# PLANTAR PRESSURE DISTRIBUTION ASSESSMENT OF YOUNG SCHOOL CHILDREN

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- plantar pressure
- children
- somatotype
- WHtR

**Abstract:**
**Background:** Plantar pressure distribution may be conditioned by several factors, such as the anatomic structure of the foot, body weight, gender and the range of joint mobility. Overweight may affect the structural and functional condition of the feet, particularly in puberty.The aim of this work was to assess the correlation between the plantar pressure and the age, gender, BMI and somatotype of school-age children. **Material and methods:** 175 healthy children, aged 10 to 15 were qualified for the study. The study comprised anthropometric measurements, such as body height, body weight and its components as well as the measurements necessary to define the somatotype by means of the Heath-Carter method. Next, the measurement of the distribution of the ground reaction force was measured. **Results:** There is a correlation between the features related to the mass, height and somatotype and the distribution of static plantar pressures in the sagittal plane. In the dynamic test, the above-mentioned features are related to the distribution of plantar pressure in the coronal plane. **Conclusions:** It is worth conducting further, deepened studies considering the correlations between the somatotype and the static plantar pressure with respect to the age of the tested people.

## INTRODUCTION

Plantar pressure distribution may be conditioned by several features such as the anatomic structure of the foot, body mass, gender and the range of joint mobility [Bennet, Duplock 1993]. An excessive body mass may have a negative influence on the structural and functional condition of the feet, due to the potential overload of the locomotor system, hence it may be related to the problems of the orthopaedic nature. It is particularly important in the phase of quick growth, which means in the case of children and youth, when overweight and obesity negatively influence the development of bones, muscles and joints and, consequently, the biomechanic parameters of their walk [McGraw et al. 2000]. In the literature, we can find numerous works pointing out essential correlations between the body mass and the size of the loads affecting the feet [Drerup et al. 2003; Vela et al. 1998; Hills et al. 2002; Nyska et al. 1997]. As the foot plays a very important role in locomotion, there is a lot of information trying to establish which areas of the foot assume a higher static pressure together with the growth of body mass both among adults [Birtane, Tuna 2004; Gravante et al. 2003; Hills et al. 2001; Hills et al. 2002] and children [Downling et al. 2001; Henning et al. 1994; Riddiford-Harland et al. 2000]. Some of these works refer also to the distribution of pressure in the dynamic test [Henning, Milani 1993]. During running, walking or standing, within feet there are pressures generated by the whole body and the position it assumes. Due to the biomechanic complexity of a human body, it can be assumed that not only the mass but also the position and the body build can have an influence on the size of the pressures in particular areas of the foot. That, in consequence, may affect the condition of foot arches, within both the longitudinal and the metatarsal arch. More detailed information concerning the body build of the child may be provided by the assessment of the somatotype. This method allows us to define, from the quantitative perspective, the type of the body build, regardless of the developmental stage, so also regardless of the body size. Body build, on the other hand, may be conditioned by the nutrition, physical activity, healthy habits, diseases and the ontogenetic stage. While it is not difficult to find works concerning the influence of the body mass and the BMI on the plantar pressure, there is no information juxtaposing those results with the type of body build and the body height of children.

The aim of this work was to assess the correlation between the plantar pressure and the age, gender, BMI and the somatotype of school age children.

## MATERIAL AND METHOD

175 healthy children, including 98 girls and 77 boys aged 10 to 15, were qualified for the study, from among 184 examined children. The non-inclusion criteria comprised injuries within the lower limbs or the spine, diseases affecting the sensorimotor system, lack of consent to participate in the study or incomplete data.

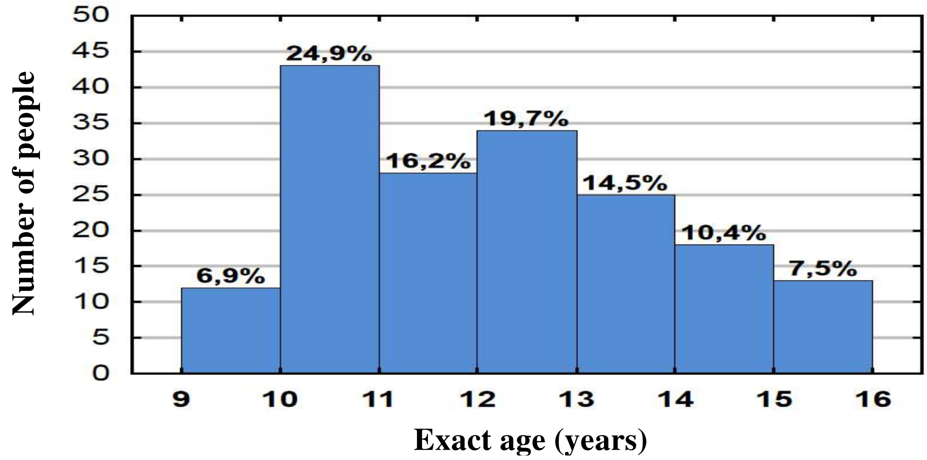


**Fig. 1** Age distribution of the test population

The tests were performed in the period of May-September 2016 among the pupils of the John Paul II School Complex in Zarzecze, in the rooms specially prepared for that purpose, ensuring peace and privacy for the tested people. The children were taking the test in light sports clothes, without shoes. The anthropometric measurements were taken in accordance with the protocol recommended by the International Society for the Advancement of Kinanthropometry (ISAK) [Norton, Olds 1996]. As the first, the anthropometric measurements were taken, during which the children provided data concerning, among others, their dates of birth and the diseases or injuries they had had which could have excluded them from the participation in the further part of the study. Body height was measured by means of the Martin-type anthropometer, the body mass and its components were determined with the use of the electronic scales Tanita Body Composition Analyzer, TBF 300. Next, the measurement of the thickness of four skin folds was performed with the Harpenden skinfold calliper with the precision down to 0.1 mm. Next, the widths of the humerus and the femur were measured with the small spreading calliper as well as the circumference of the arm with the muscles tightened and the widest circumference of the lower leg. The circumference at the waist of the tested people was also measured, half way between the last palpable rib and the top edge of the iliac crest, as well as the circumference at the hips, through the most backward points of the buttocks (in the widest place of the hips). The measurements were made by means of the Gulick anthropometric tape, with the precision down to 1 mm. On the basis of the results obtained, we calculated the WHR, as the waist circumference divided by the hips circumference, and the WHtR, as the waist circumference divided by the height, with all the variables expressed in cm. Due to the lack of constant, age-independent BMI norms for children, apart from that index, we also calculated their corresponding centiles for the gender and age, representative for the Polish population. For that purpose, we used a calculator by Anna Manerowska, prepared within the project no. PL0080 'Shaping of blood pressure norms for children and youth in Poland, OLAF'. What is more, for the BMI, z-scores were provided, calculated according to Stupnicki [Stupnicki 2014]. Table 1 presents descriptive statistics concerning particular components of the somatotype and referring to selected somatic features of the test group.

**Tab. 1** Descriptive statistics concerning selected features of the test group

| Gender | N | % |
|---|---|---|
| Male | 77 | 0.44 |
| Female | 98 | 0.56 |
| | | |
| Somatotype | x | sd |
| Endo | 4.2 | 1.6 |
| Meso | 3.5 | 1.4 |
| Ecto | 2.9 | 1.7 |

| | x | sd | Min | Max |
|---|---|---|---|---|
| Age | 12.20 | 1.70 | 9.50 | 15.90 |
| BMI | 19.90 | 3.60 | 13.80 | 32.00 |
| BMI centile | 58.20 | 31.00 | 1.00 | 99.00 |
| BMI (z-score) | 1.60 | 2.10 | -1.97 | 10.08 |
| Height | 153.78 | 10.93 | 129.00 | 186.00 |
| WHR | 0.84 | 0.57 | 0.05 | 8.33 |
| WHtR | 0.44 | 0.06 | 0.61 | 0.03 |

Next, the measurement of the distribution of the ground reaction force was performed, as generated by the feet of the people tested, while standing and walking. For that purpose, FreeMed BASE, a baropodometric platform produced by Sensor Medica (Guidonia Montecelio, Rome) was used. The platform was equipped with an aluminium structure measuring 620x440x8mm with 400x400mm of an active surface. The machine had sensors covered with 24-karat gold, assuring a repeatability and reliability of the measurements which were registered with the sampling frequency at the level of 400Hz in real time. The software of the platform, FreeStep Ver. 1.4.01, enabled the performance of the baropodometric and stabilometric examination as well as the assessment of the posture and biomechanics in motion. Both the static and the dynamic analysis allowed for the real-time observation of the three-dimensional, isobaric projection of the feet in high resolution. The software calculated also the numeric values of the plantar distribution for each of the feet, their area and percentage pressure with the differentiation into the forefoot and the hindfoot as well as the relocation of the load centre between the feet.

During the first test, the person was asked to stand in a free position on the measuring platform and look ahead at a point that was placed at the eye level on a wall located 3 meters away, while the equipment was collecting data for the static analysis. Next, the child was placed at the distance of one step away from the platform and was asked to walk freely; the procedure was repeated for the other foot, respectively. In table 2, by means of descriptive statistics, the distribution of plantar pressure in the static and dynamic test is characterized.

**Tab. 2** Descriptive statistics concerning selected parameters calculated in the static and dynamic test

| **Static test** | **x** | ***s*** | **min** | **max** |
|---|---|---|---|---|
| Whole foot L [%] | 54.9 | 5 | 43 | 70 |
| Whole foot R [%] | 45.1 | 5 | 30 | 57 |
| Forefoot pressure L [%] | 52.2 | 9.8 | 25 | 80 |
| Hindfoot pressure L [%] | 47.8 | 9.8 | 20 | 75 |
| Forefoot pressure R [%] | 54.1 | 10.2 | 30 | 83 |
| Hindfoot pressure R [%] | 45.9 | 10.2 | 17 | 70 |

| Dynamic test | x | s | min | max |
|---|---|---|---|---|
| Forefoot pressure L [%] | 67.3 | 5.7 | 43 | 81 |
| Hindfoot pressure L [%] | 32.8 | 5.7 | 19 | 57 |
| Forefoot pressure R [%] | 67.8 | 5.2 | 50 | 78 |
| Hindfoot pressure R [%] | 32.3 | 5.2 | 22 | 50 |
| Paracentral pressure L [%] | 45.6 | 7.5 | 29 | 76 |
| Lateral pressure L [%] | 54.4 | 7.5 | 24 | 71 |
| Paracentral pressure R [%] | 47.9 | 7.2 | 32 | 73 |
| Lateral pressure R [%] | 52.1 | 7.2 | 27 | 68 |

On the basis of previously conducted tests, the Somatotype was determined. In order to do that, the anthropometric method Heath-Carter was used. The Somatotype allows for a quantitative determination of the body build, regardless of the gender and the stage of development, so also regardless of the body size. It is expressed by means of a three-digit index corresponding to endomorphy, mesomorphy and ectomorphy respectively, always in the same order. Endomorphy shows the adiposity of the body, mesomorphy the musculature development and ectomorphy refers to the slenderness of the body. The values from 0.5 to 2.5 are considered as low, 3-5 as medium, 5.5-7 as high and over 7 as very high results. In order to determine the somatotype by means of this method, the following variables are needed: the mass and the height of the body, the thickness of skinfolds (brachial, subscapular, supraspinal, medial crural), transcondylar width of the femur and of the humerus and the circumference of the arm, with the biceps muscle tightened and of the lower leg, with the muscles tightened. The particular components constituting the somatotype were calculated on the basis of the following formulas: Endomorphy=-0.7182+(0.1451*X)-(0.00068*$X^2$)+(0,0000014*$X^3$), where X=(the sum of the thickness of the following skinfolds: brachial, subscapular, supraspinal)*(170.18/height[cm]). Mesomorphy=(0.858*width of the humerus)+(0.601*width of the femur)+(0.188*adjusted circumference of the arm)+ (0.161*adjusted circumference of the lower leg)-(height*0.131)+4.5, where the adjusted circumference of the arm and of the lower leg mean the circumference reduced by the thickness of the skinfold of the arm and the lower leg respectively. For ectomorphy, we used one of the three formulas, depending on the value of the HWR. When HWR was more than or equal to 40.75, then the following formula was used: ectomorphy=(0.732*HWR)-28.58. When HWR was less than 40.75 but more than 38.25, then ectomorphy=(0.463*HWR)-17.63. When HWR was less than or equal to 38.25, then ectomorphy=0.1 [Carter 2002]. The project gained the approval of the bioethical committee of the University of Rzeszów.

The data collected in the study underwent statistical analysis with the use of the Statistica 12 programme by StatSoft. For the primary calculations, the Spearman's rank correlation coefficient was used, assuming the values from the range of -1 to 1. It is resistant to the occurrence of outliers and 'detects' correlations of the monotonic character. The absolute value of the coefficient is evidence of its strength. In the case of negative values, together with the growth of the value of one feature, the values of the other one increase, and in the case of positive values, they decrease.

The results were complemented with the results of the test of significance for the correlation coefficient (p), which allowed the assessment of whether the correlation found in a given sample is a reflection of a more general relation existing in the whole population, or just a matter of coincidence. For the assessment of the significance of the differences in the indices of the plantar pressure between the groups of girls and boys, the Mann-Whitney test was used. It serves the purpose of assessing the differences in the average level of a numerical characteristic in two populations and allows for a reliable comparison of the data, even from very small samples. The numeric result of the test is expressed by means of test probability p, whose low values allow us to assume the difference between the level of a numerical characteristic in two comparable groups as statistically significant.

## RESULTS

At first, it was checked how the distribution of plantar pressure changes with age, in a static and dynamic test. For the analysis, the exact age values were used, applying the analysis of the Spearman's rank correlation. Analysing the results obtained, it could be concluded that the plantar pressure distribution in the static test between the right and the left foot did not depend on age. However, statistically significant correlations were noticed between the age and the forefoot pressure in relation to the hindfoot pressure. It turned out that the static forefoot pressure increases with age, though the strength of that correlation was small.

**Tab. 3** Plantar pressure in a static test in relation to the age of the tested people

| **Static test** | Exact age (years) | |
|---|---|---|
| Plantar pressure L [%] | 0.10 | ($p$ = 0.2082) |
| **Forefoot pressure L [%]** | **0.27** | **($p$ = 0.0004***)** |
| **Forefoot pressure R [%]** | **0.24** | **($p$ = 0.0019**)** |

However, the pressure in the dynamic test, as a matter of fact, did not depend on the age. The only exception being a statistically characteristic small downward trend of the paracentral pressure in the right foot.

**Tab. 4** Plantar pressure in a dynamic test in relation to the age of the tested people

| **Dynamic test** | Exact age (years) | |
|---|---|---|
| Hindfoot pressure L [%] | 0.04 | ($p$ = 0.5611) |
| Forefoot pressure R [%] | 0.06 | ($p$ = 0.4441) |
| Paracentral pressure L [%] | 0.01 | ($p$ = 0.9064) |
| **Lateral pressure R [%]** | **0.20** | **($p$ = 0.0083**)** |

Summing up the results of the analysis of the correlation of static and dynamic pressures and the age, the influence of that factor on the results of the measurements obtained can be considered quite small. Due to that, in further analyses of the pressure indices, the test population was treated as a whole, regardless of the age. Next, the indices of pressure were juxtaposed with regard to the gender of the tested people. In the dynamic test, no differences were noticed between the girls and the boys, while in the static test, among the boys there was a higher forefoot pressure both in the right and in the left foot. This effect showed statistical significance. Analysing the results obtained, we could observe a bigger balance in the fore- and hindfoot pressure in girls, while in the case of boys, the front of the foot is more loaded. The assessment of the significance of the differences between the groups was performed by means of the Mann-Whitney test.

**Tab. 5** Plantar pressure in a static test in relation to the gender of the tested people

| **Static test** | **Gender** | | | | | | ***p*** |
|---|---|---|---|---|---|---|---|
| | **Male** | | | **Female** | | | |
| | $\bar{x}$ | Me | $s$ | $\bar{x}$ | Me | $s$ | |
| Whole foot L [%] | 55.6 | 55.0 | 5.3 | 54.4 | 54.0 | 4.7 | 0.1327 |
| Whole foot R [%] | 44.4 | 45.0 | 5.3 | 45.6 | 46.0 | 4.7 | 0.1327 |
| **Forefoot pressure L [%]** | **53.8** | **53.0** | **10.1** | **50.8** | **50.0** | **9.3** | **0.0449*** |
| **Hindfoot pressure L [%]** | **46.2** | **47.0** | **10.1** | **49.2** | **50.0** | **9.3** | **0.0449*** |
| **Forefoot pressure R [%]** | **56.1** | **57.0** | **10.5** | **52.4** | **53.0** | **9.8** | **0.0181*** |
| **Hindfoot pressure R [%]** | **43.9** | **43.0** | **10.5** | **47.6** | **47.0** | **9.8** | **0.0181*** |

Next, applying the analysis of the Spearman's rank correlation, the influence of the BMI on the distribution of the plantar pressure in the static and dynamic test was tested. The analysis used both the raw values of the BMI and the corresponding centiles for the gender and the age as well as the normalised BMI values (BMI z-score). No statistically significant correlation was found between the BMI and the distribution of the plantar pressure in the static test. However, a weak correlation was found between the plantar pressure in the dynamic test and the BMI. It shows that the lateral pressure of the left foot increases to a slight extent together with the increase in the BMI value; this correlation is statistically significant, though its strength is small. The results of the analysis of the correlation are very similar, regardless of whether you consider raw BMI values or their reference to the norms.

**Tab. 6** Plantar pressure in a dynamic test in relation to the BMI

| **Dynamic test** | BMI | **BMI centile** | **BMI z-score** |
|---|---|---|---|
| Hindfoot pressure L [%] | 0.06 ($p = 0.4222$) | 0.05 ($p = 0.5267$) | 0.06 ($p = 0.4787$) |
| Hindfoot pressure R [%] | 0.07 ($p = 0.3617$) | 0.07 ($p = 0.3753$) | 0.06 ($p = 0.4644$) |
| **Lateral pressure L [%]** | **0.24 ($p = 0.0013$**)** | **0.25 ($p = 0.0010$**)** | **0.24 ($p = 0.0017$**)** |
| Paracentral pressure R [%] | 0.04 ($p = 0.6420$) | 0.10 ($p = 0.1866$) | 0.12 ($p = 0.1328$) |

In an analogous way to the case of the BMI, the correlation between the WHR and WHtR and the measures of the static and dynamic plantar pressures was tested. The distribution of plantar pressures in the static test did not show any statistically significant correlations with the WHR and WHtR. On the other hand, in the dynamic test, we could see statistically characteristic, but weak correlations between the values of the WHtR and the paracentral plantar pressure. Similarly to the case of BMI, the higher the WHtR, the bigger the lateral pressure in the left foot, however in the case of the right foot, together with the increase of the WHtR, the paracentral pressure rose.

**Tab. 7** Plantar pressure in a dynamic test in relation to the values of WHR and WHtR

| **Dynamic test** | **WHR** | **WHtR** |
|---|---|---|
| Hindfoot pressure L [%] | 0.02 ($p = 0.7892$) | 0.02 ($p = 0.7606$) |
| Hindfoot pressure R [%] | 0.00 ($p = 0.9984$) | 0.01 ($p = 0.8976$) |
| **Lateral pressure L [%]** | 0.04 ($p = 0.6464$) | **0.21 ($p = 0.0069$**)** |
| Paracentral pressure R [%] | 0.14 ($p = 0.0604$) | **0.15 ($p = 0.0520$)** |

We also tested, by means of the Spearman's rank correlation analysis, the relations between the body height of the children and the distribution of their plantar pressure. Additionally, the results with the division into genders of the tested people were considered. It turned out that there is a statistically characteristic correlation between the body height and the static pressure of the forefoot – it is higher in taller people; we should note, however, that this correlation occurred only in the group of boys.

**Tab. 8** Plantar pressure in a static test in relation to the body height and gender

| **Static test** | **Gender** | | |
|---|---|---|---|
| | **male** | **female** | **TOTAL** |
| | **Body height** | | |
| Whole foot L [%] | 0.06 ($p = 0.6073$) | -0.04 ($p = 0.7227$) | 0.02 ($p = 0.8114$) |
| **Forefoot pressure L [%]** | **0.39 ($p = 0.0005$***)** | 0.15 ($p = 0.1557$) | **0.26 ($p = 0.0004$***)** |
| **Forefoot pressure R [%]** | **0.27 ($p = 0.0156$*)** | 0.05 ($p = 0.5988$) | **0.15 ($p = 0.0467$*)** |

Due to a high probability of the age affecting the body height of the children, it is hard to say unambigously which of these factors decisively influences the increase in the forefoot pressure in the static test. No statistically significant correlation was found between the height and the plantar pressure in the dynamic test.

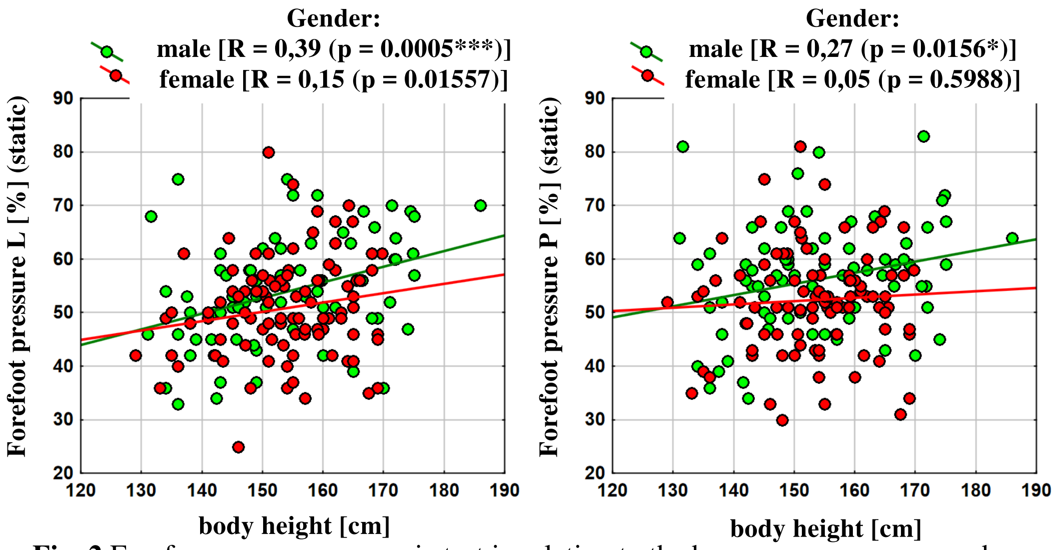


**Fig. 2** Forefoot pressure in a static test in relation to the body height and the gender

As the last one, the correlation between the measures of occurrence of particular somatotypes and the indices of plantar pressures in static and dynamic tests were examined. The analysis was made by means of the Spearman's rank correlation coefficients, considering each of the somatotype components separately. In the case of the static test, the only statistically characteristic correlations concerned the occurrence of the endomorphic build and the forefoot pressure. The bigger the share of the endomorphic type in the somatotype, the bigger the hindfoot pressure occurred (both for the right and for the left leg).

**Tab. 9** Plantar pressure in a static test in relation to the somatotype

| **Static test** | **Build: endomorphic** | **Build: mesomorphic** | **Build: ectomorphic** |
|---|---|---|---|
| Whole foot R [%] | 0.06 (*p* = 0.4429) | -0.08 (*p* = 0.2996) | 0.00 (*p* = 0.9901) |
| **Hindfoot pressure L [%]** | **0.13 (*p* = 0.0967)** | -0.01 (*p* = 0.8784) | -0.05 (*p* = 0.4756) |
| **Hindfoot pressure R [%]** | **0.15 (*p* = 0.0458*)** | 0.09 (*p* = 0.2474) | -0.11 (*p* = 0.1677) |

In the dynamic test, we noticed a statistically characteristic correlation between the paracentral pressure of the left foot and the kind of the somatotype. The higher the index of the endomorphic and mesomorphic build, with the lower the index of the ectomorphic build, the higher the lateral pressure of the left foot. The aforementioned relationships, despite their statistical significance, were characterized, however, with a relatively low strength.

**Tab. 10** Plantar pressure in a dynamic test in relation to the somatotype

| **Dynamic test** | **Build: endomorphic** | **Build: mesomorphic** | **Build: ectomorphic** |
|---|---|---|---|
| Hindfoot pressure L [%] | 0.10 (*p* = 0.2147) | 0.00 (*p* = 0.9647) | 0.00 (*p* = 0.9493) |
| Hindfoot pressure R [%] | 0.03 (*p* = 0.6626) | 0.05 (*p* = 0.4858) | -0.05 (*p* = 0.4935) |
| **Lateral pressure L [%]** | **0.20 (*p* = 0.0102*)** | **0.17 (*p* = 0.0221*)** | **-0.22 (*p* = 0.0040**)** |
| Paracentral pressure R [%] | 0.06 (*p* = 0.4587) | 0.07 (*p* = 0.3444) | -0.07 (*p* = 0.3343) |

## DISCUSSION

The static test showed a slight increase in the forefoot pressure together with the age and the height of the tested people and in the group of boys. Based on the anthropometric measurements in the test group, we could suspect that both the boys and the older children will be characterised by a bigger body mass than, respectively, the girls and the younger children. Thus, on the basis of the results of the study, we could risk a statement that a bigger body mass may predispose to a bigger forefoot pressure in the tested group. In the dynamic test, we also observed a certain disproportion in the foot pressure in the coronal plane. Older children loaded the paracentral part of the right foot more in the dynamic test; we also noticed a statistically significant correlation between the BMI and WHtR and the left foot pressure in the coronal plane. Together with the increase in the BMI and the WHtR, there was more pressure on the lateral part of the left foot. Considering the somatotype, the results of the study indicate a bigger static hindfoot pressure in the children with the predominance of the endomorphic component, so those with a more stout body build. These results do not go hand in hand with the previous correlations, indicating a bigger static forefoot pressure among older and bigger children and a higher value of the BMI or the WHtR. As the previous parameters might be strongly conditioned by the age of the tested people, it is worth conducting further, deeper studies, considering the relationships between the somatotype and the static plantar pressure. In the case of the dynamic test, the results of the study indicate a bigger lateral pressure of the left foot in children with a more stout body build (endo- and mesomorphic) in comparison with the children with a slender body build. These results are confirmed by previous analyses, considering the WHtR and the BMI.

In the source literature there are few works analysing the percentage distribution of pressures within the foot in the sagittal and the coronal planes. The vast majority of authors refer either to the average or to the peak values of the pressure in the foot as a whole or in its particular parts. The authors mostly confirm the existence of the correlation between the body mass and the distribution of plantar pressure. Some of the works, in order to verify this hypothesis, juxtapose the people whose BMI values indicate obesity with the control group; in others, the researchers compared the results of baropodometric tests in people with a normal weight who in a repeated test were carrying an additional external load in the form of a vest or backpack with weights.

The results of the research conducted by Dowling et al., among the children aged 7-9 with the BMI above the 95$^{th}$ percentile (established for the given age and gender), and the children with the BMI equal to the 50$^{th}$ percentile as a control group, showed significantly higher values of forefoot pressure on the surface among the obese children. [Downling 2001]. The authors suggest that the existence of excessive pressures of that type may lead to structural changes in the feet, especially in the case of children at puberty. That, in turn, may be the cause of a discomfort or pain within the feet or the lower limb joints, which can lead to the decrease in the physical activity of the children with an excessive body mass [Downling 2001, Riddiford-Harland et al. 2000]. Similar results were obtained by Britane and Tuna, in a tested group with the BMI indicating obesity, they observed higher values of forefoot pressure in a static test, however no statistically significant differences were found in the percentile distribution of the plantar pressure between the forefoot and the hindfoot [Britane, Tuna 2004]. Those results are partly confirmed by our own studies. Similar conclusions were reached by Teh et al.; the research conducted by them did not show any significant relationship between the gender and the plantar pressure; yet, they observed that with the growth of the BMI the maximum pressure in the hindfoot region decreases. The authors suspect that a higher pressure in the forefoot in the persons with an excessive body mass may result from the relocation of the body’s centre of gravity to the front. They also noticed a significant increase in the static plantar pressure of the foot as a whole and a higher dynamic paracentral pressure in the dynamic test of obese people; these results are reflected in the work of other authors [Teh et al. 2006]. Mickle et al., who conducted a dynamic study among kindergarten-age children observed also a higher pressure in the paracentral part of the metatarsus in obese children in comparison with their peers with a normal BMI. On the other hand, quite different results were found by Yan et al., after examining a group of 100 children aged 7-12. It turned out that among the children with the BMI above the 95$^{th}$ percentile, there is a higher pressure in the hindfoot in comparison with the control group [Yan et al. 2013]. In the works by other authors one can also notice significant correlations between the BMI and the values of pressure of the foot treated as a whole. Among the tested people with an excessive body mass, higher maximum pressures were noticed in the whole foot or its parts in comparison with the control group [Bianco et al. 2016, Gravante et al. 2003, Hills et al. 2001].

Another research methodology was adopted by Castro et al., who applied a dynamic test with and without an additional load, to 60 students whose BMI did not exceed 25kg/m2. In the second stage of the study, the students put on backpacks with a load adjusted in such a way that it gave the BMI equal to 30kg/m2; an essential increase in the parameters related to the plantar pressure was noticed in the test with an additional load [Castro et al. 2013]. Bolte et al., on the other hand, showed a significant decrease in the pressures in the metatarsus and forefoot areas in the people who took part in the weight-reduction programme, in comparison with the test before joining that programme [Bolte et al. 2000].

**CONCLUSIONS**

- There is a correlation between the features related to the mass, height and build of the body and the distribution of static plantar pressure in the sagittal plane.
- In the dynamic test, the aforementioned features are related to the distribution of plantar pressure in the coronal plane.
- It is worth conducting further, deeper studies concerning the relationships between the somatotype and the static plantar pressure with reference to the age of the tested people.

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