

## Relations between morphological features of feet in elderly people

### *Związki między cechami morfologicznymi stóp u osób w wieku geriatrycznym*

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**Key words:** ageing, healthiness, podoscopic examination.

**Słowa kluczowe:** starzenie się, zdrowotność, badanie podoskopowe.

#### Abstract

**Introduction:** Human foot make up the functional whole, thus changes in one of them may contribute to activating individual compensating mechanisms leading to disorders in the shape of the remaining segments and dysfunctions and consequently to complications in other elements of the motor system.

**Aim of the research:** Analyze correlations between characteristics of feet structure in women and men over 60.

**Material and methods:** The research conducted by podoscopic method involved seniors from the Podkarpackie and the Małopolskie voivodeships, including 116 females and 82 males. Tested persons were divided into three age groups (60–69 years, 70–79 years, 80–90 years). The following indices were analyzed: the Clarke's angle, Wejsflog's index ( $W_{wp}$ ), heel angle ( $\gamma$ ), hallux valgus angle ( $\alpha$ ), and the V toe varus deformity angle ( $\beta$ ). In order to evaluate the correlations between characteristics of feet structure the Spearman's rank correlation was employed.

**Results:** We observed a statistically significant correlations of the hallux valgus angle and Clarke's angle as well as between the V toe varus deformity angle with the Wejsflog's index and the heel angle in the absence of statistically significant associations between V toe varus deformity angle and Clarke's angle.

**Conclusions:** Changes in different parts of the foot that result from involution processes increasingly interact with one another in the elderly age. Prevention of foot deformities and dysfunctions should focus primarily on maintaining or restoring the capacity of foot muscles, improving proprioception and proper selection of footwear, which should not distort the shape and function of the frontal foot segments.

#### Streszczenie

**Wprowadzenie:** Stopa ludzka stanowi funkcjonalną całość, dlatego zmiany w jednym z segmentów mogą stanowić przyczynę uruchomienia zmiennych osobniczo mechanizmów kompensacyjnych, prowadząc do zaburzeń w ukształtowaniu pozostałych segmentów i dysfunkcji, a w konsekwencji również powikłań w obrębie innych elementów narządu ruchu.

**Cel pracy:** Analiza związków pomiędzy cechami stóp u kobiet i mężczyzn po 60. roku życia.

**Materiał i metody:** Badaniami metodą podoskopową objęto seniorów z województwa podkarpackiego i małopolskiego, w tym 116 kobiet i 82 mężczyzn. Badanych kwalifikowano do 3 przedziałów wieku: 60–69 lat, 70–79 lat, 80–90 lat. W analizach uwzględniono następujące wskaźniki: kąt Clarke'a, wskaźnik  $W_{wp}$  Wejsfloga, kąt piętowy ( $\gamma$ ), kąt koślawości palucha ( $\alpha$ ), kąt szpotawości V palca ( $\beta$ ). Do oceny związków między cechami budowy stóp zastosowano korelację rang Spearmana.

**Wyniki:** Stwierdzono statystycznie istotne związki między kątem koślawości palucha ( $\alpha$ ) a kątem Clarke'a oraz między kątem szpotawości V palca a wskaźnikiem  $W_{wp}$  Wejsfloga i kątem piętowym wobec braku statystycznie istotnych związków kąta szpotawości V palca z kątem Clarke'a.

**Wnioski:** W wieku podeszłym na skutek procesów inwolucyjnych zmiany w poszczególnych częściach stopy coraz silniej na siebie oddziałują. W działaniach zapobiegających zniekształceniom i dysfunkcjom stóp należy zwrócić szczególną uwagę na utrzymanie lub przywracanie wydolności mięśni działających na stopę, poprawę propriocepcji oraz właściwy dobór obuwia, które nie powinno zaburzać kształtu i funkcji przednich segmentów stopy.

## Introduction

Human foot is a static and dynamic part of the motor organ. Appropriate design ensures keeping the body weight, while being capable to adapt to changes of the ground and movement. That specific structure is built-up by a system of longitudinal and transverse arches, which are compared to coil springs stretching under the influence of the load and returning to their initial state during the burden [1]. In terms of proper functioning of the foot, toes play a very significant role. Their proper arrangement enables effective functioning of other segments of the foot. While loading they adhere to the surface and during locomotion, their strong adherence relieves heads of the proper metatarsus bones [2]. The anterior ball of the metatarsophalangeal articulations on one hand is related to the anterior part of “the posterior static triangle of the foot”, and on the other hand, the posterior part of “the anterior dynamic triangle of the foot”. That spot is the focus point of all impulses propelling the gait. The first radius and the great toe play a significant role in it, particularly in the view of the fact that radius is activated in the final part of terminal stance [3]. The foot, despite elaborate construction, make up a functional whole, thus changes in one of them may contribute to activating individual compensating mechanisms leading to disorders in shape of the remaining segments and dysfunctions, and consequently, to complications in other elements of the motor system [2–4]. The foot architecture is a picture of the skeletal, musculo-ligament system and possible ongoing pathological processes within other systems or organs. Static-dynamic foot failure occurs in the elderly people due to involution changes. The weakening of the skeletal, muscle, and ligament systems increases the incidence of deformations [5, 6]. Problems within the feet are linked to deteriorated stability, falls, and decrease in gait speed [7]. Menz *et al.* [8] highlighted the impact of foot flexors strength on the balance in people aged 62–96 years. Menz *et al.* [9] observed that people experiencing falls were characterized by diminished flexibility within the ankle joints, decreased strength of plantar flexors, deformities of hallux valgus, and decreased sensitivity to touch of the plantar foot surface. Presented facts became a direct reason to take-up the topic of the paper, which is aimed to analyze the relationships between the features of the feet in men and women over 60 years of age.

Research questions:

1. What are the connections of the great toe setting and the fifth toe position with longitudinal foot arch in women and men over 60?
2. What are the connections of the great toe setting and the fifth toe position with transverse foot arch in women and men over 60?

3. What are the correlations between the hallux valgus angle and the V toe varus deformity angle in women and men over 60?

## Material and methods

The examinations involved 198 seniors from the Podkarpackie and the Małopolskie voivodeships, including 116 females and 82 males. The inclusion criteria were: age in the range 60–90 years, dominating right hand and right leg determined on the basis of the Waterloo Handedness and Footedness Questionnaire – revised [10], physical fitness that allowed for walking without orthopedic equipment, and ability to take independently a standing position on a podoscop, a written consent to participate in the study.

Three age groups were distinguished. Thirty-eight women (average age,  $\bar{x} = 64.53 \pm 3.11$  years) and 31 men (average age,  $\bar{x} = 65.29 \pm 3.15$  years) were enrolled in the group 60–69. The group 70–79 consisted of 35 women (average age,  $\bar{x} = 75.13 \pm 3.45$  years) and 28 men (average age,  $\bar{x} = 73.89 \pm 2.70$  years), while the group of 80–90 years included 43 women (average age,  $\bar{x} = 85.47 \pm 3.38$  years) and 23 men (average age,  $\bar{x} = 84.96 \pm 3.97$  years).

The research tool was a podoscop (CQ-ST Electronic System). The calculations included following indices: the Clarke’s angle, Wejsflog’s index ( $W_{wp}$ ), heel angle ( $\gamma$ ), hallux valgus angle ( $\alpha$ ), and the V toe varus deformity angle ( $\beta$ ). Anthropometric measurements of the body mass and height were obtained, and the data was used to calculate BMI index. Basic descriptive statistics of the somatic features in the examined seniors is presented Table 1.

The study was granted a permission by the Ethical Review Board of the Rzeszow University. In order to preserve the integrity of the research process, all the measurements were carried out in a gym, in the morning, using the same measuring instruments operated by the authors. Seniors were wearing gymnastic costumes without shoes, after receiving detailed information concerning the aim and methodology used in the study.

Based on the gathered data, the following descriptive statistics were calculated: arithmetical mean values ( $\bar{x}$ ), standard deviations (SD), medians (Me). The normalcy of distribution of particular characteristics was verified by means of the Shapiro-Wilk test. In order to evaluate the correlations between characteristics of feet structure, the Spearman’s rank correlation was employed. Results were considered statistically significant if the probability level of the test was lower than the predetermined level  $\alpha = 0.05$ . In this paper, the STATISTICA StatSoft 10.0 was used to process statistical test results.

## Results

Table 2 presents the basic descriptive statistics of the parameters of feet structure in examined seniors.

**Table 1.** Descriptive statistics of the somatic features in the examined persons

Age [years]	Women			Men		
	$\bar{x} \pm SD$	Me	max-min	$\bar{x} \pm SD$	Me	max-min
	Body weight [kg]					
60–69	73.81 $\pm$ 15.48	75.00	105.80–40.00	81.47 $\pm$ 11.39	80.00	108.00–63.30
70–79	70.72 $\pm$ 16.29	70.00	115.00–45.00	79.41 $\pm$ 12.54	79.00	110.90–58.00
80–90	61.85 $\pm$ 12.69	59.50	96.10–38.00	77.56 $\pm$ 13.49	78.00	114.50–57.40
	Body height [cm]					
60–69	160.37 $\pm$ 7.51	162.00	172.00–135.00	171.13 $\pm$ 6.02	171.00	185.00–162.00
70–79	157.00 $\pm$ 8.64	158.00	171.00–135.00	168.68 $\pm$ 6.88	169.50	181.00–153.00
80–90	153.67 $\pm$ 8.01	153.00	177.00–138.00	168.17 $\pm$ 4.41	167.00	178.00–161.00
	BMI index					
60–69	28.52 $\pm$ 5.58	27.96	42.46–17.30	27.73 $\pm$ 3.58	27.31	37.37–20.48
70–79	28.65 $\pm$ 5.55	28.33	40.30–18.97	27.90 $\pm$ 3.76	27.62	35.40–20.20
80–90	26.68 $\pm$ 6.80	24.05	47.66–17.99	27.33 $\pm$ 4.03	27.00	36.14–20.24

In women qualified for the group 70–79 and 80–90, statistically significant negative relationships between  $\alpha$  angle and Clarke's angle was found, which means that the increase of the hallux valgus angle was accompanied by lowering of the longitudinal foot arch.

In women aged 70–79 and 80–90, negative correlations between  $\alpha$  angle and the Wejsflog's index of the right and the left foot were found. Statistically significant positive correlation between the hallux valgus angle and the heel angle of the right foot was reported in women aged 80–90.

In case of women aged 60–69 and 80–90, average correlations of the angle of the V toe varus deformity with the Wejsflog's index were reported. In individual groups of women, connections between  $\beta$  and  $\gamma$  angle in the left foot were found. The direction of this relationships indicates that the worse position of the fifth toe coexist with a forefoot widening (Table 3).

In men qualified for the group 70–79, a statistically significant negative correlation between hallux valgus angle and Clarke's angle of the left foot was presented. A strong negative correlation was reported between  $\alpha$  angle and the Wejsflog's index of the right foot, and average positive correlations between  $\alpha$  angle and the heel angle of the right and the left foot in men aged 60–69 were found. The direction of this relationships indicates that the lower transverse arch coincides with more significant hallux valgus.

In case of men aged 60–69 and 70–79, the V toe varus deformity angle in the left foot had weak positive correlations with the heel angle. In men aged 70–79, a positive correlation between the V toe varus deformity angle and the heel angle in the right foot was also found. The direction of this connections in-

dicates that the lower values of  $\beta$  angle coexist with a higher transverse arch. Additionally, men aged 70–79 showed a negative correlation between the angle of the V toe varus deformity and the Wejsflog's index of the right foot (Table 4).

## Discussion

The issues related to the foot were discussed numerously, but few studies presented the correlations between feet construction features. The research by Demczuk-Włodarczyk [2] covering a group of 1,619 children and youth from Wrocław, showed that despite the coexistence of the flat transverse and longitudinal foot, these defects are formed independently in the initial period. Nadolska-Ćwikła [11] in her study of the Polish female wrestler team and Trzcińska *et al.* [12] in the study of the students of physical education at the University of Physical Education in Warsaw observed that disturbances in longitudinal arch do not show correlation with the changes in the forefoot. Our analysis of the correlations of Clarke's angle with the Wejsflog's index and the heel angle in the elderly also indicates that these features are not related to each other. Therefore, it can be concluded that irrespective of the age, the changes in the longitudinal and transverse arch are independent of each other.

The relationships between the longitudinal arch and the great toe setting was investigated by Łuczak *et al.* [13]. In 191 people aged 22–80 years, a connection between hallux valgus and the lowered foot arch or the flat foot was found. Buchanan and Davis [14] on the basis of the research carried out in women and men aged  $34.0 \pm 11.2$  found statistically signifi-

**Table 2.** Descriptive statistics of the characteristics of feet structure in the examined persons

Age [years]	Women			Men		
	$\bar{x} \pm SD$	Me	max-min	$\bar{x} \pm SD$	Me	max-min
Clarke's angle of the right foot [°]						
60–69	31.92 ±9.63	33.50	48.00–10.00	36.64 ±7.09	39.00	47.00–17.00
70–79	27.43 ±11.43	27.00	49.00–10.00	35.21 ±8.02	39.00	46.00–15.00
80–90	26.42 ±9.36	29.00	40.00–5.00	35.48 ±7.67	38.00	48.00–19.00
Clarke's angle of the left foot [°]						
60–69	31.26 ±9.56	30.50	48.00–11.00	35.93 ±7.09	38.00	49.00–16.00
70–79	26.86 ±10.06	26.00	42.00–7.00	34.89 ±7.24	39.00	42.00–18.00
80–90	24.91 ±8.60	26.00	40.00–8.00	33.96 ±6.77	35.00	45.00–18.00
Wejsflog index ( $W_{wp}$ ) of the right foot						
60–69	2.52 ±0.17	2.53	2.91–2.21	2.59 ±0.13	2.60	2.85–2.36
70–79	2.48 ±0.15	2.49	2.78–2.13	2.58 ±0.15	2.60	2.79–2.33
80–90	2.53 ±0.17	2.51	2.88–2.04	2.59 ±0.12	2.61	2.78–2.32
Wejsflog index ( $W_{wp}$ ) of the left foot [°]						
60–69	2.52 ±0.14	2.53	2.86–2.25	2.62 ±0.15	2.59	2.94–2.35
70–79	2.50 ±0.16	2.53	2.78–2.18	2.62 ±0.16	2.61	2.94–2.35
80–90	2.53 ±0.16	2.57	2.81–2.04	2.61 ±0.11	2.59	2.84–2.40
Heel angle ( $\gamma$ ) of the right foot [°]						
60–69	17.03 ±3.05	17.00	23.00–10.00	15.93 ±2.13	17.00	20.00–11.00
70–79	16.83 ±2.08	17.00	20.00–12.00	16.64 ±2.86	17.00	23.00–11.00
80–90	15.51 ±2.27	15.00	20.00–10.00	15.74 ±2.14	15.00	20.00–13.00
Heel angle ( $\gamma$ ) of the left foot [°]						
60–69	16.66 ±2.53	16.50	22.00–12.00	16.26 ±1.97	16.00	20.00–12.00
70–79	17.28 ±1.99	17.00	20.00–10.00	16.53 ±2.33	17.00	22.00–12.00
80–90	15.63 ±2.13	15.00	20.00–11.00	15.83 ±2.57	15.00	21.00–12.00
Hallux valgus angle ( $\alpha$ ) of the right foot [°]						
60–69	11.08 ±7.18	10.50	29.00–0.00	11.22 ±7.67	10.00	35.00–0.00
70–79	16.26 ±10.28	14.00	44.00–0.00	10.11 ±4.84	10.00	21.00–0.00
80–90	15.49 ±9.12	14.00	40.00–0.00	9.30 ±7.50	8.00	33.00–0.00
Hallux valgus angle ( $\alpha$ ) of the left foot [°]						
60–69	11.26 ±6.30	10.00	30.00–0.00	11.84 ±8.23	12.00	34.00–0.00
70–79	19.46 ±10.97	20.00	45.00–0.00	11.03 ±6.82	9.00	27.00–0.00
80–90	16.21 ±9.63	17.00	45.00–0.00	9.52 ±8.29	8.00	32.00–0.00
The V toe varus deformity angle ( $\beta$ ) of the right foot [°]						
60–69	16.63 ±5.82	18.00	27.00–0.00	15.90 ±4.32	15.00	25.00–7.00
70–79	17.66 ±5.25	17.00	27.00–7.00	17.71 ±5.69	16.00	28.00–8.00
80–90	18.44 ±6.74	19.00	32.00–6.00	19.30 ±6.33	19.00	28.00–3.00
The V toe varus deformity angle ( $\beta$ ) of the left foot [°]						
60–69	15.13 ±6.50	16.00	28.00–0.00	16.13 ±6.32	17.00	24.00–0.00
70–79	15.94 ±5.72	15.00	28.00–0.00	16.21 ±6.34	15.00	27.00–0.00
80–90	17.79 ±5.68	18.00	35.00–9.00	18.17 ±5.65	18.00	27.00–5.00

**Table 3.** The coefficient values of Spearman's rank correlation between parameters of feet structure in singled out groups of women

Pair of variables	Women aged 60–69 (n = 38)			Women aged 70–79 (n = 35)			Women aged 80–90 (n = 43)		
	R	t	p	R	t	p	R	t	p
Clarke's angle & W <sub>wp</sub> index (rf)	0.15	0.92	0.363	0.18	1.08	0.288	0.09	0.59	0.558
Clarke's angle & W <sub>wp</sub> index (lf)	0.10	0.63	0.534	0.33	2.02	0.052	0.11	0.72	0.473
Clarke's angle & $\gamma$ angle (rf)	0.03	0.19	0.846	0.13	0.68	0.502	-0.11	-0.71	0.479
Clarke's angle & $\gamma$ angle (lf)	0.25	1.56	0.128	0.23	1.36	0.182	-0.10	-0.62	0.538
W <sub>wp</sub> index & $\gamma$ angle (rf)	-0.54	-3.91	0.000*	-0.63	-4.68	0.000*	-0.67	-5.73	0.000*
W <sub>wp</sub> index & $\gamma$ angle (lf)	-0.61	-4.68	0.000*	-0.40	-2.49	0.018*	-0.56	-4.32	0.000*
$\alpha$ angle & Clarke's angle (rf)	-0.21	-1.28	0.208	-0.39	-2.42	0.021*	-0.15	-0.97	0.336
$\alpha$ angle & Clarke's angle (lf)	-0.01	-0.01	0.989	-0.54	-3.72	0.001*	-0.31	-2.10	0.042*
$\beta$ angle & Clarke's angle (rf)	-0.11	-0.67	0.506	0.11	0.66	0.510	0.17	1.12	0.271
$\beta$ angle & Clarke's angle (lf)	0.12	0.75	0.457	0.10	0.60	0.551	0.06	0.40	0.692
$\alpha$ angle & W <sub>wp</sub> index (rf)	-0.20	-1.23	0.226	-0.59	-4.20	0.000*	-0.43	-3.06	0.004*
$\alpha$ angle & W <sub>wp</sub> index (lf)	-0.19	-1.15	0.256	-0.60	-4.20	0.000*	-0.39	-2.73	0.009*
$\alpha$ angle & $\gamma$ angle (rf)	0.01	0.02	0.986	0.12	0.69	0.492	0.35	2.40	0.021*
$\alpha$ angle & $\gamma$ angle (lf)	0.01	0.09	0.932	0.11	0.62	0.537	0.17	1.11	0.275
$\beta$ angle & W <sub>wp</sub> index (rf)	-0.48	-3.29	0.002*	0.07	0.41	0.682	-0.36	-2.52	0.016*
$\beta$ angle & W <sub>wp</sub> index (lf)	-0.36	-2.34	0.025*	-0.02	-0.13	0.900	-0.36	-2.47	0.018*
$\beta$ angle & $\gamma$ angle (rf)	0.30	1.92	0.062	0.28	1.71	0.096	0.13	0.85	0.399
$\beta$ angle & $\gamma$ angle (lf)	0.50	3.44	0.001*	0.55	3.83	0.000*	0.34	2.30	0.027*
$\alpha$ angle & $\beta$ angle (rf)	-0.17	-1.01	0.319	-0.21	-1.26	0.218	0.27	1.80	0.079
$\alpha$ angle & $\beta$ angle (lf)	-0.26	-1.63	0.112	-0.26	-1.58	0.124	0.10	0.66	0.514

\* $p < 0.05$ 

rf – right foot; lf – left foot

cant relationships between the setting of the great toe and the V toe and the position of the navicular bone. Also, Janchai *et al.* [15] analyzed the results of 213 Bangkok residents aged 60–80 years, and Gollightly *et al.* [16] in the study including over 1,502 people with an average age of 68, reported correlations of the hallux valgus angle with the Clarke's angle. In our study within women and men aged 60–69, there was no correlation between the setting of the great toe and the longitudinal arch of the foot, while in the case of persons in the age group of 70–79 and 80–90, correlations between these features were observed. This points to the fact that over the years, involution causes symptoms in the foot bones, deficiencies in the muscles and ligaments (which sustain its individual segments) changes in these parts of the foot increasingly, leading to a buildup of ail-

ments and persistent deficiencies in the anatomical structure of the foot. Lack of correlations between the setting of the fifth toe and the Clarke's angle is probably due to the fact that static arch on the lateral side of the foot takes the load without significant influence on the longitudinal dynamic arch located on the medial side of the foot.

The aim of the study was to analyze the correlation between the transverse arch with other features of the feet. We assumed that since the foot lifts and carries the weight of the entire body and provides mechanical conditions for maintaining balance, the forefoot has also the impact on its performance. Therefore, it seems that longitudinal arch, often regarded as the indicator of "foot health", should not be a single diagnostic criterion in this regard. Wejsflog's index is the commonly used indicator to assess

**Table 4.** The coefficient values of Spearman's rank correlation between parameters of feet structure in singled out groups of men

Pair of variables	Men aged 60–69 (n = 31)			Men aged 70–79 (n = 28)			Men aged 80–90 (n = 23)		
	R	t	p	R	t	p	R	t	p
Clarke's angle & $W_{wp}$ index (rf)	0.18	0.96	0.342	0.02	0.11	0.911	0.11	0.49	0.628
Clarke's angle & $W_{wp}$ index (lf)	0.10	0.54	0.591	0.12	0.62	0.540	0.11	0.50	0.620
Clarke's angle & $\gamma$ angle (rf)	0.10	0.53	0.601	0.11	0.58	0.567	0.11	0.52	0.606
Clarke's angle & $\gamma$ angle (lf)	0.18	0.97	0.339	0.06	0.33	0.740	0.14	0.67	0.509
$W_{wp}$ index & $\gamma$ angle (rf)	-0.72	-5.56	0.000*	-0.73	-5.39	0.000*	-0.46	-2.38	0.027*
$W_{wp}$ index & $\gamma$ angle (lf)	-0.51	-3.16	0.004*	-0.66	-4.45	0.000*	-0.67	-4.14	0.000*
$\alpha$ angle & Clarke's angle (rf)	0.01	0.32	0.754	-0.26	-1.40	0.173	-0.34	-1.65	0.114
$\alpha$ angle & Clarke's angle (lf)	0.19	1.03	0.312	-0.40	-2.09	0.046*	-0.27	1.27	0.217
$\beta$ angle & Clarke's angle (rf)	0.15	0.81	0.425	0.19	0.98	0.337	-0.09	-0.41	0.687
$\beta$ angle & Clarke's angle (lf)	0.18	0.97	0.339	0.05	0.24	0.811	0.19	0.89	0.385
$\alpha$ angle & $W_{wp}$ index (rf)	-0.50	-3.09	0.004*	-0.01	-0.06	0.952	-0.36	-1.79	0.087
$\alpha$ angle & $W_{wp}$ index (lf)	-0.18	-0.99	0.332	-0.21	-1.09	0.286	-0.34	-1.65	0.113
$\alpha$ angle & $\gamma$ angle (rf)	0.46	2.78	0.009*	-0.37	-2.03	0.052	0.09	0.42	0.680
$\alpha$ angle & $\gamma$ angle (lf)	0.38	2.21	0.035*	-0.25	-1.31	0.201	0.23	1.10	0.285
$\beta$ angle & $W_{wp}$ index (rf)	0.06	0.34	0.738	-0.46	-2.67	0.013*	-0.17	-0.79	0.436
$\beta$ angle & $W_{wp}$ index (lf)	-0.32	-1.86	0.074	-0.24	-1.29	0.207	-0.21	-1.01	0.325
$\beta$ angle & $\gamma$ angle (rf)	0.10	0.55	0.587	0.54	3.30	0.002*	0.29	1.37	0.185
$\beta$ angle & $\gamma$ angle (lf)	0.40	2.34	0.026*	0.40	2.18	0.038*	0.33	1.58	0.128
$\alpha$ angle & $\beta$ angle (rf)	-0.23	-1.26	0.216	-0.32	-1.70	0.101	-0.25	-1.17	0.257
$\alpha$ angle & $\beta$ angle (lf)	0.07	0.36	0.723	-0.34	-1.84	0.077	0.10	0.47	0.645

\* $p < 0.05$ 

rf – right foot, lf – left foot

the transverse arch of the foot. Also, the heel angle increases as the transverse arch of the foot flattens. According to some authors [17, 18], it is a measure of the transverse arch of the foot. Other authors argue that the heel angle is useful to evaluate the slenderness of the foot [19] or the heel setting [20]. This fact can be attributed to the different ways of determining these indicators. The Wejsflog's index takes into account the width of the forefoot and the length of the foot, while the heel angle is included between the lateral and medial tangent, and takes into account the width of both the forefoot and hindfoot; thus, uniform loading of front and rear support zone may decrease its value. Our studies have shown that these characteristics are correlated. Demczuk-Włodarczyk [2] on the basis of the tests of children and adolescents' feet found that abnormal adhe-

sion of toes to the substrate occurs independently of the transverse architecture of foot. Our research show that the angle of the V toe varus deformity correlates with transverse foot arch in elderly men and women. The direction of the correlation indicated that the higher values of the  $\beta$  angle is accompanied by a widening of the forefoot. Hallux valgus angle and the angle of the V toe varus deformity do not show any correlations.

The results and analysis indicate that changes in different parts of the foot that results from involution processes, increasingly interact with one another in the elderly age. The proceeding aimed at preventing deformities and dysfunctions of the foot should pay particular attention to maintaining or restoring the capacity of muscles acting on the foot and improving proprioception. Similarly, it is necessary to take

into account the relationships between different parts of the foot in footwear designed for senior citizens. Shoes should not interfere with the form and function of the front segment of the foot. Such conduct may help to maintain optimal (in relation to age) static and dynamic level of organ movement.

### Conclusions

1. Correlations between the setting of the hallux and the longitudinal arch of the foot in people aged 70–79 and 80–90 indicate that changes in those parts of the feet due to involution processes increasingly interact with each other, and the setting of hallux has an impact on the longitudinal arch in seniors' feet. No relationships between the angle of the V toe varus deformity and the longitudinal arch of the foot suggests that position of the V toe does not affect the longitudinal arch in feet of people over 60 years of age.
2. The hallux valgus angle and the V toe varus deformity angle occasionally correlated with the Wejsflog's index and heel angle. Higher values of this angles are accompanied by a widening of the forefoot.
3. Hallux valgus angle and the V toe varus deformity angle do not show any correlations in women and men over 60.

### Conflict of interest

The authors declare no conflict of interest.

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