Motor development in the first year of life versus trunk rotation angle, lumbo-pelvic-hip complex mobility and joint hypermobility in children aged 3-9

A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

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Abstract

Introduction: Infancy is the key period in human development. Disorders in the motor development during the first year of life may affect the body posture, motor patterns and functioning in the period of childhood. The study objective was to assess the correlation between motor development in the first year of life and angle of trunk rotation, lumbo-pelvic-hip complex mobility and occurrence of joint hypermobility in children aged 3-9.

Material and methods: 120 healthy children aged 3 to 9 participated in the study. The study comprised a questionnaire and a clinical trial. The children in whom the questionnaire revealed abnormal motor development in the first year of life were included in the study group, and the other children were a control group. Then, a physiotherapist assessed the value of the trunk rotation angle with the use of a scoliometer, the lumbo-pelvic-hip complex mobility with the use of TPHA test, and the occurrence of joint hypermobility with the use of Beigthon test.

Results: Children with abnormal motor development in the first year of life were characterised by a statistically significantly higher value of the trunk rotation angle in the thoracic section and they had a higher asymmetry of rotational movement of the lumbo-pelvic-hip complex, as well as higher values in the Beighton test.

Conclusions: Abnormal motor development in the first year of life is a factor predisposing to increased values of the trunk rotation angle in the thoracic section, asymmetry of rotational movement of the lumbo-pelvic-hip complex, and joint hypermobility. Studies of other factors potentially leading to development of such disorders should be continued. Children with impaired development should be included in programmes of prophylaxis.

Key words: **children, posture, development**

Introduction

Physical development covers a range of biological processes, including growing, differentiation and maturation. It comprises components referring to the body and its functions, including motor development. Motor development is understood as appearance of new movements, acquiring more complex motor activities, occurrence of more purposeful activities and higher physical performance [1]. The most intense motor development is observed in the first year of life. It involves gaining control over more and more complex body movements by coordinating the activities of neural centres, nerves and muscles, and maturation of specific levels of the nervous system [2]. Movement disorders are often diagnosed in

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the first year of life. They often involve excessive asymmetry of body positions and movements, disorders in the muscle tension or lack of expected milestones in the development at specific time [3-6]. Infancy and early childhood have a significant influence on the future functioning of the man. In the course of growing and maturation, the spine position and mobility affect the shape of single vertebrae, which consequently develops the posture and mobility of a mature spine [7,8]. The most rapid growth of human spine is observed in the period between birth and 5 years of age, during which about 52% of the spinal length measured at birth is acquired [9]. Adequate range of motion in the spine is necessary to acquire and maintain normal movement patterns by a growing child [7,10]. It is important that abnormalities in the spinal posture and mobility be detected in the early childhood.

In the biological development of man, joint mobility changes with age. The highest mobility occurs after birth, then it decreases quite rapidly during childhood, a bit more slowly during adolescence and slowly during adulthood. Generalized joint hypermobility (JH) is diagnosed when small and large joints reveal increased mobility in relation to the standard of age, sex and race, when there are no systemic diseases [11,12]. Excessive joint mobility may have negative consequences, cause pain, correlate with posture defects, or increase the risk of injury [12,13].

The study objective was to assess the correlation between motor development in the first year of life and trunk rotation angle, lumbo-pelvic-hip complex mobility and occurrence of hypermobility in children aged 3-9.

Material and methods

120 healthy children aged 3 to 9 participated in the study. Children were considered healthy if had no neurological, orthopaedic, muscular or metabolic disorders, which was determined on the basis of medical history supported by the inspection of a health record book or other medical records. The exclusion criteria were: occurrence of a neurological, orthopaedic, muscular or metabolic disorder, occurrence of any complaints of pain on the day of the study and occurrence of an injury in the last six months. Parents and guardians came in for free screening of body posture to two rehabilitation centres, where they were invited to take part in a research study. Participation in the study was voluntary. The studies were conducted in the period between October 2018 and April 2019. They took place in a physiotherapy office and were conducted by 4 trained physiotherapists. The children's parents or legal guardians were informed about the purpose of the study and signed a form in which they gave their consent to the research study. The study comprised two parts – a questionnaire and a clinical trial. In the questionnaire, the parents or guardians provided information on the child, such as date of birth, Apgar score obtained during the first assessment at birth, and answered the question if the child's motor development in the first year of life was normal. Abnormal development was when there was developmental asymmetry, delay in reaching milestones, and no ability of unassisted turning, sitting or crawling. The parents completed the questionnaire on the basis of the child's health record book or another medical document. The children with abnormal motor development in the first year of life were included in the study group, and the other children were a control group.

In the second part of the study, a physiotherapist assessed the value of the trunk rotation angle, the lumbo-pelvic-hip complex mobility and the occurrence of joint hypermobility

Angle of trunk rotation

The assessment of the angle of trunk rotation (ATR) was performed with the Bunnell scoliometer [14, 15]. The study was performed using the Adams test position (upright position, outstretched knees, Hip-width apart feet, bending forward to the floor). ART was examined at the highest eminence point in three spinal sections: thoracic, lumbar and lumbosacral. Prior to the study, correct performance of the test was presented.

Rotation of the lumbo-pelvic-hip complex.

The mobility of the lumbo-pelvic-hip complex was assessed with the use of TPHA test [16]. The subject was in a supine position with the upper limbs positioned perpendicularly to the trunk, with bent elbow joints. During the test, the bent lower limbs were drawn to the patient's chest and to the left, and then right elbow. The physiotherapist stabilised the patient's ribs to the surface. The measurement was taken using the Rippstein plurimeter (Rippstein, Switzerland) by placing the device along the long

axis of the thigh at the knee joint slit. The plurimeter was set at zero against the surface, and the result was given in degrees. Global range of motion was assessed by summing the right and left rotation (R-L sum), and asymmetry of rotational movements was assessed by determining the difference in the range of motion to the left and right (R-L asymmetry). Asymmetry of rotational movements of the lumbo-pelvic-hip complex was diagnosed when the difference between the range of motion to the right and left was 5 degrees or more.

Joint hypermobility

Hypermobility was assessed with the use of 9-point Beighton test [17, 18] which tested:

1. Passive dorsiflexion of the 5th finger of more than 90 degrees (in the right and left limb)
2. Passive abduction of the thumb to the medial side of the forearm (in the right and left limb)
3. Hyperextension in the elbow joint >10 degrees (in the right and left limb)
4. Hyperextension in the knee joint >10 degrees (in the right and left limb)
5. Placing the whole palms on the floor with outstretched knee joints in a standing forward bending position.

One point was given for each successful test. The diagnostic criterion of joint hypermobility (JH) was achieving minimum 4 points for boys and minimum 5 points for girls ([19].

Statistical analysis was performed with the use of IBM SPSS Statistics 20 statistical software.

On the basis of somatic characteristics rate in children, descriptive statistics were calculated for the results of particular tests. The mean values were compared using the Student's t-test. The analyses of percentage profiles were performed in cross tables by calculating the Pearson's chi-square test and the strength of Phi and Cramer's V relationship. The significance level was set at α=0.05.

Results

120 healthy children aged 3 to 9 years old participated in the study, including 57 girls and 63 boys. The characteristics of the study group and the control group are presented in Table 1.

Tab. 1. Group characteristics

	Abnormal development	Normal development
n	29	91
Sex	Females 15 Males 14	Females 41 Males 50
Average age (years)	6,19 ± 2,03	6,02 ± 2,09
Average APGAR score	9,51 ± 0,94	9,76 ± 0,68

The angle of trunk rotation measured in the thoracic section, the parameter determining asymmetry of the lumbo-pelvic-hip complex movement to the right and left in TPHA test, and the average result in the Beighton test showed statistical differences between the groups. Children with abnormal development were characterised by higher ATR values in the thoracic section and they had a higher asymmetry of rotational movements, as well as higher values in the Beighton test. Table 2 shows a comparison of the mean parameters tested with the Student's t test.

Tab. 2. Comparison of means of the study parameters

	Child development	Mean	SD	SE	T	df	p
ATR TH section	Normal	2,154	1,7884	,1875	-2,113	117	0,037
	Abnormal	3,000	2,0548	,3883			
ATR L section	Normal	2,549	2,1667	,2271	-,647	117	0,519
	Abnormal	2,857	2,3048	,4356			
ATR L-S section	Normal	1,132	1,6344	,1713	,536	117	0,593
	Abnormal	0,929	2,1069	,3982			
TPHA R-L sum	Sum P-L	6,714	13,7593	6,714	-,757	117	0,450
	Sum P-L	8,821	9,3454	8,821			
TPHA R-L asymmetry	Normal	2,495	3,1389	2,495	-4,310	117	0,000
	Abnormal	6,250	6,1320	6,250			
Hypermobility	Normal	2,352	2,4238	,2541	-2,653	117	0,009
	Abnormal	3,750	2,4889	,4704			

There was a statistically significant correlation between the occurrence of rotational movements in TPHA test in children aged 3-9 years old (asymmetry of 5 degrees or more) and abnormal development in the first year of life, and also between the occurrence of joint hypermobility in children aged 3-9 years old and abnormal development in the first year of life. The above correlations are presented in cross tables 3 and 4.

Tab. 3. Cross table of the occurrence of asymmetry, depending on the motor development in the first year of life

Development	R-L asymmetry		Total
	Yes	No	
Normal n=91	13,2%	86,8%	75,8%
Abnormal n=29	51,7%	48,3%	24,2%
Total	22,5%	77,5	100%
Chi-square = 17.73; p = 0.00; Phi = 0.4; Cramer's V = 0.3951			

Tab. 4. Cross table of the occurrence of hypermobility, depending on the motor development in the first year of life

Development	Hypermobility		Total
	Yes	No	
Normal n=91	30,8%	69,2%	75,8%
Abnormal n=29	58,6%	41,4%	24,2%
Total	37,5%	62,5%	100%
Chi-square = 7.28; P = 0.01; Phi = 0.23; Cramer's V = 0.2463			

Discussion

Various authors emphasise the existence of a correlation between posture defects diagnosed in the pre-school and school period, and developmental disorders occurring in the first year of life [20-22].

The study of the angle of trunk rotation (ATR) allows objective assessment of the spine in children and is a gold standard of screening. Early detection of excessive trunk rotation allows a quick diagnosis of scoliosis and prevention of its progression [15, 23-25]. According to Grivas et al., trunk asymmetry in younger children is physiological [26]. Our study has revealed that the angle of trunk rotation in the thoracic section is significantly higher in children with disturbed development in the first year of life in comparison with children with normal development. Other authors emphasise that developmental disorders may be one of the reasons for excessive trunk asymmetry. A study of Gieysztor et al. revealed a correlation between the occurrence of non-integrated primitive reflexes and increased angle of trunk rotation measured while bending in children aged 5-9 years old. Asymmetry induced by impaired muscle tone caused by involuntary primitive response causes changes in neural pathways and affects normal motor patterns later in the child's life [25]. Moreover, some authors prove that humans have pre-existing physiological vertebral rotation since birth [27, 28], which, combined with certain predisposition, may lead to development of asymmetry and scoliosis. Grivas draws attention to the fact that the angle of trunk rotation in children aged 3-9 years old is greater when it is measured in the upright position as compared with the measurement in the sitting position [26]. This might suggest the effect of the difference in the lower limb length on the trunk asymmetry. In the present study, children were examined only in the upright position. In the future, such studies should also be performed in other positions, as well.

Numerous authors draw attention to the role of the lumbo-pelvic-hip complex in the functioning of man. Rotational movements of this section are especially important for locomotion, and their limitation or asymmetry may have negative consequences and may cause undesirable compensation in remote body parts [29, 30]. There are publications discussing a study of the range of spinal motion in children, including range of rotation [7, 31, 32]. Rotational movements occur in numerous activities, so their thorough examination is highly important while working with patients. According to our studies, children with abnormal motor development in the first year of life did not show limitations of global rotational mobility in the lumbo-pelvic-hip complex, but higher asymmetry of rotational movements was significantly more frequent. 50% of children in the group with abnormal development in the first year of life showed a 5-degree or higher difference between the lumbo-pelvic-hip complex movement to the right and left, while only 13.2% of children in the group with normal development showed such asymmetry. Kondratek et al. found that there were statistical differences between the rotational movement of the lumbar spine to the right and left in the group of healthy children aged 5 and 11 [7]. However, they did not relate this data to the earlier development. Other authors studying the range of motion in healthy 8-16-year-old children showed no differences between rotation

to the right and left in the section of thoracic and lumbar spine. A statistical difference was observed only in the group of girls aged 13-14, who showed a higher rotation of the thoracic section to the right [33]. Other authors noticed significant asymmetry of rotational movements in the lumbo-pelvic-hip complex both in healthy girls and in girls with scoliosis aged 8-16. However, in the girls with scoliosis, the asymmetry was greater and movement to the right was significantly limited, as compared with healthy subjects [30]. It is worth noting that disorders in trunk rotation and abnormal rotation pattern while walking may be a factor predisposing to development or progression of scoliosis [34, 35, 36]. Limitations and excessive asymmetry of movements developed in childhood may gradually lead to compensation and deformation in the musculo-skeletal system and to complaints of pain. It seems that it is necessary to introduce prophylactic activities preventing development of abnormal compensatory mechanism and secondary deformation related to asymmetry of rotational movements in children, especially in those children with abnormalities in the motor development observed in the first year of life.

The present study has shown a significant correlation between abnormal motor development in the first year of life and the occurrence of hypermobility in children aged 3-9. In a study by Adib et al., in a group of subjects below the age of 18 with joint hypermobility syndrome, 36% showed poor motor coordination, and 48% were considered clumsy with regard to movement in their early childhood. The authors suggest that disorders in the motor development might be related to abnormalities in the central nervous system and poor proprioceptive control, which may in turn lead to development of joint hypermobility [37]. The authors of the present study are not familiar with other reports assessing joint hypermobility in children of similar age to the present group and relating its occurrence to development in the first year of life. There are publications, however, assessing motor development and joint hypermobility in a given stage of development. In their study of 8-14-month infants, Jaffe et al proved that the occurrence of joint laxity is significantly correlated with delayed development [38]. Contrary conclusions were reached by Engelbert et al., who assessed motor development of children aged 4-12 with generalized joint hypermobility diagnosed using the Bulbena scale. Despite the fact that about 25% of children showed a significant developmental delay, there was no statistically significant correlation between motor development delay and the hypermobility index [39]. It must be emphasised however, that the quoted publication used a different scale than the one used in the present study.

Considering the incidence of joint laxity and the fact that children with diagnosed joint hypermobility reveal disorders in various body systems, it seems justified to include the assessment of joint laxity in the medical ad physiotherapeutical diagnostics. In the light of the present studies, such diagnostic should especially refer to children with abnormal development diagnosed in the first year of life.

So far, no studies have been conducted on the correlation between motor development in the first year of life and the parameters analysed in the present study. This seems to be an interesting direction. The present study is certainly limited by a small number of participants. Therefore, such studies should be conducted on a larger group. It would also be recommended to conduct similar studies with long-term follow-up, in which children examined at 0-12 months of age would be followed for subsequent years.

Conclusions

Abnormal motor development in the first year of life is a factor predisposing to increased values of the trunk rotation angle in the thoracic section, asymmetry of rotational movement of the lumbo-pelvic-hip complex, and joint hypermobility. Studies of other factors potentially leading to development of such disorders should be continued. Children with impaired development should be included in programmes of prophylaxis.

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