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# Should the identified correlations between the spine, pelvis and feet be considered in the functional therapy of postural static disorders?

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**Key words:** lower limbs, pelvis, spine, functional correction and compensation

## Abstract

The human locomotor system is a complex kinematic system whose elements remain in uninterrupted mutual subtle relations. Any changes in the position or function within the spine-pelvis complex or in lower limbs trigger mutual reactions. Therefore, one should believe that the concept of tensegration and the integrity of myofascial tapes, assuming that the normal function of the musculoskeletal system depends on the correct deployment of tension between specific elements of the system, is currently the only concept that meets the needs of the comprehensive therapy of postural mistakes and defects.

**Summary**

The mentioned clinical observations confirm the correlations between the spine, pelvis and feet determined by Mrozkowiak et al. [21-28]. The authors of the study showed relationships between particular elements of the body posture. Despite extensive research material, one should not unquestioningly implement the findings referred to herein into the correction and compensation procedure as this is the first step on the way to the scientific demonstration of the correlations between such distant posture elements. Yet, failing to take into account the displayed frequency of significant correlations may lead to erroneous programming of the repair process of postural static disorders. That is why, one should be aware of the fact that modelling the foot arching with physical effort may also influence the correction of sagittal curvatures of the spine to some extent and vice-versa, the correction of axial curvatures affects the functional condition of feet.

## Introduction

The last wide-scale screening tests using the scoring method by Kasperczyk were carried out by the team managed by Mrozkowiak [1] to reveal the percentage of postural errors and defects. The studies were conducted in the years 2004 – 2007 in the group of 10,517 subjects (5,229 boys and 5,288 girls) including children and adolescents at the age from 4 to 19 years from randomly selected kindergartens, primary schools, lower-secondary schools and general secondary schools from 13 Polish voivodeships. The conducted diagnostics allowed to conclude that the most common postural defect was the left-sided scoliosis observed in 23.81% of subjects and round back in 17.34%. As regards lower limbs, the most frequent cases included valgus knees in 3.87%, valgus heels in 12.61% and flat feet in 3.52%. The percentage of body posture abnormalities among the examined population was very high and amounted to 89.05%, Fig. 1. The percentage of the postures generally regarded as normal was 20.01%, Fig. 2. In various aspects the analysis of gathered results revealed in particular regions the following percentages of postural defects: Małopolska – 93.2%, Lubelskie – 91.01%, Łódzkie – 90.49%, Kujawsko-Pomorskie – 90.39%, Wielkopolskie – 89.59%, Mazowieckie – 83.89%, Zachodnio-Pomorskie – 79.45%, Podkarpackie – 87.08%, Podlaskie – 87.57%, Pomorskie – 86.19%, Warmińsko-Mazurskie – 86.76%, Śląskie – 87.93% and Świętokrzyskie – 67.39. The largest number of correct body postures and deviations within normal ranges was observed in the following voivodeships: Świętokrzyskie – 32.6%, Pomorskie – 32.51%, Wielkopolskie –

27.13%, Zachodnio-Pomorskie – 20.54%, Warmińsko-Mazurskie – 17.23%, Mazowieckie – 16.1%, Podkarpackie – 12.91%, Podlaskie – 12.42%, Śląskie – 12.06%, Kujawsko-Pomorskie – 9.6%, Łódzkie – 9.5%, Lubelskie – 8.98%, and Małopolskie – 6.79%, Figs. 3, 4. In addition, the analysis revealed that by far the highest proportion of postures of defected spatial symmetry was reported in respondents aged 7 to 12 years. The age of eight is the period when there is a particular risk to the normal body posture. The age of 7, 8, 9 and 10 is the time which displays the highest percentage of correct postures, Fig. 5.

Fig. 1. The percentage of normal and abnormal postures in the population of individuals of both sexes aged 4 to 19 years in Poland (n) 10517 according to Mirosław Mrozkowiak, Type of defect

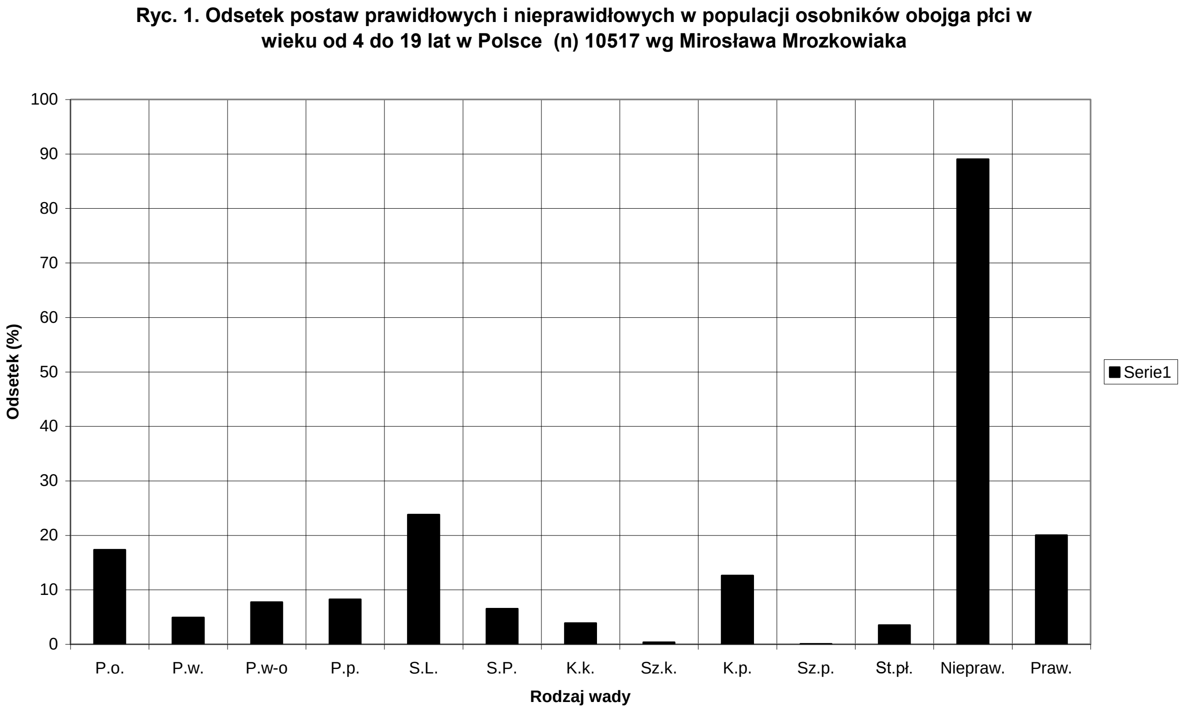


Fig. 2. The percentage of postural defects in individuals of both sexes and environments aged 4 to 19 years in 13 selected voivodeships of Poland (n) 10517

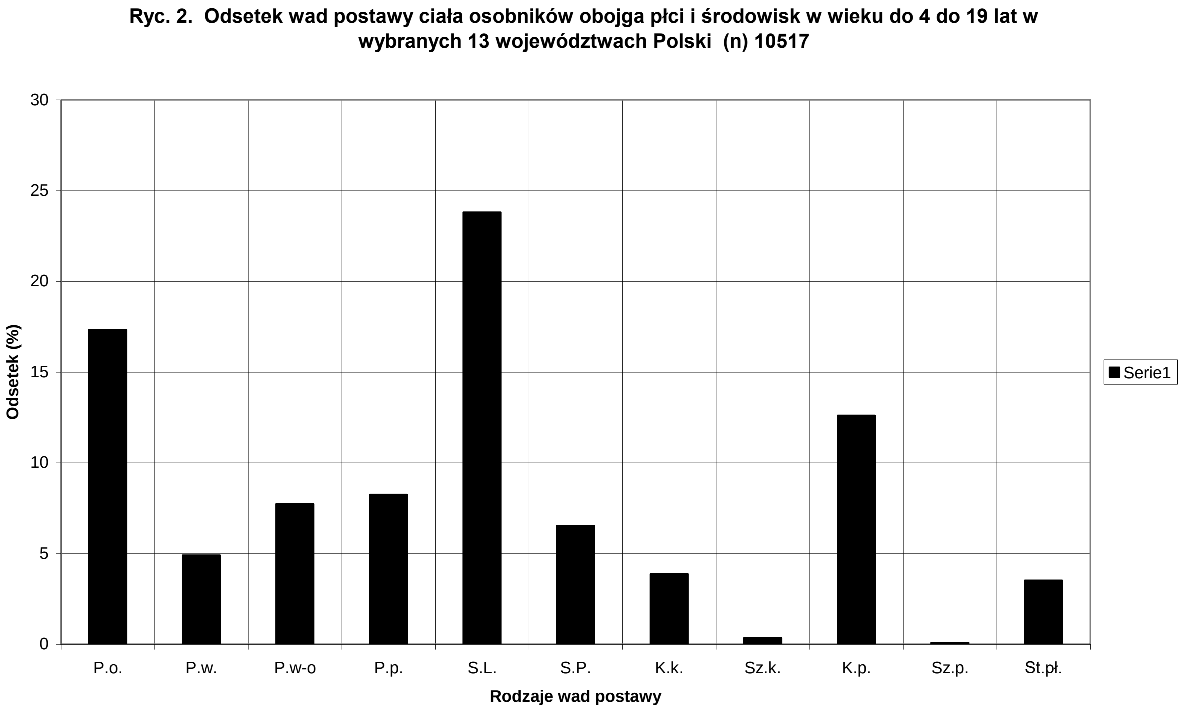



Fig.3 Differentiation of the percentage of normal and abnormal body postures in individuals of both sexes aged 4 to 19 years in 13 selected voivodeships of Poland (n) 10517 according to Mirosław Mrozkowiak.

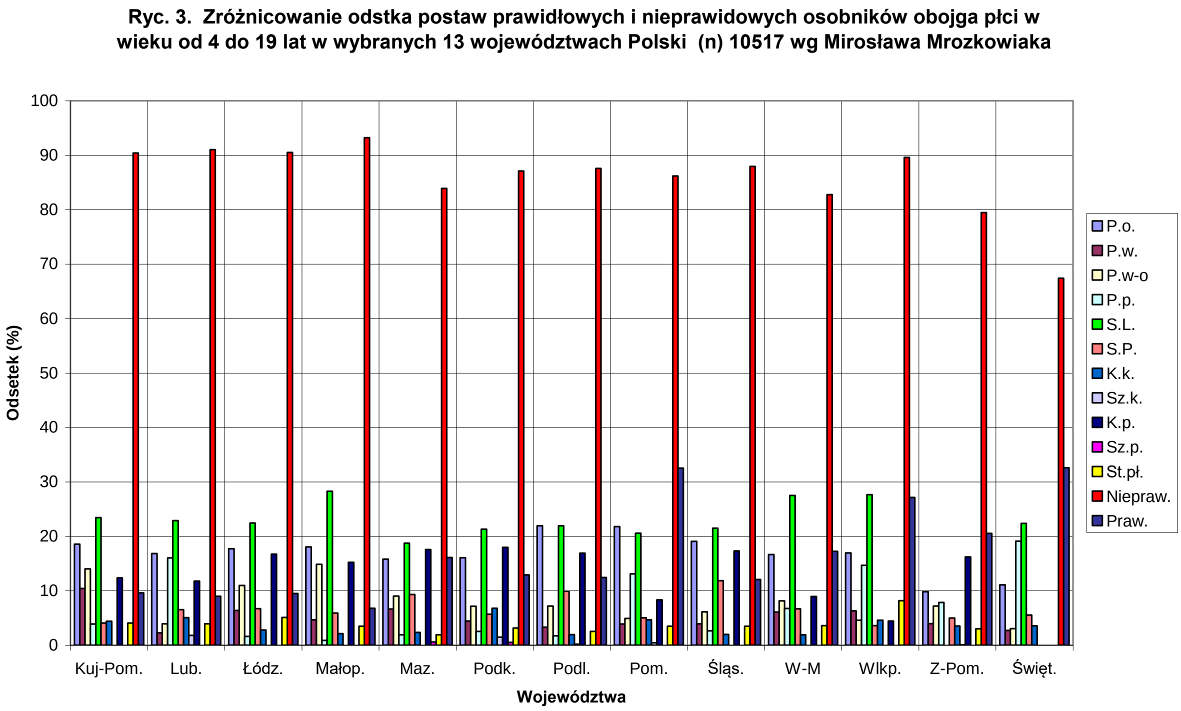


Fig.4 Differentiation of the percentage of postural defects in individuals of both sexes aged 4 to 19 years in 13 selected voivodeships of Poland (n) 10517 according to Mirosław Mrozkowiak.

**Ryc. 4. Zróżnicowanie odsetka wad postwy ciała osobników obojga płci i środowisk w wieku od 4 do 19 lat w wybranych 13 województwach Polski (n) 10517**

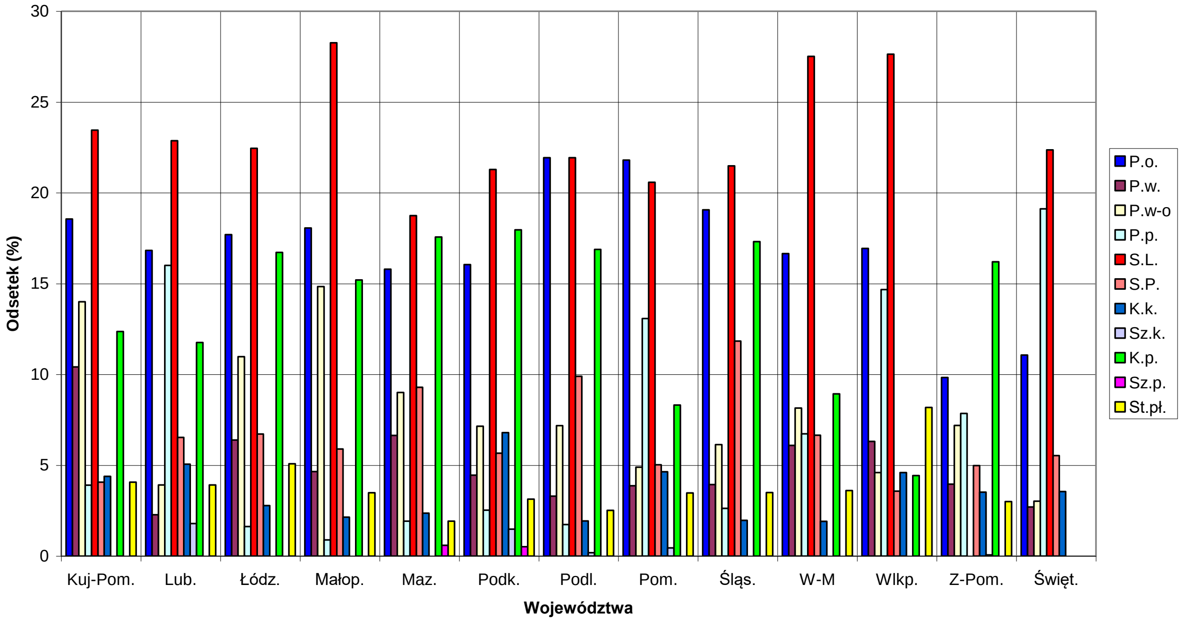
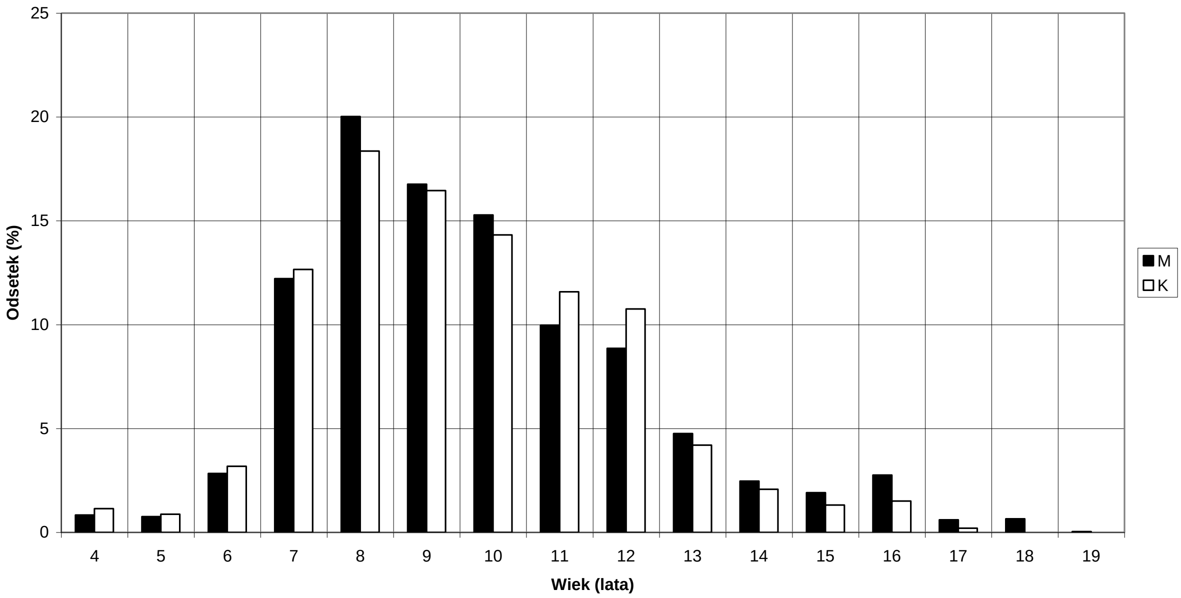



Fig. 5 Age differentiation of the percentage of abnormal postures in individuals of both sexes aged 4 to 19 years in 13 selected voivodeships of Poland (n) 10517 according to Mirosław Mrozkowiak,

**Ryc. 5. Zróżnicowanie wiekowe odsetka postaw nieprawidłowych osobników obojga płci i środowisk w wieku od 4 do 19 lat wybranych 13 województw Polski (n) 10517 wg Mirosława Mrozkowiak**



The human locomotor system is a complex kinematic system whose elements remain in uninterrupted mutual subtle relations [2]. Any changes in the position or function within the spine-pelvis complex or in lower limbs trigger mutual reactions. Disorders of their static may cause various types of spine pain, errors and then postural defects [3]. That is why, it should be expected that changes in the location or function in the region of the spine, pelvis or lower extremities will trigger mutual reactions [4, 5, 6]. The corrective-compensative procedure often covers only the area, where a postural mistake or defect has been identified. The approach to this problem should be characterized by a broad view of the musculoskeletal system as a complex kinematic chain with segments that influence one another [7]. Therefore, the construction of the corrective program shall not be limited to a local disorder in the locomotor system, but it should include the complex of biomechanically related segments that account for this system [Rolf 1989]. Such an approach can be illustrated by the concept of Nowotny [8] which takes into account most relationships between body posture elements.

The functional interpretation of the locomotor system has been recognized by reference literature [4, 6, 9]. There are relatively few publications about correlations of parameters within feet and body torso. This issue has been already mentioned by Mięsowicz [10, 11], Drzał-Grabiec, Snela [12], and Zeyland-Malawka [13]. Steinmetz [14] assumes there is a relationship between the type of the forming foot and the developing shape of the spine. He also emphasizes the reasons behind wearing corrective footwear, because a correctly positioned foot in a special footwear does not affect deformation of the spine. The pilot studies conducted by Drzał-Grabiec and Snela [12] on the population of girls and boys aged between 7 and 9, allowed to determine correlations between the longitudinal arching of the left and right foot measured with Clarke's angle, and body posture length parameters. Posłuszny et al. [15] in their paper demonstrate relationships between tensegrity systems and mathematics and fractal geometry. They pay special attention to the self-similarity principle which is characteristic of fractal geometry and which refers to tensegrity systems. The authors claim that the human system can be perceived as the construction of tensegrity. Moreover, they show that certain parameters observed in the structures characteristic of fractal geometry also appear in the human system already at the cellular level. The most visible example of the tensegrity construction and geometrical structures present in this construction is the spider's cobweb. The authors elaborate on mathematical relations of tensegrity structures with the existence of woven structures and they indicate the presence of tensegrity properties not only in the structures created on the basis of mathematics, but also in all living organisms and at all levels in the same way as some repetitive geometric elements. The researchers highlight that the concept of tensegrity captures the whole organism and its capacity captures ligaments, tendons, fascia and muscles, and they are determined as the living matrix – the integrity of tissue structure and so only the holistic approach to the human system can provide the right therapeutic effect. Cook [16], in turn, presents the concept of stability / mobility according to which every segment of the musculoskeletal system is assigned a dominant function connected with maintaining stability or proper mobility, and its disturbance may lead to a change in the function of segments located in the proximity. Sharman [17] proposed the concept of ''relative flexibility" suggesting that increasing or decreasing the mobility in one segment of the locomotor system may lead to compensative changes in adjacent segments. In addition, the idea of myofascial tapes integrity based on the theory of tensegrity play a significant role here as well. According to the theory, the normal functioning of the human musculoskeletal system depends on the correct distribution of tension between its individual elements [4, 5, 6,]. The axial organ fulfils three functions in the biomechanical system, namely, supporting, stabilizing and reflexing. The reflexive function regulates and integrates the activity of different systems and organs in the whole body, whereas the supportive function should be balanced enough to enable the spine to be mobile as needed. Thus, in the context of biomechanics, the fundamental question arises as to which function is more important, the stabilization one that ensures constant support to muscles and limbs or mobility of functional units that allow for the movement of the body torso and neck. This is a key issue as regards fitness requiring a compromise between all three functions. From the point of view of pain symptoms and joint hypermobility, the stabilizing function should prevail over the other [18], and as far as sports, motor and stabilization activity is concerned, they allow for physical efforts under the sports discipline (author's note). This is not a new concept at all as some of the first relevant mentions have been already observed in the literature before. According to Mroczkowski [19], the pelvis and spine comprise the links of the biokinetic chain in which changes occurring on one link trigger changes in adjacent links. As an illustration, the author mentions the example of scoliosis. A tilted pelvis in the frontal plane may be the beginning of the mechanical link which affects abnormal deployment of gravity to having an impact on individual spinal elements until the vertebrae rotating power occurs. Persistent tilt of the pelvis leads to changes in the deployment of gravity that affect particular elements of the spine. Such a position often results in the development of lumbar scoliosis. In the case of a growing child, long-term abnormal load of bones may lead to their incorrect growth according to Delpech–Wolff's law [20]. When introducing the concept of relative flexibility, Sharmann [17] suggests that flexibility modulation in one of the locomotor elements may cause compensation in the nearby segments. A clear example is the round back in the Scheuermann disease in which the motor deficit within the mobile spinal segment is usually in the mobile segment above. Therefore, it should be concluded that the concept of tensegrity, integrity of myofascial tapes assuming that the normal function of the locomotor system is conditioned by the correct distribution of tension between its particular elements, is nowadays the only concept that optimally satisfies the needs of comprehensive therapy of postural errors and defects. This seems to be also confirmed by the publications of Mrozkowiak et al. [21-28] which in the years 2000-2003 conducted the analysis of 21,895 parameters of body posture measured using mora projection on the group of 3,806 children, adolescents, and adults. The analysis displayed mutual relationships regarding the parameters of feet foot and the pelvic-spine complex. In the group of children aged 4 to 6 years, the parameters of the body torso in the frontal and sagittal plane revealed significantly more correlations with the parameters of feet, yet, more relationships were observed with the parameters in the sagittal plane. Feet parameters that most often correlated with torso parameters included: the length of the second longitudinal arch, heel angle of the left foot, length of the right foot, width of the first arch in the right foot and of the second arch in the left foot, and width of the first arch in the left foot. In the group of adolescents aged 7-13 years, a similar number of the parameters of the right and left foot showed a significant correlation with torso parameters. Particularly frequent correlations were revealed by such parameters as the width of feet, angle of the 5th toe valgus and of the big toe in the left foot, heel angle and height of the 2nd arch in the right foot, height of the 2nd longitudinal arch and length of the left foot, and the length of the 1st arch in the right foot. Feet parameters most often significantly correlated with torso parameters in the frontal plane, less in the sagittal plane and sporadically in the transverse plane. Torso parameters with which feet parameters most often correlated included: the height and length of lumbar lordosis, height of thoracic kyphosis, angle of torso bend in the sagittal plane, length of thoracic kyphosis, angle of the thoracic and lumbar inclination, depth of thoracic kyphosis, depth of lumbar lordosis, and angle of the upper thoracic spine inclination. It should be noted that the most frequent relationships were observed between feet parameters and lumbar lordosis parameters. Yet another and one of many analyses of findings regarding the correlations of the values of torso parameters with feet parameters in the group of 14-18-year-old adolescents showed that the values of torso parameters in the frontal and sagittal plane revealed a significant correlation with foot parameters, and the most significant correlations were demonstrated between the sagittal plane parameters and feet parameters. Further analysis led to the conclusion that feet parameters most often significantly correlated with: the values of the angle of torso flexion in the sagittal plane, height of thoracic kyphosis, angle of the protrusion line of lower should blade angles or left angle is more protruding, length of lumbar lordosis, asymmetry of the height of waist triangles with the right triangle up, angle of the thoracic and lumbar inclination, angle of the shoulders line with the left angle higher and the angle of pelvic twist to the right in the transverse plane. Feet parameters with which torso parameters significantly correlated included: the width of the 1st longitudinal arch, length of the 2nd longitudinal arch in the right foot, angle of the 5th toe varus, width of the right foot, length of the 1st arch in the left foot and the length of the right and left foot. Other surveys showed dependency of the body posture quality on epigenetic factors and the lifestyle [29, 30]. Czaprowski and Leszczewska [31] seem to prove the assumed viewpoint as well. They mentioned the Trendelenburg test well described in the reference literature as an illustration of functional correlations between the segments of the musculoskeletal system. As a result of the middle gluteus muscle weakness, the pelvic stabilization in the frontal plane is reduced which leads to dysfunctions in the pelvic region or, to be more specific, in the hip joint. Here, observations included femoral adduction and femoral internal rotation, then knee joint valgus, tibial external rotation, and increased eversion of the feet. Another example that confirms the assumed procedure is the situation in increased pelvic anteversion and consequently lumbar hyperlordosis. The analysis of mutual relations of posterior femoral muscles suggests they should be characterized by extension and weakness. However, the study of the popliteal angle when lying back with thigh bent at a 90-degree angle and the model of sitting up straight suggest significant deficits within the motion of hip and knee joints. According to Gajdosik et al. [32], the weakness and extension of posterior muscles are not responsible for pelvic retroversion, but they prevent excessive pelvic anteversion. Central stabilization disorders demonstrated in the survey, trigger a compensatory stabilization mechanism in the regions distant from the axial organ, and here, in a form of overactivity of these muscles. In such a situation, treatment, despite positive test results, should not concentrate on the stretching of these muscles, but on the improvement of stabilization muscles (gluteus maximus muscles) [16,17]. If in the same condition (lumbar hyperlordosis), the patient adopts a correct body posture through active correction of the pelvic position tending to retroversion and makes a correction movement by trunk extension which increases pelvic anteversion and lumbar lordosis, the most likely cause is increased tension of flexor muscles of hip joints and decreased tension of rectus abdominal muscle. Therefore, the question arises as to the cause of muscular dystonia. An answer should be sought in the above-mentioned lifestyle and epigenetic factors. The student's time balance is: 4-7 hours at school, 2-3 hours of doing homework, 3 hours of relaxing, and 1 hour for meals. As a result, the students spend 6-10 hours sitting on a chair. Often, rest comes down to sitting in front of the computer which takes another 3 hours so 6 to 13 hours. The muscular, bone and nervous system and in consequence the body posture adapt to the environment. Thus, the corrective and compensatory treatment should tend towards restoring eutonia among the elements of the musculoskeletal system. Another example of functional connections of the spine-pelvis-lower extremities complex is the SLR test used to assess the flexibility of posterior femoral muscles [3]. The patient lies on his back. Grasping the patient's heel with one hand, the therapist bends the straight lower limb in the hip joint and controls the pelvic position and lumbar spine with the other hand. If while bending the lower limb to the angle of e.g. 30 degrees the values of pelvic inclination and lordosis depth are reduced, this suggests a negative test result. Therefore, increased tension of posterior femoral muscles with attachments on pelvis and thigh. Czaprowski and Leszczewska [31] refer to the example of a sitting posture including increased thoracic kyphosis and flattened lumbar lordosis. Postural correction aimed at reconstructing physiological lumbar lordosis of relevant gender and age and simultaneous knee joint extension become impossible due to motility deficit. Yet another example cited by the authors is difference between the position of pelvis and the long axe of lower extremities and the longitudinal arching of feet in lumbar lordosis, and after active correction of lumbar lordosis to gender and age-based values. The other illustration is difference regarding torso rotation in the Adams Forward Bend Test with feet set parallel to the width of thighs and with the right foot holding the short foot position. Another example is the difference of the angle of trunk rotation when lying on abdomen measured with the Bunnell scoliometer at the height of lumbar lordosis in the situation of isometric tension of flexor muscles in the right foot and of the extensor muscle in the left one, and next flexor muscles of the left foot and extensor muscles of the right one. According to the authors, this led to a change in the direction of torso rotation. This observation should be taken into consideration when assessing the functional state of myofascial tapes as the corrective and compensatory process should determine which of them needs to be made shorter and which requires extending.

Clinical observations referred to in this paper confirm the existence of correlations between spine, pelvis and feet as identified by Mrozkowiak et al. [21-28]. The authors demonstrated relationships concerning particular elements of body posture. Despite extensive research material, one should not unquestioningly implement the findings referred to herein into the correction and compensation procedure as this is the first step on the way to the scientific demonstration of the correlations between such distant posture elements. Yet, failing to take into account the displayed frequency of significant correlations may lead to erroneous programming of the repair process of postural static disorders. That is why, one should be aware of the fact that modelling the foot arching with physical effort may also influence the correction of sagittal curvatures of the spine to some extent and vice-versa, the correction of axial curvatures affects the functional condition of feet.

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