 9	Name of procedure
93.13	Exercises in a special training device relieving pressure of the joint in hanging position using counterbalance
93.13	Exercises in a special training device providing support load on the joints
93.13	Exercises with support on the joint using dynamic endurance computer control system and control of isometric tension and load on the joint
93.15	Muscle electrostimulation

Programme including exercises aimed at increasing general and power performance efficiency (endurance):

93.09	Exercising in cycloergometer with computer assessment of general performance capability (endurance)
93.09	Exercising on a treadmill with electric control
93.09	Exercises on power endurance in training devices

Programme aimed at forming right motor stereotype:

93.16	Exercises improving movement technique of upper, lower limbs and torso according to individual method including physical therapy
93.14	Exercises improving movement technique according to individual method in the pool in hanging position (like in a parachute), on a treadmill, on a walk with intergal analysis of present movement abnormalities on the basis of a film shot by a therapist

F) Orthopedic equipment.

A patient is provided with orthoses and orthopedic devices improving and relieving his motor functioning.

G) Patient and care-taker training.

Training is arranged in the form of lectures, presentations, exercises, film demonstrations. Participants of educational sessions receive specially selected and prepared materials on the following topics:

- correct usage of orthoses, devices and technical means of rehabilitation;
- application of kinesitherapy in rheumatology.

PROGRAMME 5

Rehabilitation treatment of obesity and other acquired deformities of limbs in children

1. Patient groups

E 66 Obesity.

M 21 Other acquired limb deformities.

Refferals to the rehabilitation treatment under this programme are issued to those patients who are diagnosed with one of the above stated diseases.

2. Aims of rehabilitation

Aims of rehabilitation include:

- body mass reduction;
- changing habitual diet;
- correction of general stereotype of living.

3. Rehabilitation plan

A) Average time spent by a patient in-hospital is from 3 weeks to 3 months.

B) Diagnostics.

Within kinesitherapy the following measures are held:

- assessment of power capability;
- assessment of motor capability.

C) Plan of health improvement.

The plan includes:

- low-calory diet 1800 KKal/day;
- individual classes arranged with regard to patient's abilities;
- therapy is essential to be performed several times a day;
- active exercises of aerobic nature (brisk walking, jogging, swimming) out of hospital, in summertime – at the lake, seaside;
- training of muscle endurance including cycling, exercises with cycloenergometer, step machine, tradmill;
- various outdoor exercises.

D) Orthopedic equipment.

It is necessary to use:

- orthopedic shoes;
- corrective insoles.

E) Patient and care-taker training.

Training is arranged in the form of lectures, presentations, exercises, film demonstrations. Participants of educational sessions receive specially selected and prepared materials on the following topics:

- keeping to a right diet (consultation of a dietarian);
- correct organization of motion state.

PROGRAMME 6

Rehabilitation for children with congenital developmental abnormalities and deformities of muscular-osseous sceletal structure

1. Patient groups

Q 65. Congenital deformity of coxofemoral joint.

Q 66. Congenital foot deformity.

Q 68. Other congenital deformities of muscular-osseous tissues.

Q 71. Deformities in the form of shortened upper limbs.

Q 72. Deformities in the form of shortened lower limbs.

Q 74. Other developmental abnormalities of limbs.

Q 79. Congenital non-classified developmental abnormalities of muscular-skeletal structure.

Patient are appointed to the rehabilitation under this programme if one of the above listed diseases was diagnosed.

2. Aims of rehabilitation treatment

Rehabilitation treatment is to achieve the following aims:

- improvement of motor functions in pre- and postoperative periods;
- increase of volume of joint movements;
- increase of muscular endurance and performance efficiency;
- correction and development of manual and manipulative functions of hand;
- preparation for prosthetics and training to use prosthesis in case of severe deformities;
- selection of necessary orthopedic equipment.

3. Rehabilitation plan

A) Average time spent by a patient in-hospital is from 3 weeks to 3 months.

B) Diagnostics.

Diagnostic measures include:

- RTG;
- MRI;
- KT-3D;
- EMG (electromyography);
- assessment of muscle strength using Lovetta test, myodynamometer;
- assessment of interfacial and deep sensibility;

- functional motor tests;
- estimation of volume of movements in movable and immovable joints.

C) Improvement of overall condition.

Kinesitherapy is applied:

- passive exercises;
- exercising according to postisometric relaxation method;
- exercises for stretching muscles;
- active-passive exercises;
- relieving exercises and exercises on fitballs;
- exercises for reducing pressure on the joint done with support;
- optional exercises;
- isometric exercises;
- manual therapy;
- exercises improving manipulative functions of hands;
- exercises according to PNF-therapy method;
- water exercises (hydrokinesitherapy);
- walking with crutches;
- teaching how to use a prosthesis and walking with a prosthesis;
- independent walking training;
- exercises training to overcome various obstacles.

Physical therapy. The following methods are used:

- electrostimulation of muscles;
- electrotherapy;
- cryotherapy;
- irradiation with polarised light;
- laser therapy;
- hydrotherapy;
- water exercises (hydrokinesitherapy);
- underwater massage;
- classic massage.

D) Orthopedic equipment.

In course of orthopedic correction the following is used:

- prostheses of upper and lower limbs;
- ortheses of upper and lower limbs;
- compensation shoes;
- corrective insoles.

E) Patient and care-taker training.

Training is arranged in the form of lectures, presentations, exercises, film demonstrations. Participants of educational sessions receive specially selected and prepared materials on the following topics:

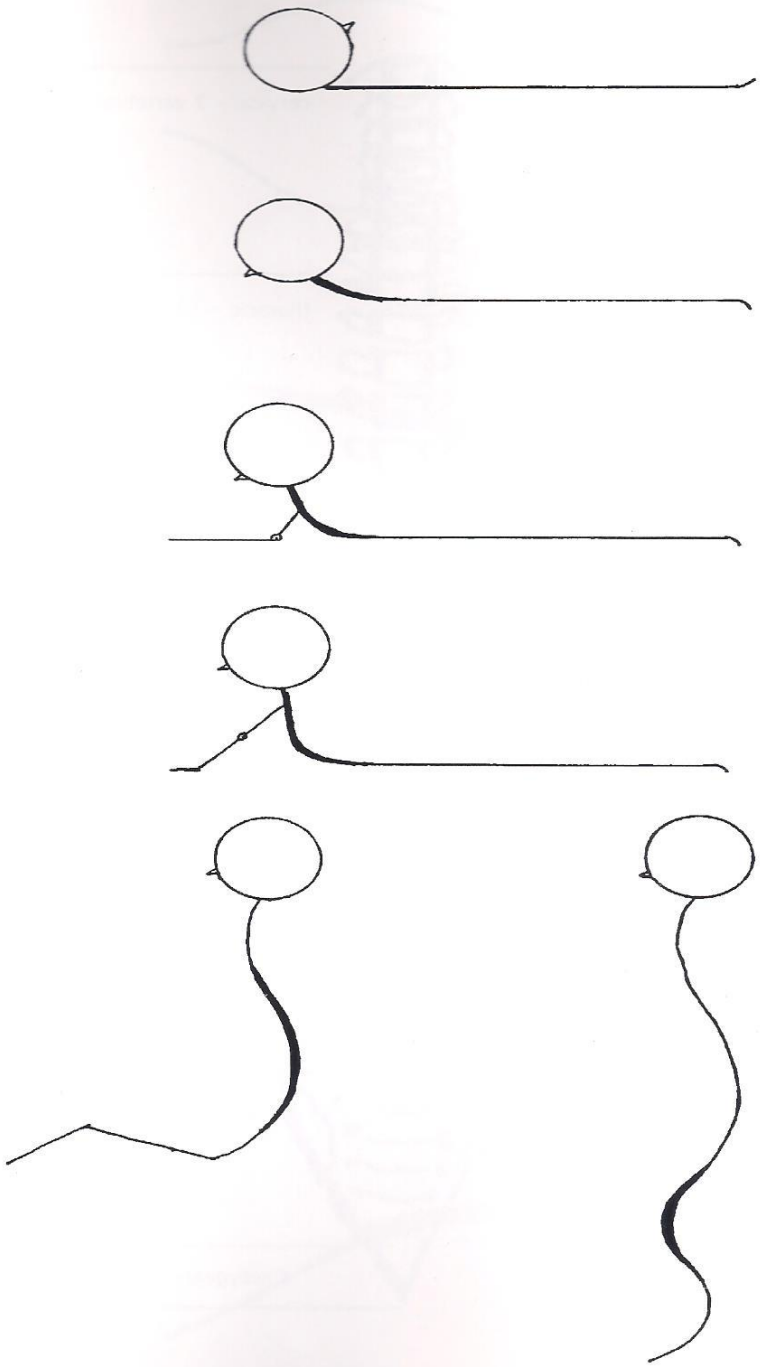
- care issues;
- how to use orthopedic equipment;
- functional abilities and motion states.

F) Psychotherapy.

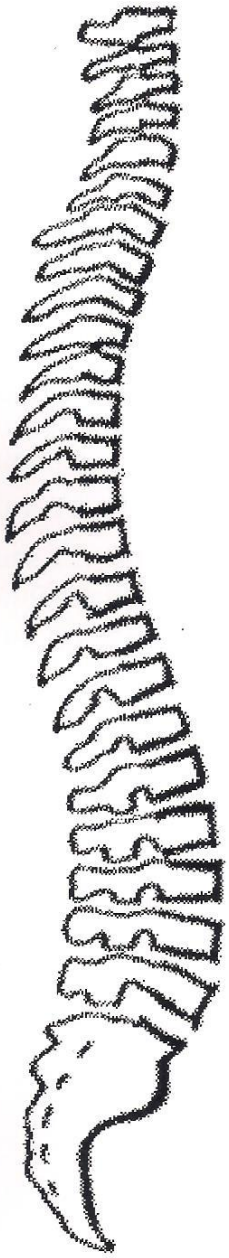
Concerning presence of severe limb deformities in these patients, distracting emotional and economic welfare, an important part of the programme is establishing a systematic support of a patient and his/her family.

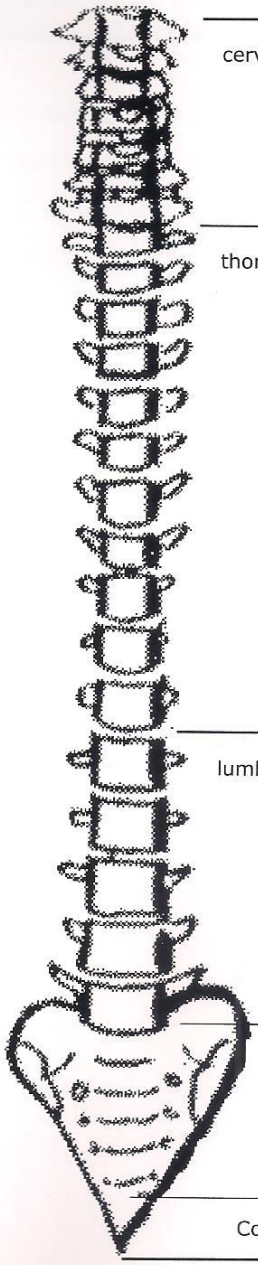
ADDENDUM 2. ILLUSTRATIONS

Picture 1. Forming physiological curves of vertebral column at the age of 1, 2, 3, 4, 6, 12 months



Picture 2. Lateral and anterior-posterior view of vertebral column





cervical – 7 vertebrae

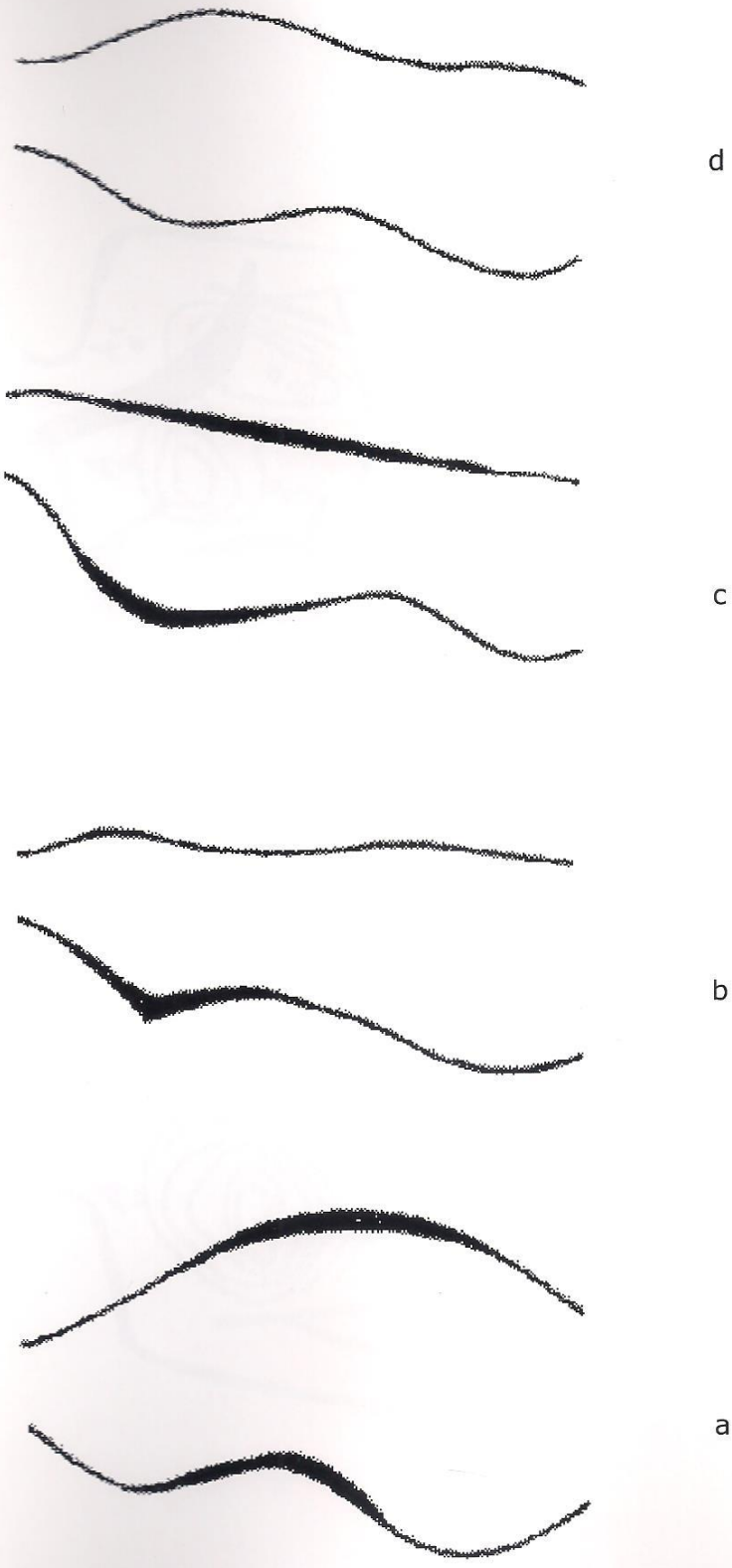
thoracic – 12 vertebrae

lumbar – 5 vertebrae

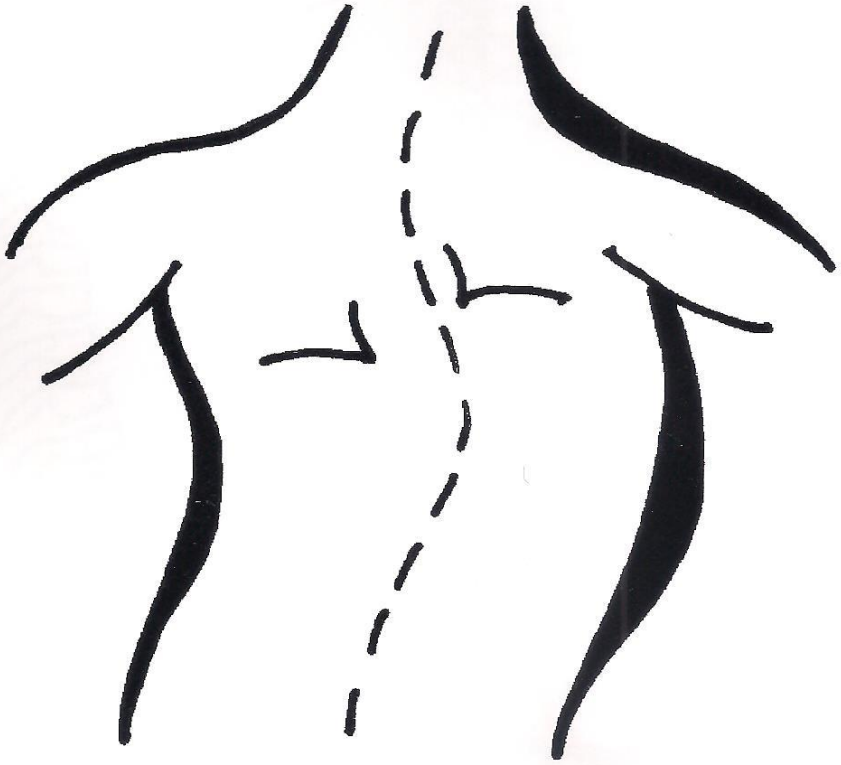
sacral – 5 vertebrae

Coccygeal–2-5 vertebrae

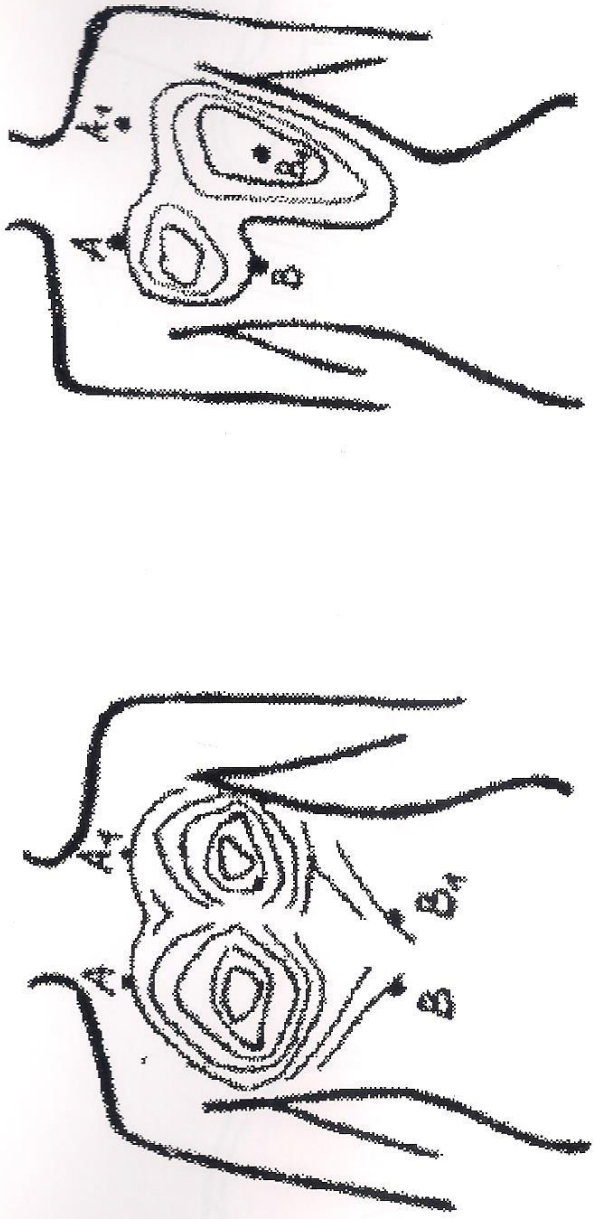
Picture 3. Diagram of habitual posture: lateral view: infancy (a), childhood (b), puberty (c), adulthood (d).



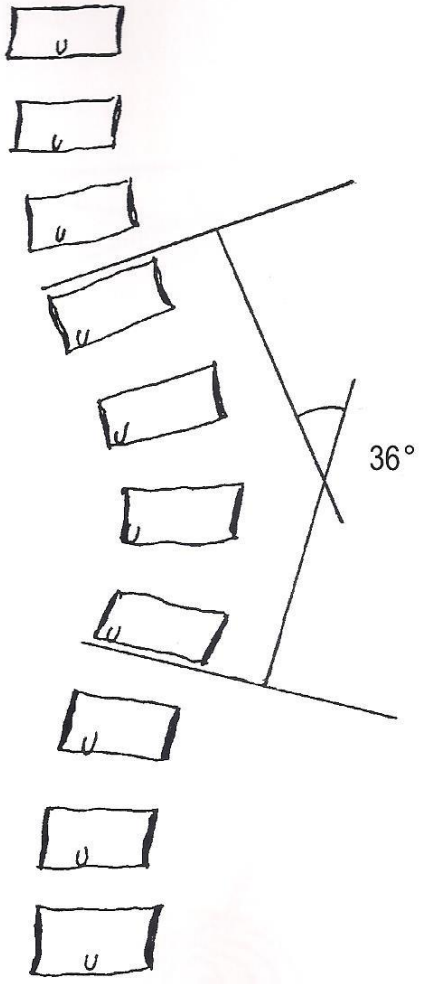
Picture 3a. Examples of postural abnormalities viewed from the rear



Picture 4. Moiré's photopographic method.



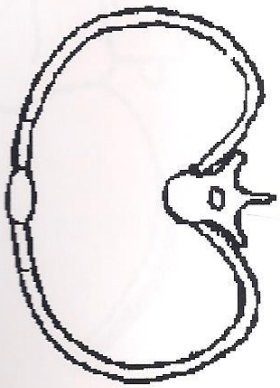
Picture 5. Cobb angle measurement of a curvature of vertebral column



Picture 6. Scheme of chest circumference and rotation of vertebrae: correct (a), medium form (b), severe from (c).

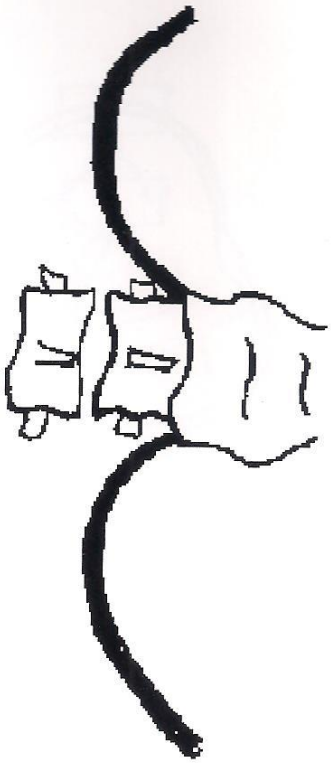
c

b

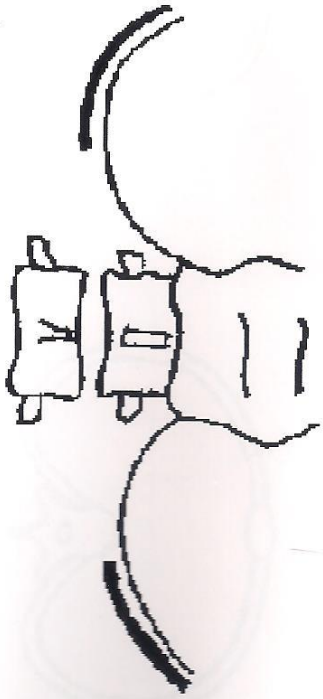


a

Picture 7. Risser test: a) 2nd degree test (-); b) 5th degree test (+).

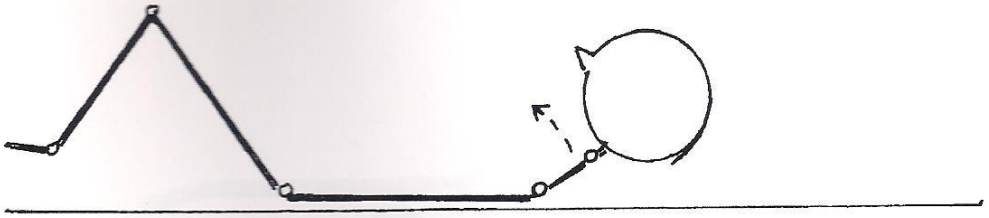


b

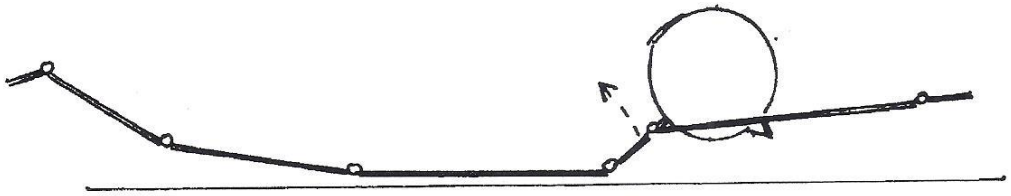


a

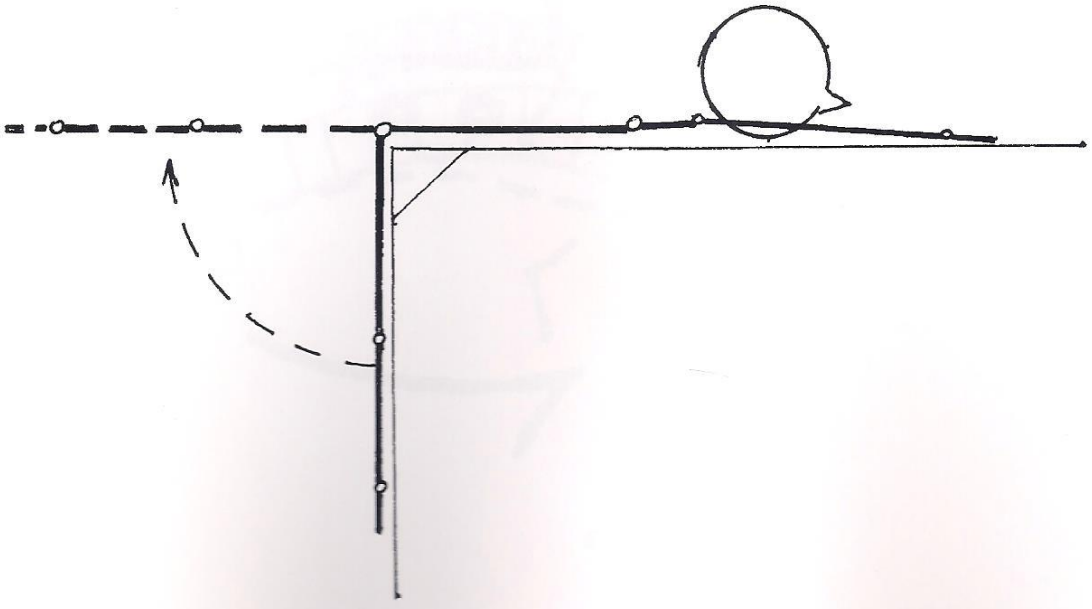
Picture 8. Testing abdominal muscles



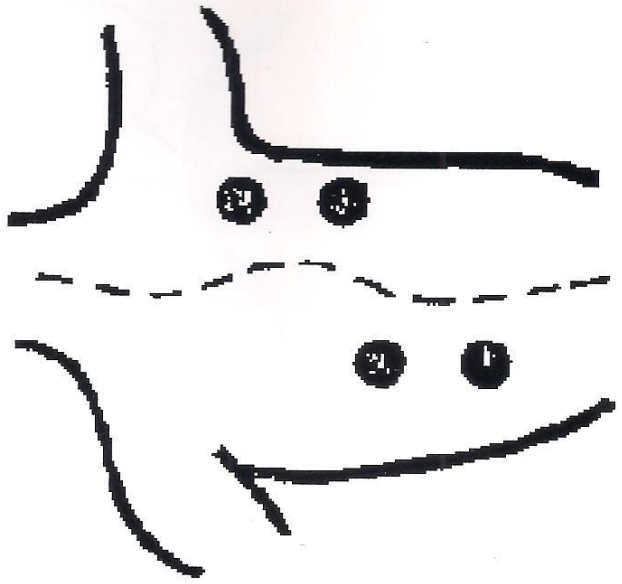
Picture 9. Testing dorsal muscles



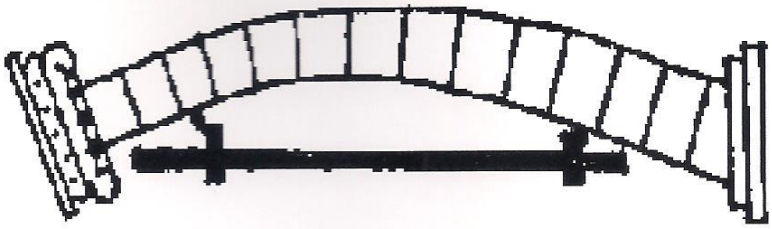
Picture 10. Testing gluteal muscles



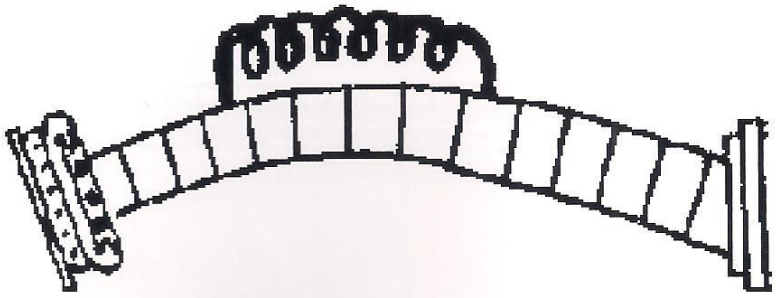
Picture 11. LESS electrostimulation method



Picture 12. Scheme of operation in accordance to Grucy's method and Harrington-Bobechko's method a) Grucy's method; b) Harnington-Bobechko's method

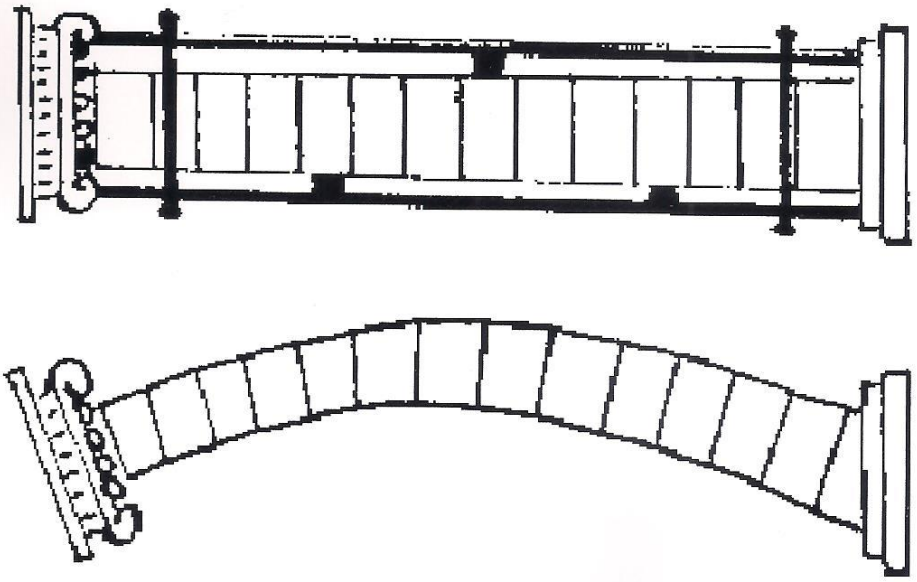


b



a

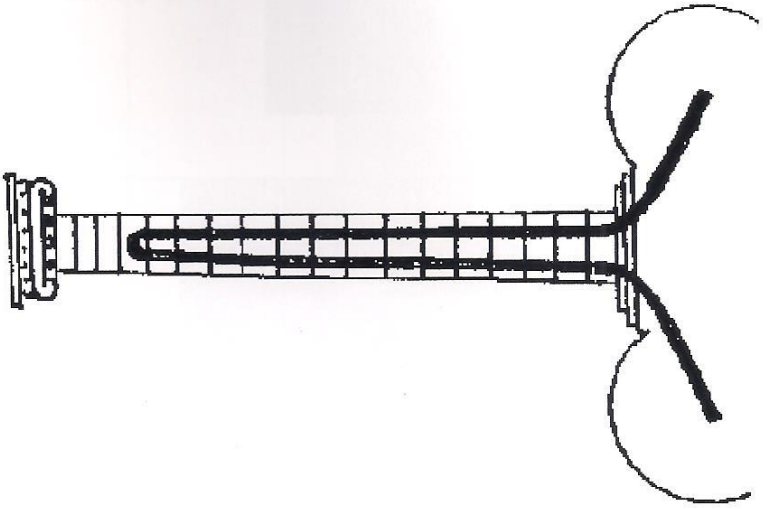
Picture 13. Correction scheme using C. D. Instrumenrarium: a) before; b) after correction using C. D. Instrumenrarium



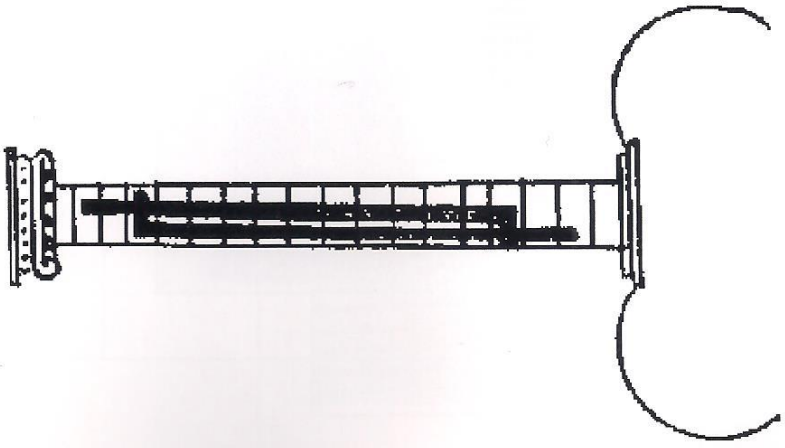
b

a

Picture 14. Scheme of Lukue technique and Gelveston technique: a) Lukue technique; b) Gelveston technique, Lyndleya's rods.

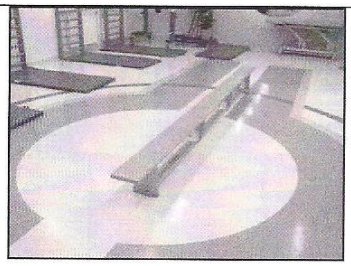
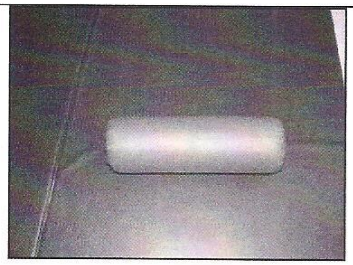
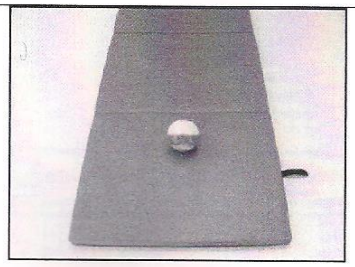


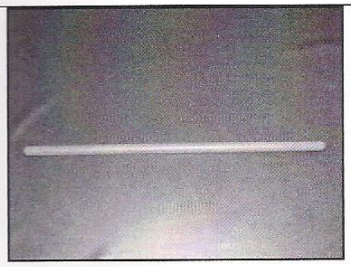
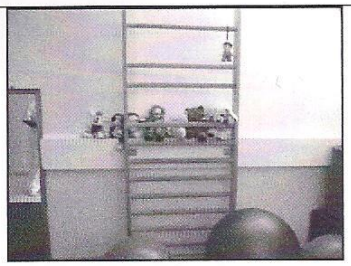
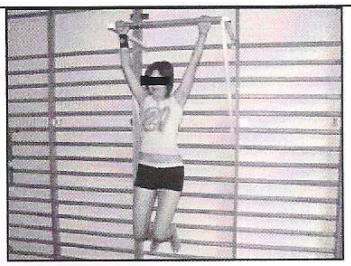
b

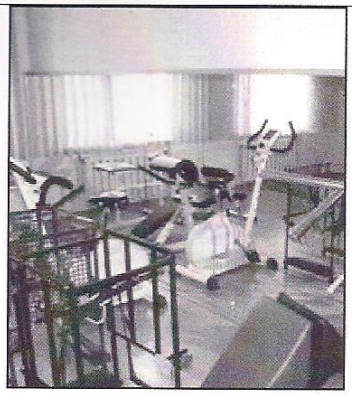


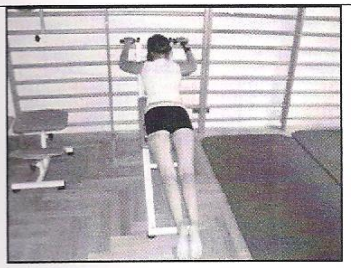
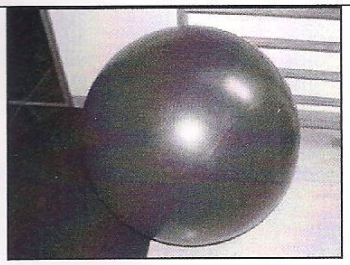
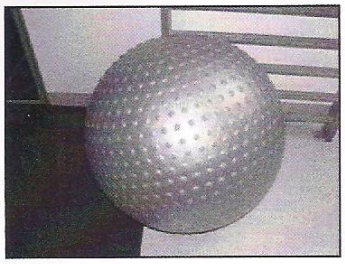
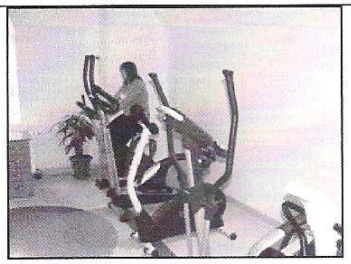
a

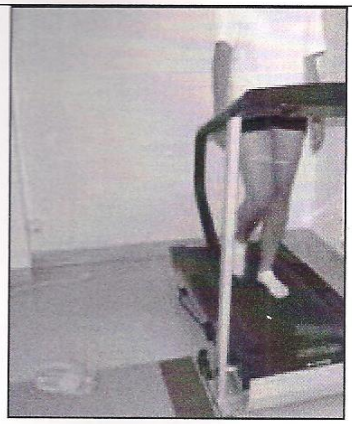
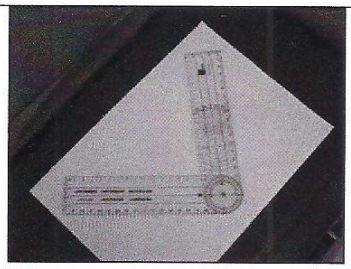
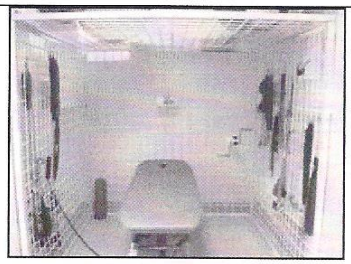
ADDENDUM 3. LIST OF EQUIPMENT NECESSARY TO IMPLEMENT REHABILITATION PROGRAMMES

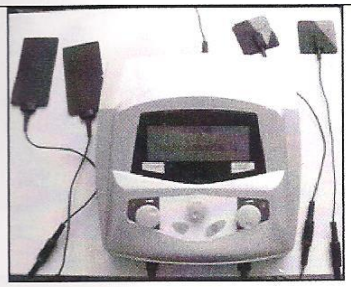
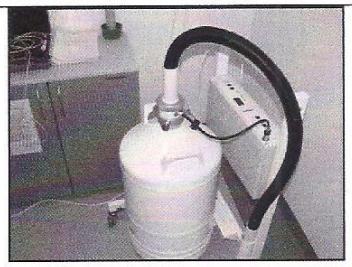
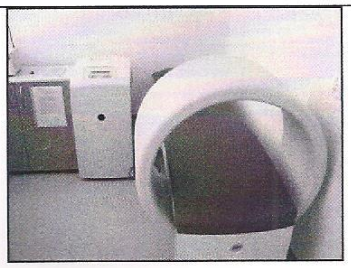
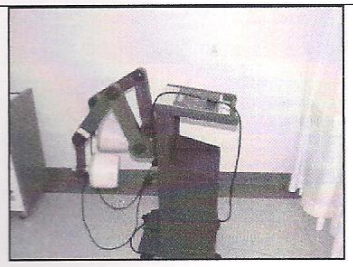
No.	Compulsory equipment		Number
1.	Mats		20 units
2.	Exercise benches		5 units
3.	Exercise rolls size 50 cm -60 cm (length), 15 cm-20 cm (diameter)		20 units
4.	Small balls of about 15 cm-20 cm in diameter		20 units

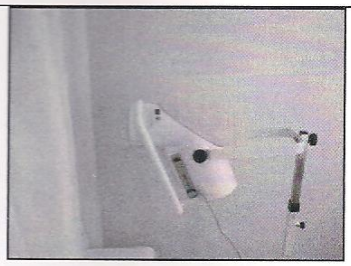
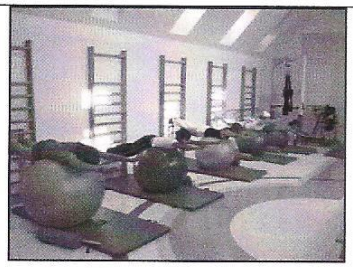
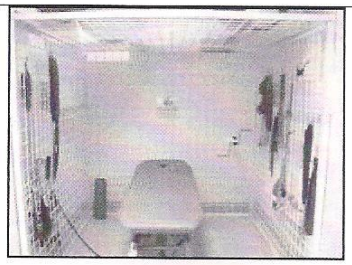
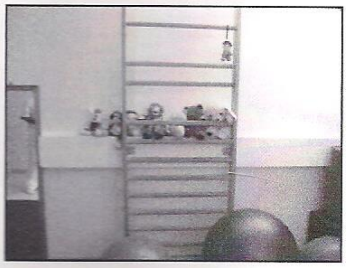
5.	Dumbbells for exercises 1 kg		20 units
6.	Exercise bar 60 cm – 80 cm		20 units
7.	Wall bars		20 units
8.	Swing bar hung on the wall bars		10 units
9.	Swing bar for exercising abdominal muscles		2 units

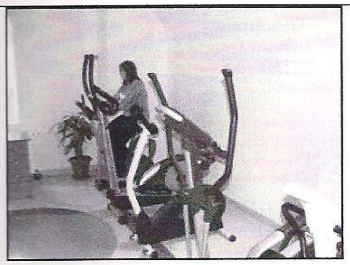
10.	Device for antigravitational exercises with corrective bench		2 units
11.	Corrective mirror		4 units
12.	Roman chair for abdominal muscles training		2 units
13.	Roman chair for dorsal muscles training	 	2 units

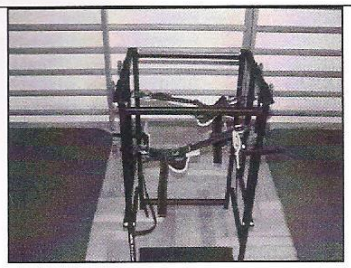
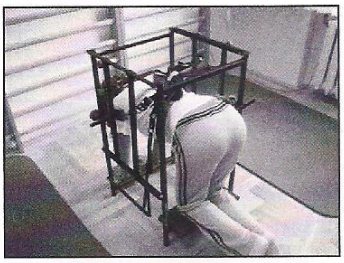
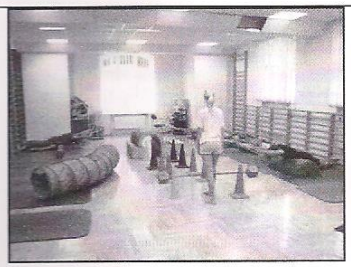
14.	Inclined bench for training arm and body muscles		1 units
15.	Fitball	 	10 units
16.	Exercise bike, step machine, ski machine		3 units
17.	Twisting platform for obliques training		2 units

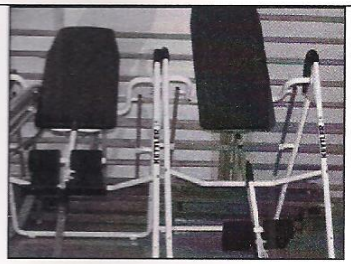
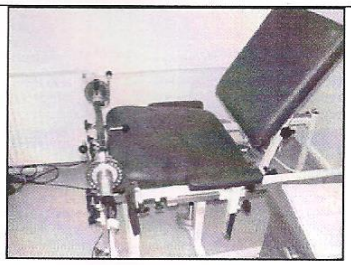
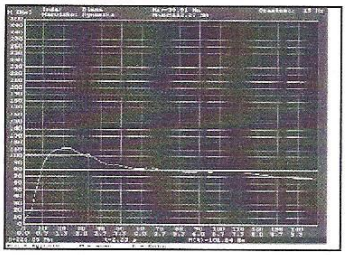
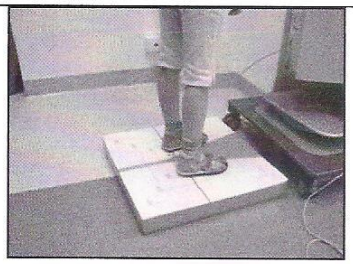
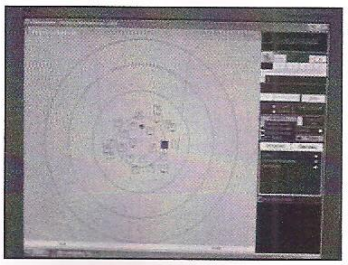
18.	Electric treadmill		1 unit
19.	Pronometer (for arthrometry)		1 unit
20.	Equipment for exercising in hanging position (eliminating gravitation) with counterbalances and ropes (set for one person) and exercise table of adjustable height		1 unit
21.	Pool for exercises		1 unit
22.	Vibromassage bath		1 unit

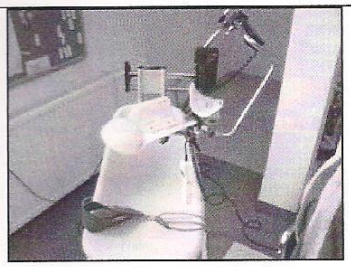
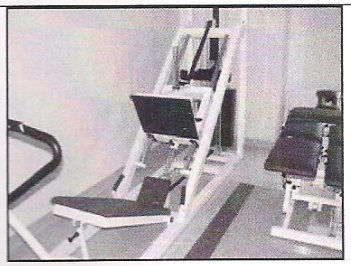
23.	Electrotherapy device		1 unit
24.	Laser therapy device (if possible with a scaner)		1 unit
25.	Cryotherapy device		1 unit
26.	Low-frequency magnetic field therapy device		1 unit
27.	Low-frequency magnetic field therapy device		1 unit

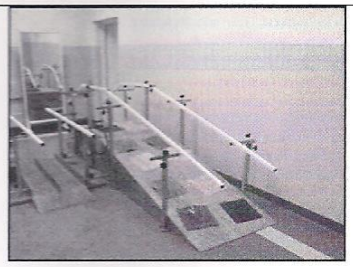
28.	Lamp for polarized light therapy		1 unit
29.	Spirometer		1 unit
30.	Gym for group exercises		1 unit
31.	Gym for individual exercises (one for individual correction of abnormalities, the other for conditioning exercises, for special exercises with counterbalance systems	  	2 unit

			
32.	Manometer		1 unit

No	Facultative equipment for implementation of the programme		Number
1.	Self-corrector Exercises in self-corrector	 	1 unit
2.	Big octangular pad and other pads		1 unit
3.	Set of equipment for group exercises		tunnel, stands 10 units, modules 6 units, bars with stands 14 units, bars 10 units, hoops 15, ribbons 20 units.

4.	Benches for abdominal muscles training in vertical position		2 units
5.	Equipment for densimetric muscle analysis by computer Record of a test of strength of quadriceps	 	1 unit
6.	Platform for measuring stability for global centre of body weight control training and percentage measuring of load on lower limbs Record of point of gravity track	 	1 unit

7.	CPM splint for passive movement of elbow joint and radial joint		1 unit
8.	CPM splint for shoulder joint		1. unit
9.	CPM splint for knee and thigh joints training		1 unit
10.	Rotor for training lower and upper limbs in active and passive movements		1 unit
11.	Inclined leg press for training lower limbs support in closed kynematic circuit		1 unit

12.	Obstacle course (in the picture a slide with rails, bars with feet split rail, corrective mirror – portative, mats with "spike" coating for foot training)		1 unit

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Kaliningrad 2008