

# The foot's key structural variables as essential diagnostic predictors in assessing overall postural stability in school-aged children: a cross-sectional study

## *Zmienne strukturalne stopy jako istotne predyktory diagnostyczne w ocenie stabilności postawy u dzieci w wieku szkolnym: badanie przekrojowe*

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**Key words:** foot, baropodometric platform, children.

**Słowa kluczowe:** stopa, platforma baropodometryczna, dzieci.

### Abstract

**Introduction:** The WHO Health Behaviour in School-aged Children study (2018) on the health status of adolescents in Europe highlights an escalation of factors instrumental in the development of postural defects, which may consequently deteriorate into serious postural complaints in adulthood.

**Aim of the research:** To investigate the correlations between the morphological structure of the foot and postural stability in children and adolescents.

**Material and methods:** The study sample comprised 627 children (aged 10–15 years), who had the plantar part of their feet assessed in static conditions with a 2D Podoscan. Individual foot loading paradigm variables were assessed with a baropodometric platform. Postural assessment was completed with 2D Videography, facilitating morphological measurements of body asymmetry.

**Results:** Valgus of the knees, Clarke's left foot angle, and Wejsflog index values also doubled as strong predictors of centre of the foot's pressure (COP) length. A negative correlation was established between the COP length and obesity, hallux valgus of the left foot, flat-footedness, and lowered longitudinal foot arches.

**Conclusions:** Higher COP surface area values were observed in the children affected by valgus of the knees, higher angle of the hallux valgus in the left foot, and those with longer feet. Clarke's L-foot angle, Wejsflog index, and valgus of the knees proved to be strong predictors affecting key postural stability variables.

### Streszczenie

**Wprowadzenie:** Badanie WHO Health Behaviour in School-aged Children (2018) dotyczące stanu zdrowia nastolatków w Europie wskazuje na eskalację czynników przyczyniających się do rozwoju wad postawy, które mogą przeradzać się w poważne dolegliwości w wieku dorosłym.

**Cel pracy:** Zbadanie zależności między budową morfologiczną stopy a stabilnością postawy u dzieci i młodzieży.

**Materiał i metody:** W badaniu wzięło udział 627 dzieci (w wieku 10–15 lat), u których oceniano podeszwową część stóp w warunkach statycznych za pomocą podoskanu 2D. Poszczególne zmienne obciążenia stopy analizowano za pomocą platformy baropodometrycznej. Ocenę postawy uzupełniono wideografią 2D, ułatwiającą morfologiczne pomiary asymetrii ciała.

**Wyniki:** Koślawość kolan, kąt Clarke'a stopy lewej i wartości wskaźnika Wejsfloga to silne predyktory wpływające na długości COP. Stwierdzono ujemną korelację między długością COP a otyłością, paluchem koślawym lewej stopy, płaskostopiem i obniżonymi podłużnymi łukami stopy.

**Wnioski:** Wyższe wartości pola powierzchni COP zaobserwowano u dzieci z koślawością kolan, większym kątem palucha koślawego w stopie lewej oraz u dzieci z dłuższymi stopami. Kąt L-stopy Clarke'a, indeks Wejsfloga i koślawość kolan okazały się silnymi czynnikami prognostycznymi wpływającymi na kluczowe zmienne stabilności postawy.

## Introduction

A WHO Health Behaviour in School-aged Children collaborative cross-national study (2017/2018), comprising data on the health of adolescents in Europe, highlights an escalation of factors instrumental in the development of postural defects among children and adolescents [1]. In Europe, many children have been diagnosed with postural defects, located mostly in the spine, knees, and feet [1].

Overall support, locomotion, and cushioning make up the foot's key functions. The cushioning is facilitated by the "springs", i.e. the foot's longitudinal arches. Provided those arches are adequately developed structurally, they can effectively offset all the loads that naturally occur when walking and running [2–5].

Changes in the anatomical structure of the foot may prove detrimental to the entire bio-kinetic chain of the lower limbs, both in static and dynamic conditions [6]. Any structural irregularities appearing within the foot may adversely affect the actual mechanics of the joint and overall postural stability, and appreciably modify an individual foot-loading paradigm, whilst also affecting balance [7].

Numerous studies prove beyond a reasonable doubt that specific types of footwear may appreciably affect the actual development of the child's foot and its overall mechanics [8–10]. The vulnerable structure of a child's foot is susceptible to numerous environmental factors, which naturally enforces the need for footwear as an adequate everyday protection. Yet another factor identified as appreciably affecting both structural and functional changes in the child's foot is posed by excessive body weight. Numerous studies also highlight the correlation between congenital sensory deficits and individual postural paradigm [11].

Assessment of overall postural stability is based on the interpretation of graphic records of the centre of the foot's pressure (COP) sways. In static conditions, the COP record takes into account the inclination of the centre of gravity (COG), as well as the foot's pressure on the ground. A computerized, posturo-graphic platform may be used for this purpose in view of its objectivity [7]. The device commonly used in clinical practice, which is quite inexpensive and simple-to-apply, which may also prove convenient for the screen-

ing purposes, is a Podoscan. Whilst making routine use of it, we aimed to detect any foot abnormalities, as well as establish whether they affected the subjects' postural stability in any way.

The general scarcity of research reports on the impact of foot structure on overall postural stability among children and adolescents, in conjunction with an acknowledged need to gain an insight into those correlations, as which was also shown in the Authors' own preliminary research, prompted them to have this deficit addressed in some depth, predominantly through assessing and comparing the morphological features within the structure of the foot, with a view to establishing any potential correlations with individual postural stability.

## Aim of the research

The aim of the study was to investigate the correlations between the morphological structure of the foot and postural stability in children and adolescents.

## Material and methods

The study group consisted of 627 children, aged 10–15 years, including 299 (47.7%) girls and 328 (52.35%) boys (Table 1).

The assumptions of the study took into account the inclusion criteria, i.e. informed consent to attend the study protocol, complete documentation of the study, and no defects in the locomotor system. The exclusion criteria comprised a lack of informed consent to attend the study protocol, incomplete documentation of the study, and any defects in the locomotor system, as established through an interview.

A series of pertinent measurements were taken, i.e. individual body height was measured with the aid of a German-made SECA meter (93/42/EEC, 2007/47/EC), and body weight by Japanese-made Tanita BC-418MA scales (93/42/EEC Annex II). Assessment of the plantar part of the foot in static conditions was made with a 2D Podoscan. The plantar pressure of the foot exerted against the surface in static conditions was assessed with an Italian-made FreeMed platform, operated with FreeStep Pro software (FreeMed, Sensor Medica Italy, no. 10806). Postural assessment was completed with 2D Videography (Sensor Medica, Ita-

**Table 1.** Basic characteristics of the study group

Variable	Girls (n = 299) Mean ± SD	Min.–max.	Boys (n = 328) Mean ± SD	Min.–max.	Z	P-value
Body mass [kg]	43.86 ± 11.48	21–77	45.28 ± 13.21	23–99	–0.764	0.445
Height [cm]	151 ± 10	128–173	152 ± 12	126–183	–0.250	0.803
BMI	18.84 ± 3.35	11.35–29.32	19.24 ± 3.72	12.37–36.51	–1.008	0.314

Mean – arithmetic mean, SD – standard deviation, Z – statistical values of the Mann-Whitney-Wilcoxon test for 2 independent samples, BMI – body mass index, p – significance level.

ly), a device facilitating morphological measurements of body asymmetry.

The 2D FootCAD Podoscan is a computerized podoscope assessing the plantar part of the foot. The length, width, pertinent angles, and axes of the foot are determined, and the load-bearing zones of the foot are also subjected to interpretation [3, 8, 9].

The following indicators were assessed: foot length in millimetres, forefoot width in millimetres, Clarke's angle in degrees, Wejsflog (W) index, hallux valgus angle ( $\alpha$ ) in degrees, and the angle of the varus deformity of the fifth toe ( $\beta$ ) in degrees (Figure 1) [3, 12, 13].

The Clarke angle values were the basis for the assessment of the longitudinal arch of the foot. Hence, flat foot occurs in the range  $< 30^\circ$ , foot with a reduced arch  $31^\circ\text{--}41^\circ$ , properly arched foot  $42^\circ\text{--}54^\circ$ , and foot with a raised arch  $> 55^\circ$  [3, 12–14].

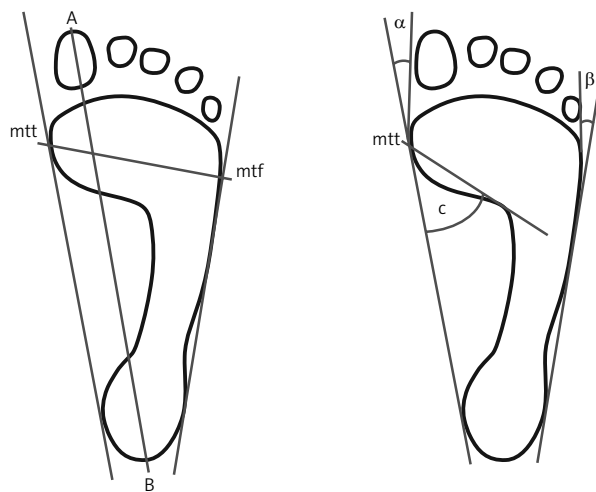
The Wejsflog index (foot length/width, ratio 3 : 1) was used to assess the transverse arch. The transversely flat rate is indicated by the values closer to "2", the values of the correct rate are closer to "3". The correct valgus angle ( $\alpha$ ) is up to  $9^\circ$  [3, 4].

A dynamometric platform (FreeMed, Sensor Medica, Italy), operated by FreeStep Pro software, was used for all stabilometric tests [3, 15]. The duration of the measurement was 30 s. The subject was in a free-standing position, with feet parallel, upper limbs hanging loosely along the trunk, eyes looking straight ahead.

The interpretation of the movement of the foot pressure centre (COP) was made during the assessment of the following indicators: length of sway – determines the length of the COP trajectory in mm – COP length; surface – surface area of the COP sway in  $\text{mm}^2$  – COP field area; mean X – mean value in mm of the COP trajectory in the X axis – COP X mean; mean Y – mean value in mm of the COP trajectory in the Y axis – COP Y mean; X axis – the range of COP movement in the X axis in mm in the mid-lateral direction of ML – COP X; Y axis – the range of COP movement in the Y axis in mm in the antero-posterior direction AP – COP Y [3, 13].

Currently, the most common method of assessing individual balance is COP signal measurement. In stabilometry, the most frequently analysed variables attesting to a correlation with deteriorated balance are the length of the COP trajectory, the actual size of the COP deflection area, the mean COP X and Y, and COP shifts in the X and Y axis [15].

2D Videography is yet another software package powering the FreeMed Posture (Sensor Medica, Italy) device applied in the study. It is a system dedicated to postural and gait assessment, fitted with a camera and a tripod. 2D Videography (Video Pack) makes it possible to take comprehensive morphological measurements of any possible body asymmetries. The readouts are subsequently processed by FreeStepPro software



**Figure 1.** The method of determining the foot variables under study

A–B – foot length, mtt–mtf – foot width, C – Clarke's angle,  $\alpha$  – hallux valgus angle,  $\beta$  – varus deformity of the 5<sup>th</sup> toe. Source: Own research [3]. "Feet deformities and their close association with postural stability deficits in children aged 10–15 years" by B. Szczepanowska-Wolowicz, P. Sztandera, I. Kotela, and M. Zak, 2019, *BMC Musculoskeletal Disorders*, 20: 537, p.3 (<https://doi.org/10.1186/s12891-019-2923-3>). Copyright 2019 by the BMC

(no. 10806), which automatically measures and compares possible asymmetries and pertinent angles.

The subjects' knee valgus was successfully assessed with the aid of 2D Videography.

### The Ethics Approval Statement

The study design and protocol were granted approval and duly endorsed by the Bioethics Review Committee, established in pursuance of pertinent statutory constraints at the Faculty of Medicine and Health Sciences, Jan Kochanowski University of Kielce, Poland, following rigorous appraisal of the investigators' application for ethics approval, completed on June 20, 2016 (Ethics Approval Ref. No. 26/2016).

### Statistical analysis

Statistical software R v.4.0.1 was used to process the data yielded throughout the study protocol. The arithmetic mean, standard deviation, Mann-Whitney-Wilcoxon test for 2 independent measurements, and the significance level were applied for the basic description.

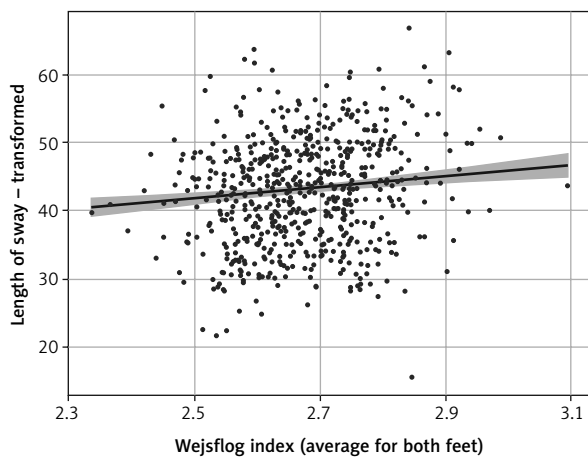
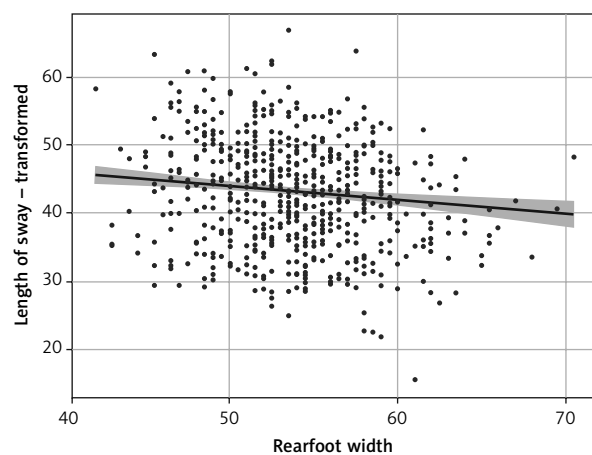
Morphological variables of the feet, i.e. hallux valgus angle, Clarke's angle, and Wejsflog index were taken into account, as well as the key somatic variables, i.e. age, sex, and body mass index (BMI).

With a view to checking the correlation between the stability indices and the above-referenced variables, linear regression models were applied. Dependent variables were subjected to a transformation. For

**Table 2.** Correlations between the COP length, the foot's morphological variables, and valgus of the knees

Dependent variable	Predictor	t-value	P-value
COP length	Valgus of the knees	2.94	0.003
	Obesity (BMI)	-3.00	0.003
	Hallux valgus angle $\alpha$ L	-2.48	0.013
	Clarke's angle L (flat foot and foot with a reduced arch)	-3.11	0.002
	Clarke's angle L (foot with a raised arch)	1.86	0.063
	Wejsflog index	4.14	< 0.001
	Foot width	-3.77	< 0.001

The model comprised the age variable ( $t = 1.75$ ,  $p = 0.08$ ). Model parameters: Adjusted  $R^2 = 62.3\%$ . Statistics  $F$  Snedecor-Fisher = 74.62 with number of degrees of freedom  $df_1 = 14$  and  $df_2 = 609$ ,  $p$ -val < 0.001. VIF (variance inflation factor) does not indicate any collinearity issues for all VIF predictors < 2.

**Figure 2.** The correlation between COP length and the Wejsflog index**Figure 3.** The correlation between COP length and the hindfoot width

the variables with positive values, Box-Cox transformation was used, whereas for the remaining variables, the Yeo-Johnson counterpart was used. All variables were selected using stepwise backward regression, based on Snedecor's  $F$  statistics.

In view of the risk of strong collinearity in the case of several variables, the mean values were prepared instead of considering the right and the left foot separately. The correlation coefficient for both feet was established to have oscillated above 0.75, which makes it possible to have both feet taken into consideration conjointly whilst making use of average values. The Wejsflog index and the forefoot, hindfoot, and foot length appeared in the model as an average for both feet.

## Results

A Box-Cox transformation ( $\lambda = 0.421$ ) was applied with a view to having the distribution of the explained variable transformed into a more Gaussian-like form. The following table presents the results of the modelling –  $t$ -value and  $p$ -value statistics.

A longer COP path is associated with the valgus of the knees and higher Wejsflog index. Also, for the Clarke's left foot angle, indicating a foot with a raised arch, a longer COP path is encountered. A negative correlation was established between the length of COP and obesity, hallux valgus of the left foot, flat-footedness, and lowered arches (Table 2, Figures 2, 3).

Regarding the regression model, where the explained variable was the COP area, it also proved expedient to have the Box-Cox transformation ( $\lambda = -0.099$ ) applied. It is worth noting that the model no longer boasts as much explaining force as the COP length. The COP area was not as strongly determined by the available variables, as taken into consideration in the model (adjusted  $R^2 = 13.9\%$ ).

Additionally, the variables such as age ( $t = -4.109$ ,  $p < 0.001$ ) and gender were incorporated into the model, where the reference category was gender = female ( $t = 3.161$ ,  $p = 0.002$ ).

When assessing the COP area, a significant correlation was noted between the subjects' age and gender. Their age ranged from 10 to 15 years, the COP

**Table 3.** Correlations between the COP surface area of the foot's morphological variables and valgus of the knees

Dependent variable	Predictor	t-value	P-value
COP surface area	Valgus of the knees	1.391	0.165
	Hallux valgus angle $\alpha$ L	1.535	0.125
	The fifth toe angle $\beta$ L	-1.762	0.079
	Foot length	1.719	0.086

**Table 4.** Correlations between the stability indicators comprised within the foot's morphological variables and valgus of the knees

Dependent variable	78,291 mm	t-value	P-value
COP mean X	Valgus of the knees	2.251	0.025
	Hallux valgus angle $\alpha$ L	-1.294	0.196
	Clarke's angle P (foot with a raised arch)	2.047	0.041
	Overweight (BMI)	-2.622	0.009
	Obesity (BMI)	1.870	0.062
COP mean Y	Hallux valgus angle $\alpha$ L	1.620	0.106
	Clarke's angle L (foot with a reduced arch)	3.240	0.001
	Clarke's angle L (foot with a raised arch)	-3.570	0.000
	Hindfoot width	-2.411	0.016

area was larger in younger children, and smaller in older ones. Differences in the COP area between girls and boys were also observed, i.e. in boys this area was notably larger.

Regarding postural and foot characteristics, higher COP surface area values were observed in the children affected by the valgus of the knees, with a higher angle of the hallux valgus in the left foot, and longer feet, whereas a smaller COP surface area was encountered in the individuals with a larger angle of the 5<sup>th</sup> toe of the left foot (Table 3).

In the model for the average X, the Yeo-Johnson transformation was applied ( $\lambda = 1.037$ ). The model for the average X, making use of the available variables, was characterised by a very low model adjustment value (adjusted  $R^2 = 6.98\%$ ).

Larger values of mean X were observed for the individuals with valgus of the knees and a foot with a raised arch (based on Clarke's angle), whereas the smaller values of mean X were associated with overweight subjects (Table 4).

Apart from the variables presented in the model below, there was also gender to be considered ( $p = 0.052$ ).

For the average Y value, the quality of model adjustment was higher (adjusted  $R^2 = 13.68\%$ ). In this case it also proved necessary to have the Yeo-Johnson transformation applied ( $\lambda = 0.870$ ).

As may be inferred from Table 3, higher average Y values appeared in the children with a lowered arch in the left foot (based on Clarke's angle). The lower

mean Y values were associated with the left foot with a higher arch and a narrower hindfoot.

The value of the X-axis following the Yeo-Johnson transformation was modelled ( $\lambda = -0.254$ ); model adjustment is expressed with the aid of the adjusted  $R^2 = 12.58\%$ .

The model demonstrated a statistically significant positive correlation between the X-axis and the valgus of the knees, and the Wejsflog index (Table 4). The model also comprised such variables as age ( $t = -3.638$ ,  $p < 0.001$ ) and male gender ( $t = 3.616$ ,  $p < 0.001$ ).

In the case of the model for the Y-axis, the Box-Cox transformation ( $\lambda = -0.228$ ) and adjusted  $R^2 = 14.88\%$  were applied.

Additionally, the model also comprised age ( $t = -4.714$ ,  $p < 0.001$ ), and male gender ( $t = 2.91$ ,  $p = 0.004$ ). This means that older children had lower Y-axis values, whereas the boys had higher Y-axis values (Table 5).

## Discussion

Approximately 90% of children are born with healthy feet, but with age they become affected by various factors, which account for a diversity of subsequent complaints, notably those of structural character. European studies indicate that only 3% of individuals over the age of 60 have structurally sound feet [16].

What happens to the delicate structure of the foot that results in so few adults with fully fit and functionally efficient feet? The fact that so few adults boast

**Table 5.** Correlations between the stability indicators comprised within the foot's morphological variables and valgus of the knees

Dependent variable	Predictor	t-value	P-value
COP X	Valgus of the knees	2.248	0.025
	Hallux valgus angle $\alpha$ L	2.497	0.013
	Wejsflog index	2.345	0.019
COP Y	Hallux valgus angle $\alpha$ L	2.069	0.039
	The fifth toe angle $\beta$ L	-1.644	0.101
	Foot length	2.043	0.042

functionally efficient feet nowadays is not only attributable to various ailments and physical injuries sustained throughout one's lifetime, but also to wearing ill-fitting footwear. Children are especially prone to be affected by many environmental factors in their adolescence, most of them of lifestyle origin [14, 16–18].

Our own research outcomes indicate that dysfunctions in any part of the lower limb also affect overall postural stability, especially the standing posture. This consequently places an extra burden on the neuromuscular system, whose basic function consists of stabilising the foot and maintaining overall balance control [19–21].

The results of our own research indicate that certain aspects of postural stability are affected by abnormalities in the lower extremities. Currently, the most common method of assessing individual balance is COP signal measurement. In stabilometry, the most frequently analysed variables proving association with deteriorated balance are the length of the COP trajectory, the area of the COP deflection area, the mean COP X and Y, and the COP shifts in the X and Y axis [15].

The positions of respective toes, especially the hallux and the 5<sup>th</sup> toe, should be considered in terms of the COP trajectory. Any deviation in the position of the hallux and the small toe are reflected in the postural stability variables. The angle  $\alpha$  of the left hallux valgus correlates with the length of COP, COP area, average COPX, average COPY, COP X, and COP Y. The angle of the small toe  $\beta$  correlates with the COP and COPY surface area. Any alteration in the positioning of those 2 is then bound to affect overall postural stability, apart from being statistically significant, as shown throughout the body of the authors' own research.

When taking due note of the above-referenced aspects, defective status of the lower limbs and its impact upon overall stability should also be considered. Brzeziński *et al.* [22], when examining 6992 children aged 8–12 years, encountered lower limb defects in 90.2% of the subjects, the boys being more frequently affected. Much like in our own research, age and male gender significantly affected postural stability vari-

ables. A significant predictive variable was the knee valgus, confirmed to affect the length of COP, COP surface area, mean COP X, and COP X. Apart from the COP surface area, this dependence was also deemed appreciably significant.

There are numerous studies corroborating the correlation between the foot arching and postural stability. An ostensibly trivial, painless problem of the lower longitudinal arches may account for an adverse knock-on effect on the physiological gait pattern, whereas prospectively it may cause pain in the peripheral joints and the spine. Clarke's angle is a reliable and commonly applied diagnostic tool in assessing podiatric disorders [23]. The select variables under study indicate that Clarke's angle is a prognostic variable for the COP path length, and mean COP X and Y axis. The Wejsflog index as the indicator also proved a strong predictor for the COP length, and the range of COP movement in the X-axis. Puszczalowska-Lizis and Ciosek [24], whilst examining the structure of feet in conjunction with the somatic features in pre-school children, highlighted a negative effect of body weight on the development of the foot's longitudinal arch among their subjects.

The present authors noticed the effect of sexual dimorphism on the differences in modelling the preferential character of the manipulative and stabilising functions of the lower limbs. In the study by Puszczalowska and Ciosek [24], the effect of gender and excessive body weight on the size of longitudinal and transverse arches was readily acknowledged. The correlation between the foot arches and overall postural stability in young adults and elderly persons was observed by Kim *et al.* [25], i.e. a greater difference in COP sways between the flatfooted individuals and those with the properly arched feet.

Also, Tahmasebi *et al.* [26] and Chao and Jiang [27] reported deterioration in overall stability in individuals presenting with lowered longitudinal arches. The effect of reduced mobility of the foot arch on postural control and COP sways was also observed by Birinci and Demirbas [28], and Mun *et al.* [4], Wilczyński and Paprocki [29]. Based on the results of our own research, it was established that the knee valgus,

Clarke's angle, and Wejsflog's index affected the variables of postural stability, also being strong predictors of COP length ( $R^2 = 62.3\%$ ).

Interesting conclusions may be drawn from assessing the effect of BMI on postural stability variables, although this invariably calls for separate studies. Negative correlation was noticed between COP length and obesity, mean COP X, and overweight, and a positive correlation between mean COP X and obesity.

The effect of foot structure on overall postural balance among adults has been addressed by numerous investigators [30], although a manifest deficit of such investigative effort is reported with regard to children and adolescents. When assessing the morphological structure of the foot, account must be taken of its correlation with overall postural stability. The results of our own research gave us sufficient grounds to venture the following conclusion: abnormalities in the morphological structure of the foot affect the variables of overall postural stability among children and adolescents. The morphological variables of the feet, as distinguished following linear regression analysis, effectively justify the selection of postural stability variables under study.

The conclusion took into account the characteristics of the anatomical structure of the feet for which the model variables turned out to be of the highest values. It is our assumption, therefore, that the strongest predictors affecting the length of COP are the valgus of the knees, L toe angle and L Clarke's angle, and Wejsflog index ( $R^2 = 62.3\%$ ). It may then be inferred that the left limb, which boasts a stabilising function, affects overall stabilisation of the standing position, as opposed to the right one.

Whilst acknowledging the strong effect of abnormal morphological structure of the feet on overall postural stability, the consequences of which may be distant but capable of adversely affecting the entire biokinetic chain, we have been looking for specific solutions that would facilitate reliable and accurate assessment of morphological variables of the foot among children and adolescents. To the best of our knowledge, ours is the first study to highlight the overall significance of abnormalities in the morphological structure of feet and their effect on overall postural stability among children.

A Podoscan., an assessment instrument frequently used in routine clinical practice, may easily be applied in the screening tests. Any abnormalities detected at this point should then be subject to further, more accurate diagnostic procedures. Bearing in mind the likely subsequent costs of treating the resultant complaints located in the musculoskeletal system, it seems expedient to have specifically structured prevention measures put in place to facilitate their early detection.

Our quest was therefore focused predominantly on looking for simple, objective, non-invasive, cost-effective, yet reliable solutions, which, when applied in clinical practice, would immediately draw attention to any abnormalities encountered in the feet and their crucial correlation with overall postural stability. Encouraging results clearly indicate that taking adequate interest in the overall functionality of the feet, especially throughout adolescence, has become a generally acknowledged necessity.

The appreciable effect of consistently pursuing a target-oriented, physiotherapeutic management, specifically aimed at improving an individual sense of balance in various disorders, is already well addressed and documented in numerous studies [31–34].

Ensuring the appropriate conditions for the structural development of the feet and educating children and adolescents on how to move about safely may contribute to minimising the need for subsequent remedial/therapeutic management.

It proved unfeasible to have a group of individuals actively involved in sports effectively identified within the study population. Otherwise, comparison of the respective results/variables under study conclusively highlighted the adverse effects of physical inactivity. Also, there was no possibility to have the study population stratified by specific age-ranges, so the study outcomes may not fully reflect the key characteristics of respective age groups, owing to the small sample sizes.

Initially, we had assumed that all footwear worn by the study subjects was adequately selected and well-fitting. As we progressed through the study protocol, however, we had to concede we were confronted with an altogether different situation, as numerous subjects tended to wear either too tight or far too loose-fitting footwear.

## Conclusions

Clarke's L-foot angle, the Wejsflog index, and valgus of the knees are strong predictors established to affect postural stability variables. The position of the hallux and the small toe is a predictive variable affecting postural stability variables. Making use of an assessment of the key structural variables of the feet and overall postural stability in school-aged children during common rehab practice helps draw attention to the issue and take appropriate and timely preventive measures, with a view to precluding adverse consequences directly resulting from functional disorders of the feet, which are likely to jeopardise postural stability in later life. Determining unequivocally the existing correlations between the key morphological variables of the feet and postural stability may well become instrumental in the development of an effective, target-oriented physical rehabilitation pro-

gramme for school-aged children affected by various deformities and dysfunctions of the feet.

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### Conflict of interest

The authors declare no conflict of interest.

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