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The evaluation of the influence of the body mass index on body posture parameters and selected parameters of the dynamic feet analysis

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Summary
Introduction and purpose. The proper process of body shaping in children is extremally important in preventing present and future pain complaints. According to the source literature, a proper body weight is one of the most important factors in children which have an influence on body shaping . The aim of the study was to evaluate the correlations between the body mass index and body posture parameters as well as selected parameters of the dynamic feet analysis.
Material and method. The study involved 106 children aged 10−15 years old from the Świętokrzyskie Voivodeship. While undergoing the examination, the children were dressed in sportswear and had no shoes. The body height was measured using the SECA 213 stadiometer

with an accuracy of 0.01 m, the body weight with the Tanita device with an accuracy of 0.01 kg. The next stage involved the assessment of the body posture using Diers Formetric 4D system. Then the child had to walk several times on FreeMed platform.
Results. The dependencies of selected parameters of the dynamic feet analysis from the BMI of the examined children were assessed using Spearmann's correlation. All examined correlations were statistically significant. The dependencies between body posture parameters assessed using Diers Formetric 4D and the BMI of the examined children were assessed by Spearmann's correlation. A statistically significant negative correlation were observed only between the pelvic torsion and the body mass index.
Conclusions. The majority of parameters of the dynamic feet analysis evaluated in the paper increase with the increase of the body mass index of the examined children. Only the parameter, namely the number of steps per minute decreases when the BMI of the examined children grows. Higher values of the body mass index in children were observed when the pelvic torsion to the left was assessed. The BMI of the examined children did not affect the remaining parameters assessing the body posture.

Key words: dynamic feet analysis; Diers; BMI.

Introduction

Overweight and obesity are a significant social problem also among children. According to the data provided by the World Health Organization, the number of overweight and obese children in 2016 increased from 4 to 18% in comparison with the data from 1975. There are approximately 340 million children aged 5–19 around the world with determined excessive body weight [1, 2]. Appropriate physical activity and a balanced diet make a strong foundation for the body formation of a young person and the prevention of overweight or obesity [3, 4, 5, 6]. Absence of proper physical activity might have an impact on the increase of body weight and will be a risk factor for a number of diseases or the emergence of pain [7, 8, 9, 10, 11, 12, 13]. According to the guidelines of the World Health Organization, children aged 5–17 should exercise for at least one hour per day – various forms of exercise are included [14]. Wasiluk et al. [15] noted that girls whose body weight exceeded the norm were less physically active as compared to girls with body weight within the norm values. A passive lifestyle, an increasing body weight, no physical activity also affect the shaping posture in children [16, 17, 18, 19, 20]. The research conducted by Paskalev et al. [21], Lastro et al. [22] suggest that active children demonstrate fewer abnormal posture habits. Among physically active people i.a. tension is normalized and the awareness of their own body improves. The body posture should constitute a balance between bone and skeletal tissues, and provide a reasonably symmetrical body system. It is evaluated both under static and dynamic conditions, and is influenced by many external factors [23]. Therefore, one of the assumptions of the study was to assess the BMI impact on posture parameters assessed with the use of Dires system.

The second assumption hereof was to evaluate the BMI impact on selected parameters of the dynamic analysis. The study of feet pressure under static and dynamic conditions is becoming an increasingly widely used tool which is applied both by physiotherapists and representatives of other medical specialties. The proper understanding of factors influencing changes in the pedobarography forms the basis in order to take full advantage of the technical possibilities of the device. The information obtained thanks to those paths makes it possible to assess the patient in a full and comprehensive manner and should be an element complementing the diagnosis and therapy. This examination will thus assess not only the patient's foot, but will also provide information about higher parts of the body [24, 25, 26, 27].

The aim of the study. The aim of the study was to evaluate the correlations between the body mass index and body posture parameters as well as selected parameters of the dynamic feet analysis.

Material and method.

The study involved 106 children (54 girls representing 51% and 52 boys – 49%) aged 10–15 years old from the Świętokrzyskie Voivodeship. The average age was 12,01. The basic parameters characterizing the study group are presented in Table 1. The Bioethical Commission of the Jan Kochanowski University in Kielce gave its consent for the study which was conducted in 2017 and 2018 in the Posturology Laboratory of the Jan Kochanowski University in Kielce The inclusion criteria: the written consent of parents or legal guardians for the examination, no current orthopedic problems related to the motor system, i.e. fractures, dislocations. The exclusion criteria: no written consent of parents or legal guardians for the examination, current orthopedic problems related to the motor system, i.e. fractures, dislocations.

The test was performed in the morning. While undergoing the examination, the children were dressed in sportswear and had no shoes. The first stage of the study was to determine the body height and weight. The body height was measured using the SECA 213 stadiometer with an accuracy of 0.01 m, the body weight with the Tanita device with an accuracy of 0.01 kg. From the obtained data, the body mass index was calculated according to the following formula: body weight (kg) / body height^2 (cm^2) [23]. The next stage involved the assessment of the body posture using Diers Formetric 4D system. An examined child was supposed to stand in a natural way without underwear with his/her arms along the body, having their back to the device at a distance of 2 m. Children with long hair had to tie it up. All decorations had to be removed. The device analyzes the body posture using a three-dimensional light-optical system [28]. Then the child had to walk several times on FreeMed platform. The total surface of the platform is: 635 mm x 700 mm – the active surface of the sensors is not less than 500 mm x 600 mm. The real-time sampling frequency under dynamic conditions is 300–350 Hz [29]. The parameters of the dynamic feet analysis which were taken into account in the paper included: maximum feet load, mean feet load, feet load area cm^2, contact time with the surface and the number of steps per minute. Body posture parameters assessed in the paper include: deviation from vertical VP-DM [mm], pelvic tilt DL-DR [mm], pelvic torsion DL-DR [°], surface rotation (rms) [°], lateral deviation VPDM (rms) [mm], ICT-ITL kyphosis angle (max.) [°], ITL-ILS lordosis angle (max.) [°].

Table 1. The specification of the study group.

	Mean	Standard deviation	Minimum	Maximum
Body height	1,53	0,10	1,34	1,8
Body weight	46,78	11,53	27	77
BMI	19,38	13,16	28,63	3,25

MS Office Excel and statistical program R.3.3.1 were used to analyze the research. For all parameters, basic measures of the descriptive statistics were calculated, i.e. arithmetic means, standard deviation, minimum and maximum for the entire group. To examine the correlations between the variables, Spearmann's rank correlation analysis was applied. The result was considered statistically significant when the significance level amounted to p <0.05.

Results

The maximum load of the left foot was on average – 1200,43, SD 224,81 gr/cm^2, min. –700, max. – 1996, of the right foot was on average 1208,58, SD 225,90 gr/cm^2, min. –756, max. – 2220; the mean load of the left foot was on average – 443,13, SD 75,59 gr/cm^2, min. 300, max. – 655, of the right foot was on average – 429,13, SD 67,16 gr/cm^2, min. – 275, max. – 601; the load area of the left foot was on average – 134,31, SD 22,39 cm^2, min. – 88, max. – 203, of the right foot was on average – 135,37, SD 21,42 cm^2, min. – 81, max. – 202; contact time of the left foot with the surface – on average – 847,21, SD 115,09, min. 417, max. – 1137, of the right foot – on average – 867,10±160,66, min. – 469, max – 1660 and the number of steps per minute – on average – 69,40, SD 9,71, min. 42, max – 91. Basic measures of the descriptive statistics characterizing posture parameters are presented in Table 2.

Table 2. The characteristics of the selected parameters assessing the body posture of children

The parameters assessing the body posture	Mean	Standard deviation	Minimum	Maximum
Deviation from vertical VP-DM [mm]	-1,22	7,83	-26	15
Pelvic tiltDL-DR [mm]	-0,76	4,66	-15	9
Pelvic torsion DL-DR [°]	0,17	3,12	-8	7
Surface rotation (rms) [°]	3,80	1,62	1	10
Lateral deviation VPDM (rms) [mm]	3,54	1,74	1	9
Kyphosis angle ICT-ITL (max) [°]	47	6,22	35	66
Lordosis angle ITL-ILS (max) [°]	40,26	8,5	10	66

Table 3 and Figures 1–5 present the dependencies of selected parameters of the dynamic feet analysis from the BMI of the examined children which were assessed using Spearmann's correlation. All examined correlations were statistically significant. Figures 1–5 illustrate how the studied parameters change depending on the increasing BMI in children.

Table 3. The depenence of the body mass index and selected parameters of the dynamic feet analysis (Spearmann's correlation).

Parameters of the dynamic analysis	ρ	p
Maximum load gr/cm2 L dynamic examination	0,554	<0.001
Maximum load gr/cm2 R dynamic examination	0,593	<0.001
Mean load gr/cm2 L dynamic examination	0,496	<0.001
Mean load gr/cm2 R dynamic examination	0,569	<0.001
Area cm^2 L dynamic examination	0,579	<0.001
Area cm^2 R dynamic examination	0,568	<0.001
Steps per minute	-0,212	0,029
Contact time with the surface L	0,244	0,012
Contact time with the surface R	0,237	0,014

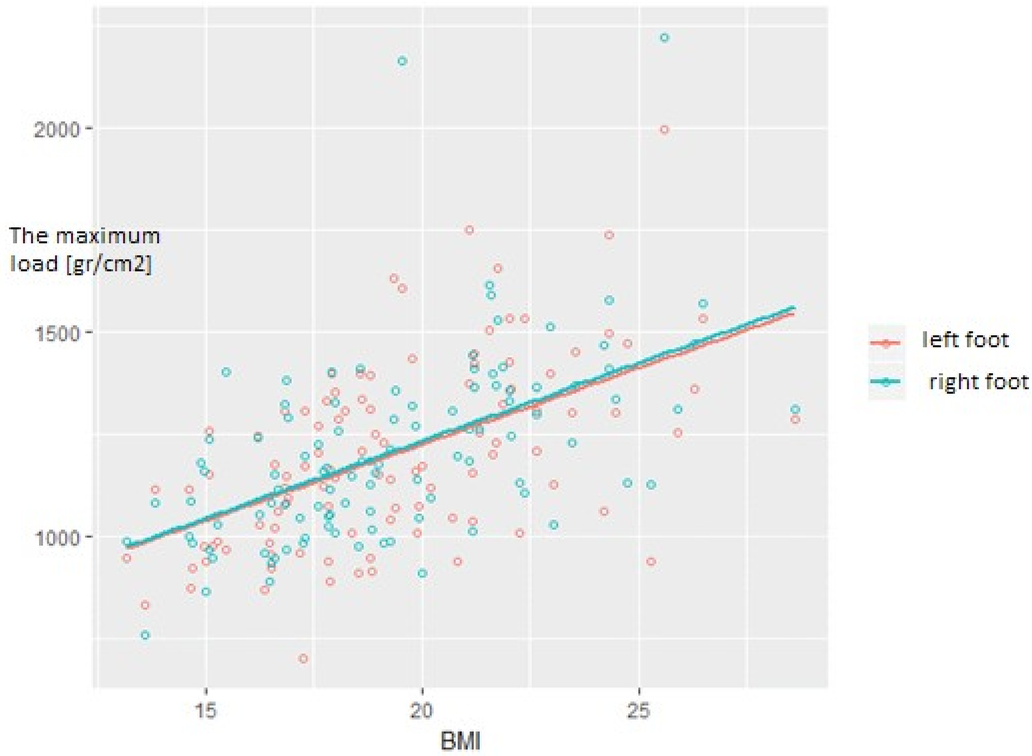

Fig. 1. The dependence of the maximum load from the BMI of the examined children.

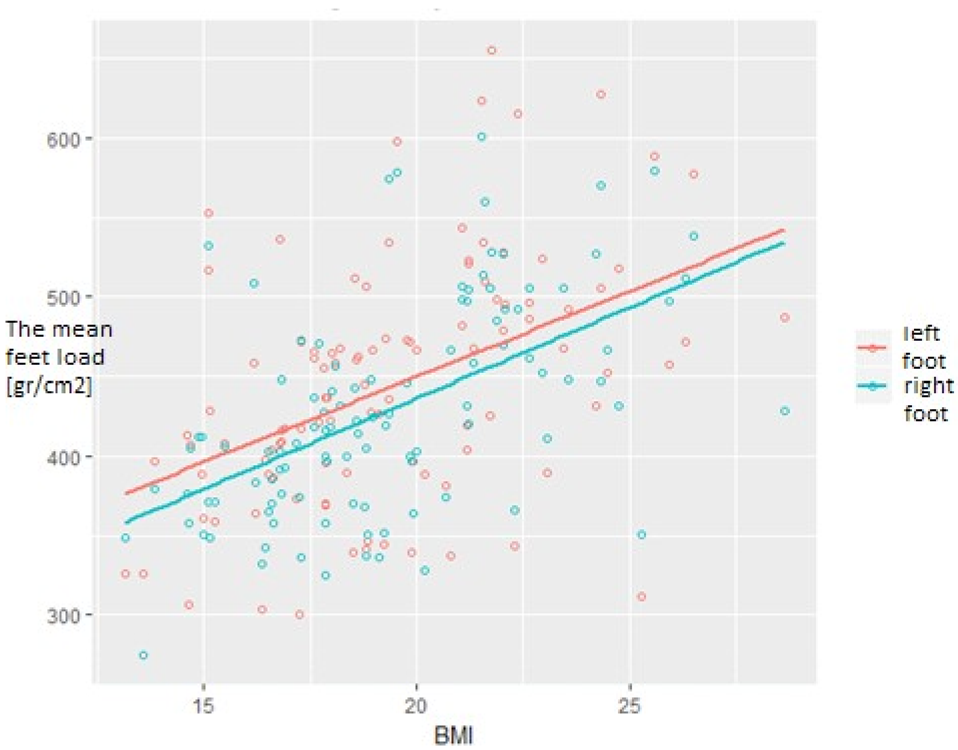

Fig. 2. The dependence of the mean feet load from the BMI of the examined children.

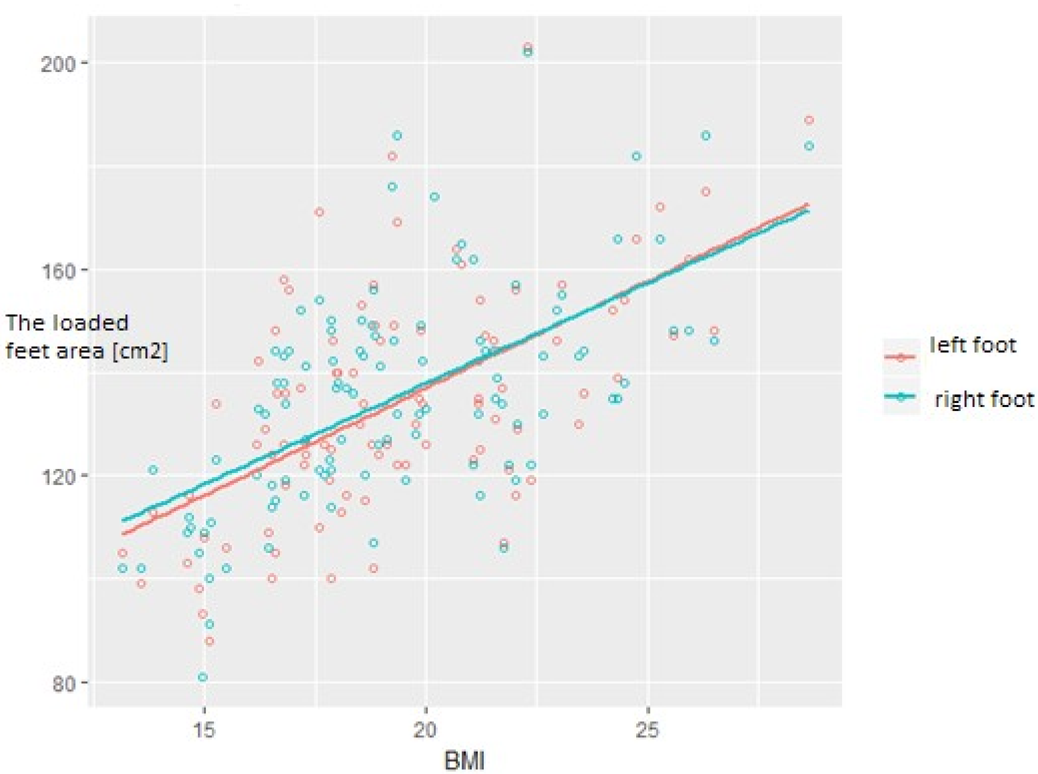

Fig. 3. The dependence of the loaded feet area from the BMI of the examined children.

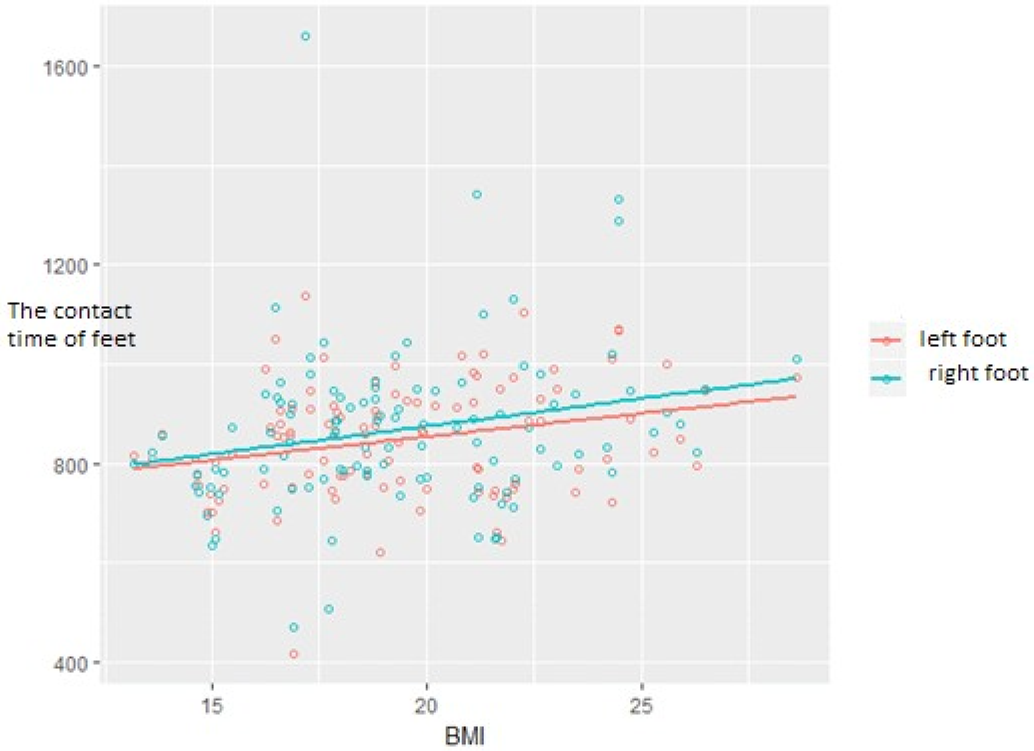

Fig. 4. The dependence of the contact time of the feet with the surface from the BMI of the examined children.

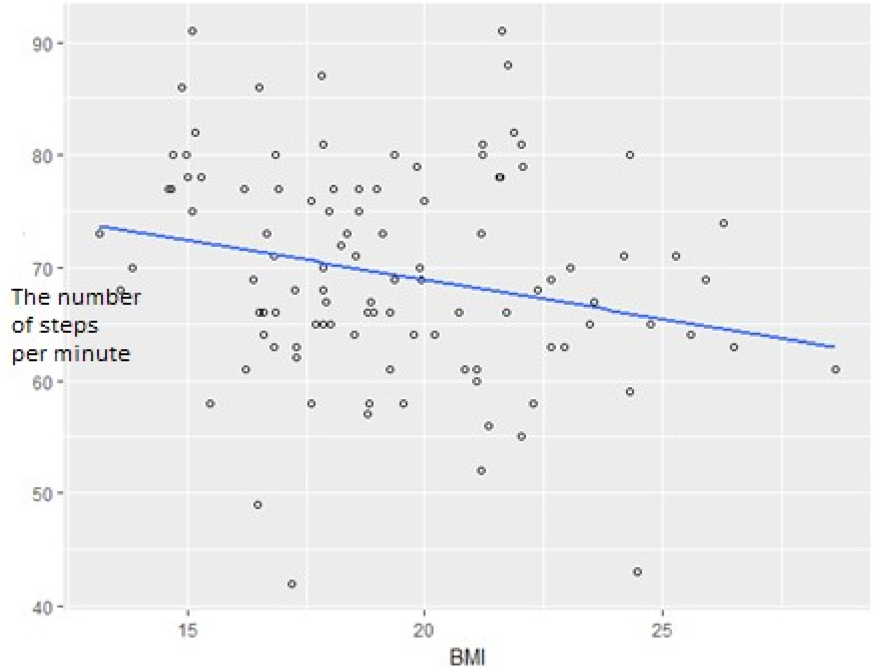

Fig. 5. The dependence of the number of steps per minute from the BMI of the examined children.

Table 4 presents the dependencies between body posture parameters assessed using Diers Formetric 4D and the BMI of the examined children. A statistically significant negative correlation illustrated in Fig. 5 is observed only between the pelvic torsion and the body mass index.

Table 4. The dependence of the BMI and body posture parameters (Spearmann's correlation)

Body posture parameters	ρ	p
Surface rotation (rms) [°]	-0,139	0,154
Lateral deviation VPDM (rms) [mm]	-0,089	0,362
Kyphosis angle ICT-ITL (max.) [°]	0,181	0,064
Lordosis angle ITL-ILS (max.) [°]	-0,076	0,441
Deviation from vertical VP-DM [mm]	0,068	0,490
Pelvic tilt DL-DR [mm]	0,012	0,902
Pelvic torsion DL-DR [°]	-0,233	0,016

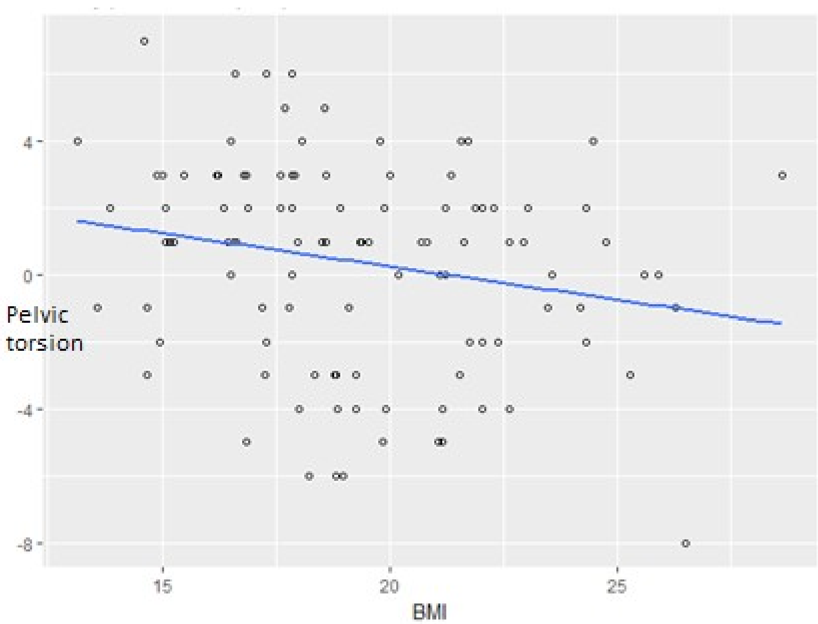

Fig. 6. The dependence between the pelvic torsion and the BMI of the examined children.

Discussion.

The body posture should be evaluated and examined during each visit at a physiotherapist who the most frequently assesses it visually under static and dynamic conditions. However, noteworthy are as well additional tools that objectivize and complement this assessment and give an opportunity to monitor the patient's condition in a better way. Not only endogenous factors but also exogenous, i.e. external factors affect the body posture of children. The source literature includes many references that an appropriate body weight affects the development of a proper body posture [15–22] which is inextricably linked to the amount of physical activity of a child as well as his/her appropriate diet. Body weight affects as well the parameters of pedobarography under both static and dynamic conditions during the gait. Currently, pedobarographic paths are used to assess the feet load. Thanks to them a therapist can assess not only feet but also the higher parts of the body. The author concentrated in this paper on evaluating the impact of the changeable BMI on body posture parameters as well as selected parameters of the dynamic analysis.

While assessing the correlations of the dynamic analysis it might be noticed that all parameters included in this paper are statistically dependent on the changeable BMI. The majority of those parameters, i.e.: maximum feet load, mean feet load, feet load area cm^2, contact time with the surface increase with the increase of the BMI in both the left and right foot. The only parameter which decreases when the BMI of the examined children grows is the number of steps per minute. Those observations coincide with the observations gained by i.a. Tidbury [30] or Muller et al. [31]. Muller et al. [31] suggests as well that an excessive body weight changes the walking pattern of those children. Walh et al. [32] observed parameters of the dynamic feet analysis of his patients after a period of time of two years during which the body weight increased on average by 2 kilos. The increase in body weight was linked to the increase in pedobarographic parameters, as well as the emergence of foot pain among those people. The pedobarographic parameters are also affected by a low level of physical activity, which was examined by Riddiford et al.

While assessing the dependencies between body posture parameters and the body mass index, it was observed that the BMI of the examined children did not affect the majority of those parameters. A statistically significant relationship was observed only between the pelvic tilt. Higher BMI values in children were noticed when the pelvic torsion to the left was assessed which coincides with the observations made by Degenhardt et al. [34], Mohokum et al. 35, Goh [36], Peeters et al [37], who found no influence between the BMI and the parameters assessing the trunk. Those authors [34, 35, 36, 37] evaluated the body posture of the examined using Diers device. However, the following researchers: Matusiak et al. [38], Wyszyńska et al. [39], Górniak et al. [40] found dependencies between the body posture parameters and the increasing adipose tissue mass. However, those authors applied other research tools to assess the body posture, and instead of the body mass index, the adipose tissue mass was evaluated.

The authors hereof recognized the need to continue the research in order to broaden the study group and compare the classification of children by the BMI values in the case of underweight, norm, overweight and obesity. As a result of enlarging the study group, it will be possible to conduct an in-depth assessment of the impact of the BMI on body posture parameters.

Conclusion

1. The majority of parameters of the dynamic feet analysis evaluated in the paper increase with the increase of the body mass index of the examined children. Only the parameter, namely the number of steps per minute decreases when the BMI of the examined children grows.
2. Higher values of the body mass index in children were observed when the pelvic torsion to the left was assessed. The BMI of the examined children did not affect the remaining parameters assessing the body posture.
3. It is recommended to continue the research in order to broaden the study group and compare the classification of children by the BMI values in case of underweight, norm, overweight and obesity.

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