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Review Article

Analysis of diagnostic methods in trunk deformities in the developmental age

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ABSTRACT

Introduction: Postural disorders are classified as simple, often called faulty posture, and complex, which are associated with spine curvature disorders. Postural disorders correctable with passive and active correction need to be distinguished from severe spinal disorders such as idiopathic scoliosis, Scheuermann's disease and congenital spine deformities.

Aim: The aim of this research was to prove the necessity of combined clinical and instrumental examination in the diagnosis of trunk deformities.

Material and methods: Trunk abnormalities and deformities in the developmental age affect approximately 50%–60% of population, depending on the region of Poland. In this study, clinical and instrumental diagnosis of trunk deformities was analyzed.

Results: Clinical assessment with the use of instrumental methods is fundamental in diagnosis of trunk deformities. Causes of faulty posture need to be identified, both in terms of location within the musculoskeletal system and etiology, and pathologies that require different diagnostic and therapeutic approaches need to be excluded.

Discussion: Diagnosis of the cause of faulty posture is frequently possible only after a clinical and instrumental evaluation is performed. It results in isolating a group of children with structural deformities of musculoskeletal system that require a separate, specific treatment, from a group of children with postural disorders that require physiotherapy.

Conclusions: There is a need for implementing combined clinical and instrumental examination in the diagnosis of trunk deformities in the developmental age.

1. Introduction

In the literature one can find numerous definitions of faulty posture in reference to good posture, meaning a harmonized, symmetrical and energetically balanced system of individual body parts (head, trunk, pelvis, limbs) in a relaxed erect position.[5,10] Particular emphasis is put on frontal symmetry, maintaining physiological curvatures and normal joint range of motion.[19] Defining good posture must take into account differences of various stages of child development, their gender,

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constitutional body type, population characteristics. It is important to identify key factors that influence posture formation, and therefore determine possibility of re-education. Emphasis should be put on the role of control organ – central nervous system – which by harmonious development of musculoligamentous structures and muscle system is responsible for programming and postural memory patterns.[5,10,19,22] There are simple postural disorders, frequently called faulty posture, and complex postural disorders that are associated with the change in spinal curvatures. Postural disorders correctable with passive and active correction need to be distinguished from severe spinal disorders, such as idiopathic scoliosis, Scheuermann's disease and congenital spine deformities that involve spine, chest, hip joints, feet. Numerous classifications of postural disorders include a reference to physiological curvatures of the spine, pelvic anteversion angle, shape of the chest, and position of the head, shoulders and scapulae.[22]

2. Aim

The aim of this research was to prove the necessity of combined clinical and instrumental examination in the diagnosis of trunk deformities.

3. Material and methods

3.1. *Material*

Trunk abnormalities and deformities in the developmental age occur in approximately 50%–60% of population, depending on the region of Poland. In general, these are the habitual faulty postures that significantly contribute to the increase of postural disorders in population. Postural changes of skeletal elements directly connected to the spine (chest, pelvis) and disorders of the remaining components of the motor system (upper and lower limbs) constitute in total 45%–55% of the overall postural disorders.

3.2. *Methods*

Clinical and instrumental diagnosis of the following trunk deformities was analyzed:

- rounded back – hyper-kyphosis and compensatory deepening of cervical lordosis, forward tilt of head and shoulders, protruding scapulae, reduced pelvic anteversion angle;
- hollow back – increased lumbar lordosis, reduced thoracic kyphosis, increased pelvic anteversion angle;
- flat back – reduced thoracic kyphosis and lumbar lordosis, reduced pelvic anteversion angle, flattening and limited mobility of the chest;
- round-concave back – increased lumbar lordosis, compensatory increase of thoracic kyphosis, increased pelvic anteversion angle, protruding scapulae, flattening and limited mobility of the chest;
- cradle back – short increased lumbar lordosis, long kyphosis of the thoracolumbar spine, increased pelvic anteversion angle;
- buckling of the spine – usually a slight C-shaped curvature of the spine, without a three-dimensional curvature (scoliosis), which may be accompanied by typical abnormalities of physiological spinal curvatures.[5,10,19,22]

4. Results

Of particular importance in the diagnosis of trunk deformities is a clinical examination, including evaluation of standing and sitting posture and gait, based on detailed examination of musculoskeletal system, with the assessment of resting position of joints, range of motion, muscular strength and alignment of body parts in relation to one another. Physical examination of a child with suspected postural disorder should include: clinical assessment of the quality of posture with the use of documented instrumental methods, identification of causes of faulty posture, both in terms of location within the musculoskeletal system and etiology, and exclusion of pathologies that require a different diagnostic and therapeutic approach.[3,7] An important role in posture assessment is played by a rehabilitation physician that has the knowledge and skills for a proper functional diagnosis, based on which the appropriate measures, forms and methods of therapeutic program are chosen. Considering the characteristics of ontogenetic changes in posture, physiological changes in the maturing body and stages of development of the various motor skills, it is essential that the diagnosis and physiotherapy of children with postural disorders were performed by physiotherapists specializing in the treatment of children and adolescents with musculoskeletal disorders.[5] Cooperation between rehabilitation specialist, orthopedist and physiotherapist who specialize in diagnosis and treatment of postural disorders, with the school nurse, physical education teacher and corrective exercise specialist is required. This cooperation should include creating a coherent system of diagnosis and treatment, as well as preventive measures.[5,7,19]

4.1. *Instrumental examination*

One of the methods used in the assessment of posture is photogrammetry.[14,21] This is a method that provides imaging and physical measurements by means of electromagnetic radiation in a wide range of wavelengths. Limited use of this contemporary non-invasive diagnostic techniques results from unavailability of new technologies, as well as ignorance of the advantages offered by measuring devices. The use of photogrammetry in biological sciences and medicine is called biostereometry. Conventional method of stereometry includes measurement of an object using two pictures taken with cameras of a known geometry in two various positions. This allows restoring the shape of light beams that irradiated the pictures. Intersection of pairs of beams that passed through the image of a point on both pictures creates a spatial image. This way a three-dimensional model of the object recorded on the picture is created.[14,21]

Another method widely used in the assessment of body posture is a light beam refraction technique (interference of light waves), which uses a device called “raster” for measurements. As a result, an image contour map is created, which

after mathematical analysis and calculation of height of each contour generates a spatial image of body points.[14]

This method has been updated by introducing an optical raster that produces fringes projected on patients body. Further development of this method involves the use of computer technology. Raster image of an object may be captured by a special optical system of a camera (TV-CCD) and then transferred to an analog monitor and into a computer. With the appropriate software automatic analysis of body posture is obtained (Fig. 1).[21]

The above photogrammetric methods were related to the assessment of solid. A breakthrough in the development of photogrammetry came with digital technology. Thus, digital imaging allows fast activation, processing and automation of measurements. The assessment of motion uses analysis of coordinates of the selected points of a measured object (special natural points or markers). Two types of markers are used: passive (reflecting the infrared light emitted by cameras) and active (emitting flashes of light in a specific order). Several (usually five) digital cameras record the position of markers (points) in a measurement space. Recorded data are then computer analyzed. Special software allows calculating the characteristic parameters describing motion.[14,21]

Objectification of measurements in the diagnostic and therapeutic process is one of the most important factors that contribute to therapeutic success. Repeatable, objective measurements are possible with compact three-dimensional posture and motion analysis systems based on measurements of ultrasonic pulse transit time, e.g. ZEBRIS CMS system.[16] This system allows to evaluate the whole body as well as its individual parts and generates a three-dimensional image of the body. Examination and measurements are non-invasive and not inconvenient for the patient, which is a major advantage in comparison to the conventional radiography. Since any musculoskeletal abnormalities change ground reaction forces, postural disorders may be assessed through observation of changes within density distribution of ground reaction forces. It is possible with a use of multifunctional platforms, e.g. ZEBRIS FDM-S (Fig. 2). This complex may be supplemented with a set of devices for recording muscle tone of postural muscles (system for EMG recording and analysis).[6,16]

Tone of muscles that maintain a symmetrical upright position may be assessed by electromyography (EMG apparatus).[6] With the use of surface electrodes, EMG enables a non-invasive measurement and recording of static and dynamic muscle activity. Analysis of results allows identification of muscle groups exposed to greater work load and overload. By means of surface EMG recording a self-correction biofeedback therapy may be conducted.[6]

Changes in spinal curvature in extreme flexion, extension and lateral flexion correlating with spine mobility may be presented graphically and mathematically by MediMouse computer-based tool (Fig. 3).[15] Gradually increasing possibilities of processing data gathered from complex location and motion detectors enable creating new devices for imaging sagittal and frontal position of the spine and position of individual body parts in relation to each other.[13,15]

In addition, the assessment of body posture utilizes thermal imaging cameras.[17,20] Infrared radiation is an electromagnetic radiation with a wavelength range between 0.78 μm and 1000 μm. Recorded changes in the emission of heat by the living tissues create thermograms, which are subsequently analyzed (Fig. 4).

Changes in the symmetry of muscle tension of paraspinal muscles at workload are reflected by changes in tissue heat emission as thermographic pattern of the back.[17] Analysis of mean temperatures measured on body surface allows to determine tension balance of individual muscle groups (at rest) that are crucial to maintain correct posture.[20] Symmetric thermographic pattern of the back proves a normal metabolism and uniform muscle tone of spine stabilizing muscles.[17,20]

Less technically advanced devices help to assess individual qualities of the body or pathologies, such as for example degree

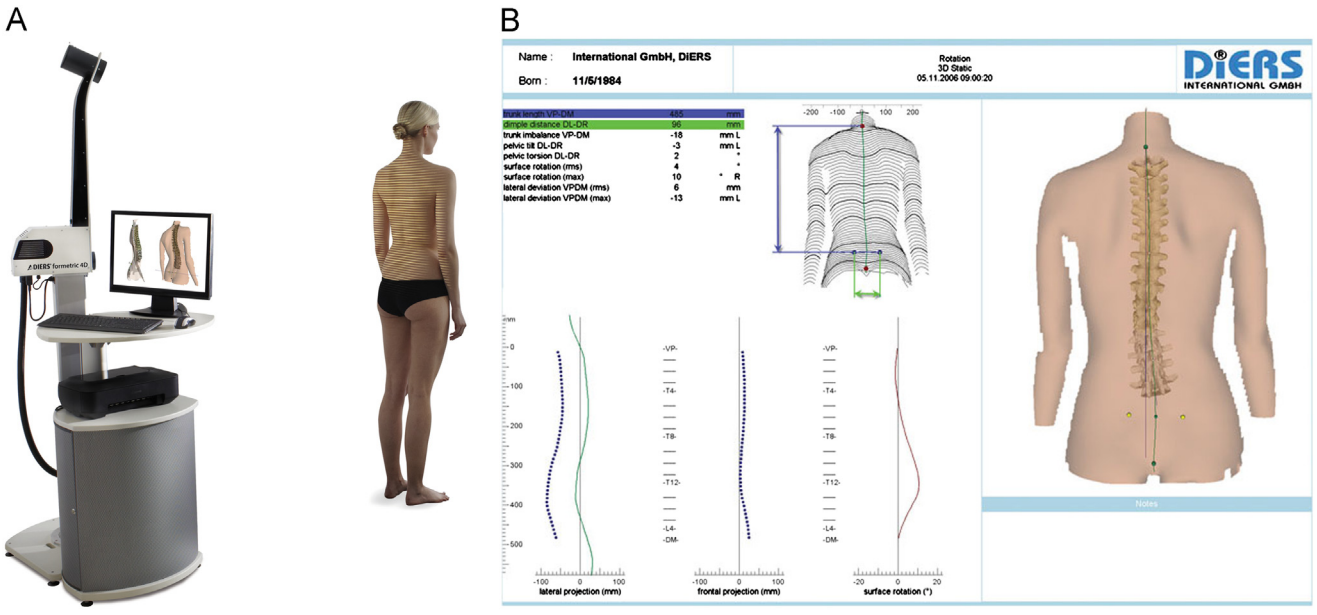
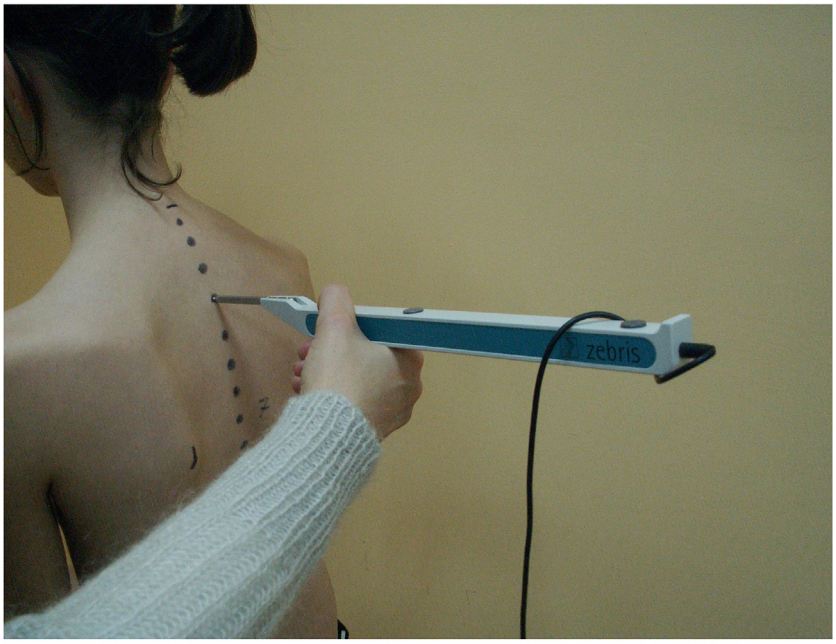


Fig. 1 – Trunk surface metrics by means of FORMETRIC raster-stereography system.[23]

A



B

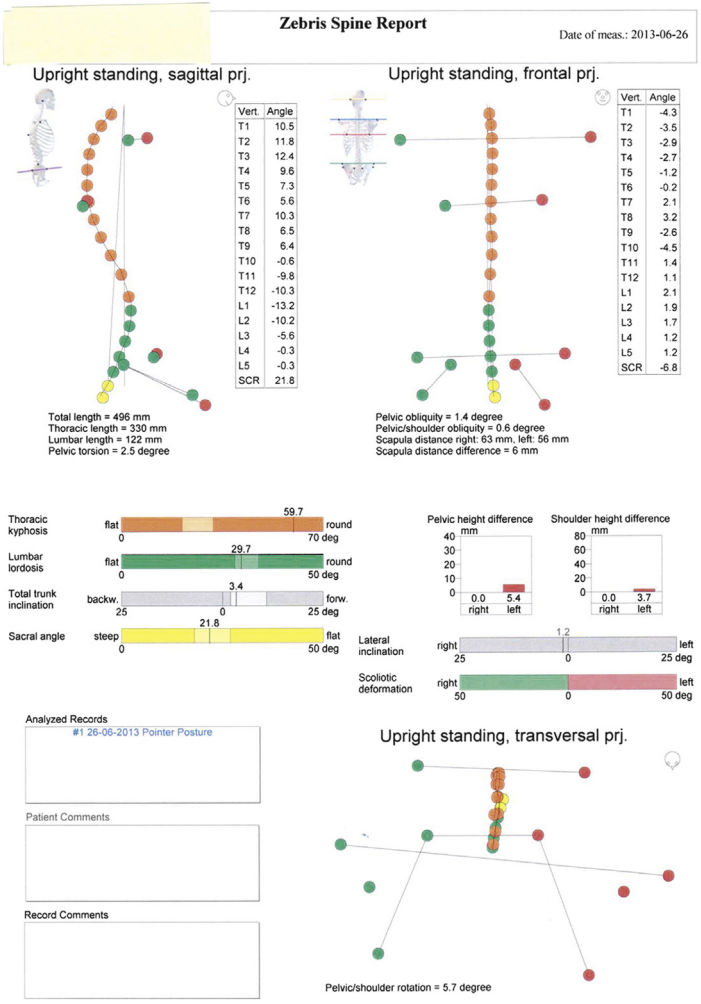
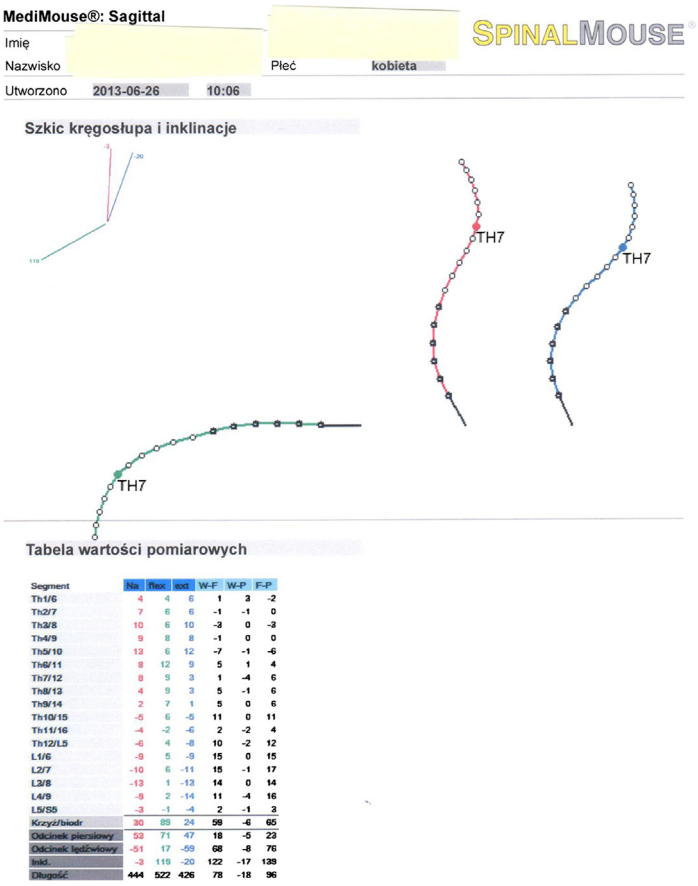


Fig. 2 – The assessment with ZEBRIS system. Measurement with the use of ultrasonic pointer stick (A) and model posture report (B).

A

B



Segment	Na	flex	ext	W-F	W-P	F-P
Th1/6	4	4	6	1	3	-2
Th2/7	7	6	6	-1	-1	0
Th3/8	10	6	10	-3	0	-3
Th4/9	9	8	8	-1	0	0
Th5/10	13	6	12	-7	-1	-6
Th6/11	8	12	9	5	1	4
Th7/12	8	9	3	1	-4	6
Th8/13	4	9	3	5	-1	6
Th9/14	2	7	1	5	0	6
Th10/15	-5	6	-5	11	0	11
Th11/16	-4	-2	-6	2	-2	4
Th12/L5	-6	4	-8	10	-2	12
L1/6	-9	5	-9	15	0	15
L2/7	-10	6	-11	15	-1	17
L3/8	-13	1	-13	14	0	14
L4/9	-9	2	-14	11	-4	16
L5/S5	-3	-1	-4	2	-1	3
Krzyż/biodr	30	89	24	59	-6	65
Odcinek piersiowy	53	71	47	18	-5	23
Odcinek lędźwiowy	-51	17	-59	68	-8	76
Inkl.	-3	119	-20	122	-17	139
Długość	444	522	426	78	-18	96

Fig. 3 – Measurement by means of MediMouse in forward-bending position (A) and report (B). Reprinted from: http://www.zdroweplecy.com.pl/medimouse.html.

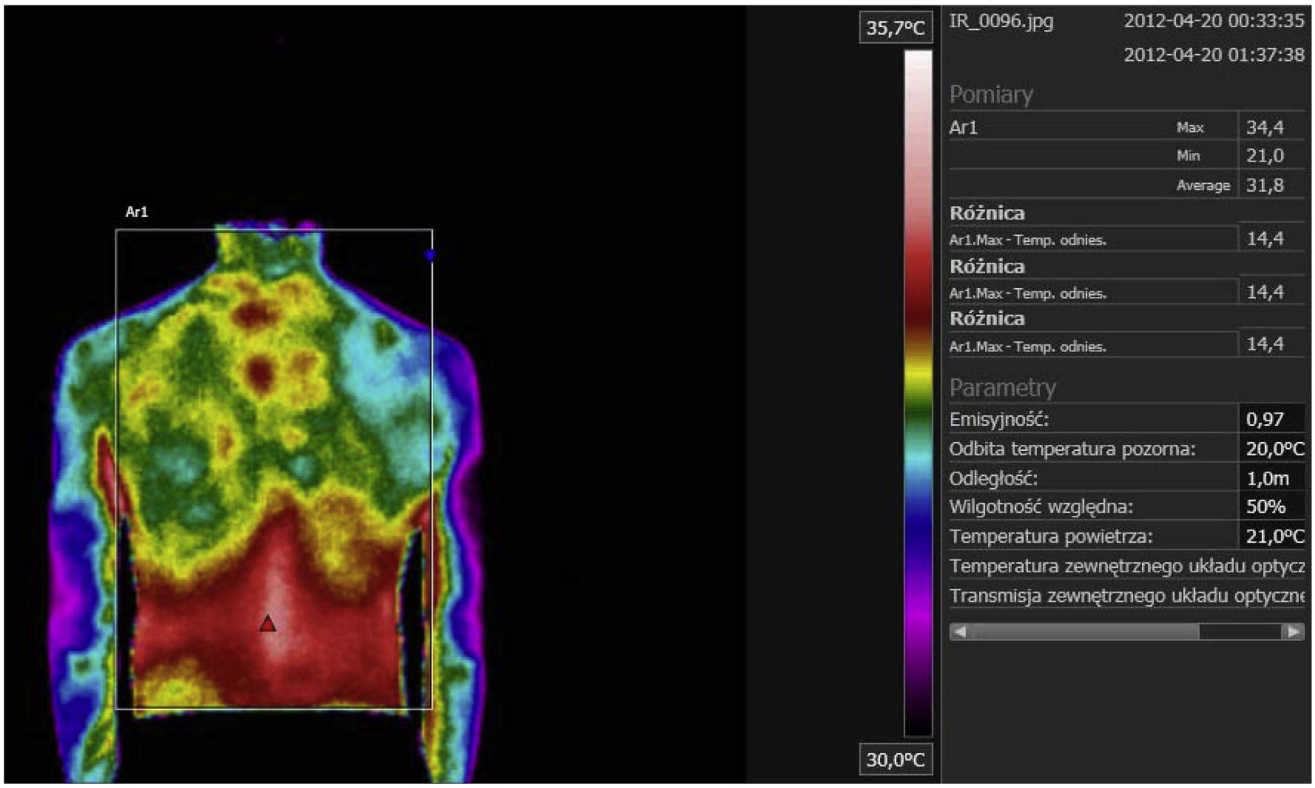


Fig. 4 – Example of the thermographic pattern of the back.

of spine rotation with the use of scoliometer or "gibotorakometr," spinal mobility with the use of digital inclinometer or plurimeter. Low costs, availability and repeatability of measurements are undoubtedly the advantages of technically simple devices used in clinical practice. They do not however provide a three-dimensional visualization of the body and more thorough analysis of pathophysiology of postural disorders.[2,12,13]

5. Discussion

The above mentioned diagnostic methods are used in diagnosis, research and scientific works. The use in screening aims at identifying subjects within the pediatric population that require clinical assessment conducted by a medical professional. They may use performed analyses and if necessary, conduct additional tests (radiology, computer tomography, MRI and other).[1,7,9] Considering the need to establish appropriate prophylactic or therapeutic measures, it is essential that physiotherapy was based on a detailed clinical diagnosis. Its major role is determining whether a child asymmetry is substantial for their health and results in possible future risks (e.g. back pain or increased risk of injury from sports and recreation activities).[5] Determining the cause of faulty posture is usually possible after clinical and instrumental examination has been completed. This stage also results in separating children with structural deformities of musculoskeletal system that require individual specific treatment from children with postural abnormalities that require physiotherapy. Due to insufficient care of children in developmental age in our country, this difficult task in practice is often placed on physicians, physiotherapists, physical education teachers and school nurses, who provide screening for children and adolescents.[5,19]

It is important to determine if the postural abnormalities present are a typical postural disorder or one of the symptoms of the disease (e.g. postural disorder in idiopathic scoliosis or Scheuermann's disease). In each of these cases objectives of physiotherapy are different. In the first case, the aim is to eliminate or reduce postural disorder; in the latter, the primary objective is to treat underlying disease in accordance with current recommendations.[3,11,18] In case of the spine, structural disorders need to be excluded at first: idiopathic scoliosis and juvenile kyphosis (Scheuermann's disease). Structural scoliosis is diagnosed as a three-dimensional deformity with flattening of physiological thoracic kyphosis and rotation observed in forward bending position (Adam's Forward Flexion Test). In children with juvenile kyphosis in forward bending position an excessive forward curve of the spine is observed, corresponding to wedge-shaped vertebrae of the thoracic spine.[4] A suspicion of both disorders is the basis for commencing radiological examination and specific treatment.[3,4,18]

Conditions that require separate diagnostic and therapeutic approach while examining children with faulty posture suspicion also include pain in the spine and other parts of the musculoskeletal system. Mechanical and inflammatory causes should be differentiated. Inflammatory pain, relatively well-localized, persists in spite of rest, occurs at night, is the alarm signal and requires extensive diagnostic procedures. Such complaints often indicate neoplasms (benign and malignant) and infectious and non-infectious inflammatory diseases of the musculoskeletal system. Mechanical pain, more difficult for a child to locate, reduced in certain positions and after a night's rest, is in a domain of physiotherapy.

However, the possibility of conditions requiring further consultation should be noted: spondylolysis and spondylilis thesis, and outside the vertebral column, rare congenital disorders, e.g. tarsal coalition, and diseases of rapid growth, e.g. avascular necrosis. Although all of the presented conditions result in a widely understood faulty posture, evidently initiating causal treatment should be a priority. In the remaining large group of children with faulty posture there are no identified structural deformities within the musculoskeletal system.[5,7,22]

Diagnosis of faulty posture, though seemingly simple, requires meticulous clinical examination, supported by experience in conditions typical for children and adolescents. After the exclusion of underlying diseases, analytical identification of causes of faulty posture in an individual may be initiated. Useful, though schematic, is qualification of symptoms into one of the two categories: shortening or weakness of the muscle.[7,9] Predominantly, shortened are: hip flexors (rectus femoris and iliopsoas), knee flexors (semitendinosus, semimembranosus, biceps femoris), plantar flexors of the foot (gastrocnemius, soleus), within the spine – quadratus lumborum muscles and within the upper limb – pectoralis major muscles. Diagnosis of disorders associated with shortening of the muscle is based on known clinical tests. Quantitative measurement is recommended, e.g. value of popliteal angle to determine the degree of ischiotibial muscle shortening. Shortened muscles require physiotherapy with post-isomeric relaxation, trigger-point therapy and stretching.[7,8] Weakened muscles typically include: gluteus maximus muscles, abdominal muscles (obliquus, transversus, rectus) and dorsal muscles. As a consequence of muscle weakness, physiological sagittal spinal curvatures become deeper and pelvic anteversion angle and thoracic outlet angle are increased. One of the most common presentations of a faulty posture is a condition that results from postural insufficiency of muscles and no sense of good posture: caved-in chest, protruding abdomen, deepened lordosis, forward head, forward shoulders, protruding scapulae, rounded back. Inability to actively correct abnormal posture (body side view) is an indication for exercise. Strengthening weakened postural muscles is a basic element of postural correction physiotherapy. It should be noted however, that exercises alone will be insufficient, unless the remaining components of the treatment program are fulfilled, including removing mechanical obstacles to the correction, such as shortened muscles, and educating a child about normal and abnormal posture with training in active correction.[5,7,9,11]

Hence, a summary diagnosis of faulty posture will include not only the descriptive postural characteristics (e.g. hollow round back) but also identification and location of cause (e.g. hollow round back due to increased pelvic anteversion caused by shortening of rectus femoris muscle and weakened gluteus maximus muscles).[8] Hereby, the purpose of therapy is determined, which in the above mentioned example will not aim at active straightening of the thoracic spine, but at stretching hip flexors and active correction of pelvic tilt to achieve functionally normal positions.[8] Simplified examination of children with faulty posture, limited to observing body posture in order to match it with pathological patterns, does not however provide etiopathogenetic data. In consequence, it is a waste of parents and therapists time together with child's compliance on ineffective exercise determined on the basis of body shape alone, which is a final result of biomechanical chain in the growing body.[7,8,9]

6. Conclusions

1. There is the necessity of combined clinical and instrumental examination in the diagnosis of trunk deformities of the developmental age.
2. The use of measuring instruments in screening aims to isolate from the whole pediatric population clinical cases that require further specialist assessment.
3. Kyphotic spinal deformities and structural scolioses are indication for radiological examination and specific treatment.

Conflict of interest

None declared.

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