fizjoterapia polska
nr 3/2014 (14)

Analiza wpływu wartości (BMI) na wskaźnik Wejsfloga, a ocena bólu stóp

The impact of BMI value on the Wejsflog index, and the foot pain assessment

Mateusz Curyło[1(A,B,C,D,E,F,G)], Magdalenna Wilk-Frańczuk[2(B,C)], Marlena Rynkiewicz-Andryśkiewicz[3(C,D)], Jan W. Raczkowski[4(D,A,F)]

[1]Krakowska Akademia im. Andrzeja Frycza Modrzewskiego, Wydział Medyczny i Nauk o Zdrowiu, Kraków, Polska
[2]Wyższa Szkoła Społeczno Przyrodnicza im. Wincentego Pola w Lublinie, Wydział Nauk o Zdrowiu, Lublin, Polska
[3]Specjalistyczny Psychiatryczny Zespół Opieki Zdrowotnej w Jarosławiu, Polska
[4]Oddział Kliniczny Rehabilitacji Pourazowej, Uniwersytet Medyczny w Łodzi, Polska

Streszczenie:

Wstęp. Stopa to narząd charakteryzujący się dużą stabilnością i wytrzymałością na przeciążenia, a zarazem dynamiczny resor dzięki, któremu spełnia funkcje amortyzatora.

Cel pracy.

1. Określenie czy istnieje korelacja pomiędzy wskaźnikiem Wejsfloga, a masą ciała pacjenta;
2. Określenie czy masa ciała jest czynnikiem ryzyka obniżenia sklepienia poprzecznego;
3. Określenie czy masa ciała i budowa sklepienia poprzecznego stopy, mają wpływ na pojawienie się dolegliwości bólowych.

Materiał i metody. Badania przeprowadzone zostały w Krakowie w okresie 2012-2013 r. Materiał badań stanowiło dwieście czterdziestu dziewięciu pacjentów, sto siedemdziesiąt osiem kobiet i siedemdziesięciu jeden mężczyzn, w przedziale wiekowym 21- 88 lat, (średnia wieku 52 lata).

Wyniki. Wartość p z testu chi-kwadrat jest niższa od 0,05, a więc wartość wskaźnika Wejsfloga zależy istotnie od BMI: im wyższe BMI, tym częściej występuje obniżenie sklepienia poprzecznego. Wartość p z testu Manna-Whitneya jest większa od 0,05, a więc ocena natężenia bólu nie zależy istotnie statystycznie od wskaźnika Wejsfloga.

Wnioski

1. Potwierdzono wpływu korelacji wskaźnika masy ciała (BMI), na częstotliwość występowania obniżenia sklepienia poprzecznego ocenianego wskaźnikiem Wejsfloga.
2. Zwiększona masa ciała, określona wskaźnikiem masy ciała (BMI) jako nadwaga i otyłość jest istotnym czynnikiem ryzyka obniżenia sklepienia poprzecznego stopy.
3. Zwiększona masa ciała oraz obniżenie sklepienia poprzecznego stopy ocenianego wskaźnikiem Wejsfloga, nie mają wpływu na pojawienie się dolegliwości bólowych stopy.

Słowa kluczowe:

Wskaźnik masy ciała (BMI), wskaźnik Wejsfloga, sklepienie poprzeczne stopy

Abstract

Introduction. *The foot is not only the organ having great stability and overload endurance, but also one being a dynamic spring and, due to this feature, functioning as a shock absorber.*

Aims of the work

1. Determining if there exists a correlation between Wejsflog index and the body mass of patient;
2. Determining if the body mass is a risk factor for the transverse arch lowering;
3. Determining if the body mass and the structure of the transverse foot arch influence the appearance of the foot pain ailment.

Material and methods. *The research was carried out in Krakow in 2012-2013 period. The examined group of the research consisted of 249 patients, including 178 women and 71 men, aged 21-88 (average age of 52 years).*

Results. *P-value of the chi-square test is less than 0.05, thus the value of Wejsflog index significantly depends on the BMI: the higher the BMI, the more frequently the transverse arch lowering occurs. P-value of the Mann-Whitney test is greater than 0.05, thus the evaluation of the pain strength is statistically not dependent on the Wejsflog index.*

Conclusions

1. The influence of the correlation between the body mass index (BMI) and the frequency of occurrence of the transverse foot arch lowering measured by the Wejsflog index has been proven.
2. Increased body mass defined by the body mass index (BMI) as overweight and obesity is a significant risk factor for the transverse foot arch lowering.
3. Increased body mass index as well as the transverse foot arch lowering measured by the Wejsflog index have no influence on the occurrence of the foot pain ailment.

Key words:

body mass index (BMI), Wejsflog index, transverse arch of the foot

Preface

As early as the sixteenth century, Leonardo da Vinci described the foot as a masterpiece of art and biomechanics. The foot, as the most peripheral part of a lower limb, is an important element of the locomotor system and is responsible for our mobility and independence.

It is a highly stable and overload resistant organ. It also operates as a dynamic spring through which the function of the shock absorber is fulfilled. These two tasks are extremely difficult to reconcile and it is the complex anatomical and biomechanical structure of a healthy foot makes it possible. The biomechanics of a foot and body posture are issues which still raise discussions and doubts [1, 2, 3, 4, 5, 6, 7]. The approach to foot defects differs between the authors; this, however, only indicates the complexity of the subject and the classification of foot defects in adults. It also proves that there is a strong interdisciplinary team operating in this scientific field. The teams of scientists consist of orthopaedists, physiotherapists, biomechanics, biomedical engineers and anthropologists, although they complement the picture, they also create an approach to the subject which is true to their discipline [8, 9, 10, 11]. Both Polish and foreign scientists have defined the concept of foot static disorder; one common definition and criteria have not yet been yet agreed, however. [12, 13, 14, 15, 16].

Research objective

1. This paper aims to determine whether a correlation between the Wejsflog index and body weight of the patient exist;
2. Also to determine if body weight is a risk factor of the falling of the transverse arch of the foot measured with Wejsflog indicator.
3. The correlation between body weight / the structure of transverse arch of the foot and the occurrence of pain is also to be researched.

Research material and methods

The study was conducted in Krakow in 2012 and 2013. The research group of two hundred and forty-nine patients comprised one hundred and seventy eight women and seventy-one men, aged 21 to -88 with an average age of 52. Four hundred and ninety eight feet were examined with an electronic podoscope. The criteria that had to be met for a prospective respondent to be included in the study was; being over 21 years of age; declaration of no previous fractures and/or serious injuries of the foot and the ankle; lack of identified systemic diseases and nervous system damage. Any surgical procedures performed on the foot, ankle and toes meant that a prospective respondent was excluded from the research group. To measure the arch of the foot a non-invasive test with an electronic podoscope was used. This test provides an objective assessment of the plantar of the foot when carrying actual load. It also later allows appropriate angular and millimetre measurements to be taken through the computer system; these results can be analysed. In addition to a precise analysis of the footprint the test also shows the dynamics of support surface which simpli-

fies the diagnostic and therapeutic process to a great extent by differentiating support and contact zones [17]. The test was conducted through the adoption of a proper standing position on the podoscope. The device would then take a picture of the plantar surface of the foot. The data was then used to calculate angular and millimetre values of the corresponding measurements.

Test results

The impact of BMI on the Wejsflog index

457 out of 498 of respondents (91.77%) had a normal transverse arch of the foot; 41 examined feet (8.23%) had transverse flat foot (Table 1, Fig. 1).

Table 1. Analysis of the falling of the transverse arch of the foot in the research group

Wejsflog index	N	%
Transverse flat foot (the indicator nearer to 2 than 3)	41	8.23%
Correct transverse arch of the foot (the indicator nearer to 3 than 2)	457	91.77%

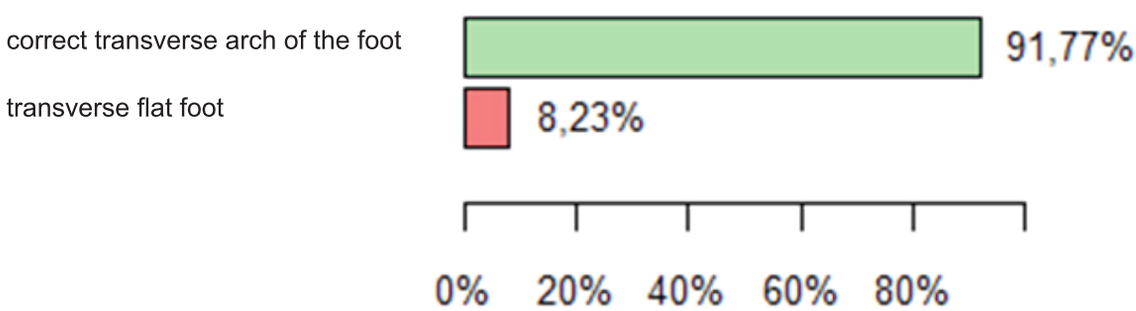

Fig. 1. Analysis of the falling of the transverse arch of the foot in the research group

The following shows the values of the Wejsflog index relating to the feet measured (498), depending on the respondent's BMI. The p value of chi-square test is lower than 0.05 signifying that the Wejsflog index is highly dependant on the BMI: the higher the BMI, the more often the transverse flat foot is observed (Table 2, Fig. 2).

Table 2. The impact of BMI on the Wejsflog index

Wejsflog index	Underweight		Normal weight		Overweight		Obesity		Test χ^2
	N	%	N	%	N	%	N	%	
Transverse flat foot	0	0%	7	4.22%	17	10.62%	17	14.41%	χ^2=15.55
Correct transverse arch of the foot	54	100%	159	95.78%	143	89.38%	101	85.59%	p=0.0010

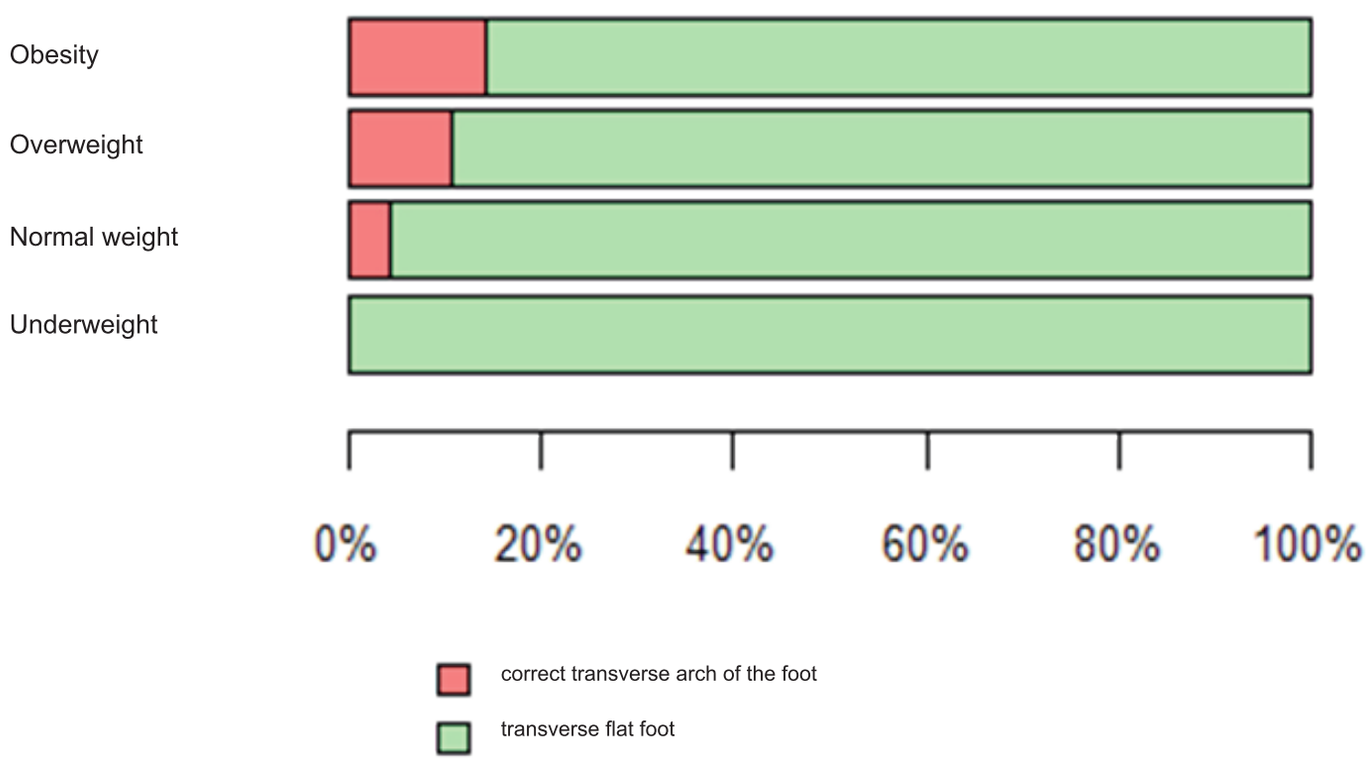

Fig. 2. The impact of BMI on the Wejsflog index

The impact of BMI on the Wejsflog arch of foot index

113 feet out of 498 examined (22.69%) had correct arching. In 176 (35.34%) fallen arches in stage I were observed; 93 feet (18.67%) had fallen arches in stage II , 90 feet (18.07%) were hollow, 21 feet (4.22%) had fallen arches in stage III and 5 feet (1.00%) had hollow arches in stage IV (Table 3, Fig. 3).

Table 3. The impact of BMI on the Wejsflog index

Wejsflog index	N	%
Hollow foot (index up to 27%)	90	18.07%
Correct arching (index value 28-38%)	113	22.69%
Flat foot (fallen arches) stage I (index value 39-50%)	176	35.34%
Flat foot (fallen arches) stage II (index value 51-66%)	93	18.67%
Flat foot (fallen arches) stage III (index value 67-100%)	21	4.22%
Flat foot (fallen arches) stage IV (index value over 100%)	5	1.00%

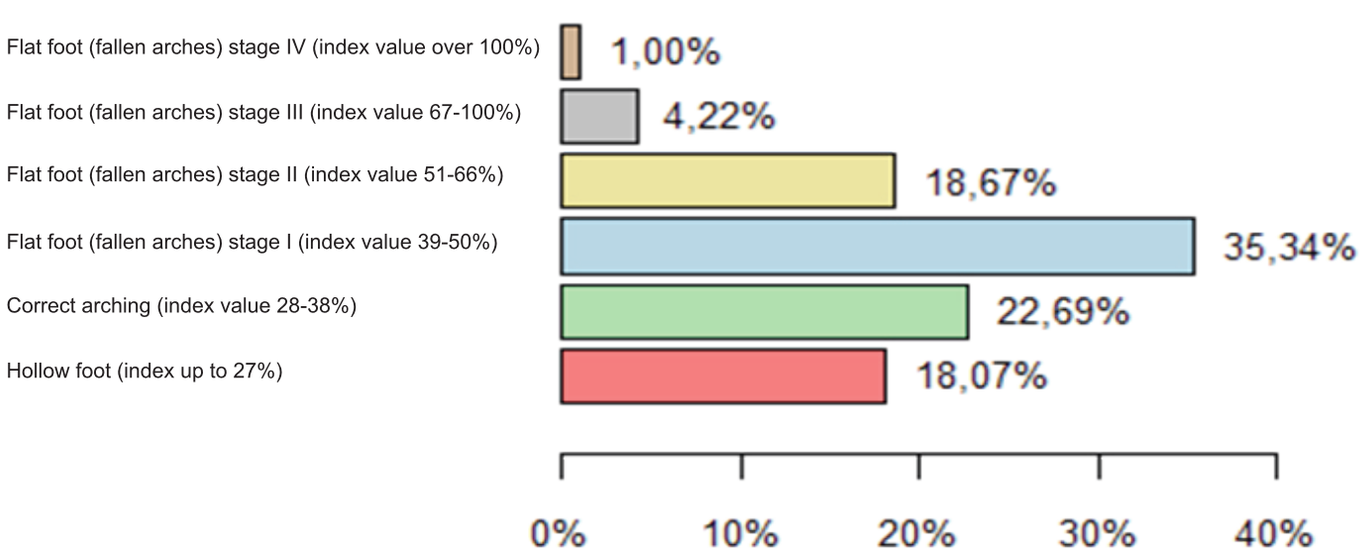

Fig. 3. The impact of BMI on the Wejsflog index

The values of the Wejsflog arch of foot index is presented for the 498 feet examined, depending on the respondent's BMI. Because there were not many fallen feet in stage III and IV, they were added to the stage II group. The p value of the chi-square test is lower than 0.05 signifying that the Wejsflog index is highly dependant on the BMI: the higher the BMI, the more often the flat feet and the more infrequently a hollow foot is observed (Table 4, Fig. 4).

Table 4. The Wejsflog index depending on the BMI

Wejsflog index	Underweight		Normal weight		Overweight		Obesity		Test χ^2
	N	%	N	%	N	%	N	%	
Hollow foot	16	29.63%	46	27.71%	23	14.37%	5	4.24%	
Correct arching	17	31.48%	45	27.11%	30	18.75%	21	17.80%	χ^2=56.70
Flat foot (fallen arches) stage I	14	25.93%	54	32.53%	59	36.88%	49	41.53%	p<0.001
Flat foot (fallen arches) stage II-IV	7	12.96%	21	12.65%	48	30.00%	43	36.44%	

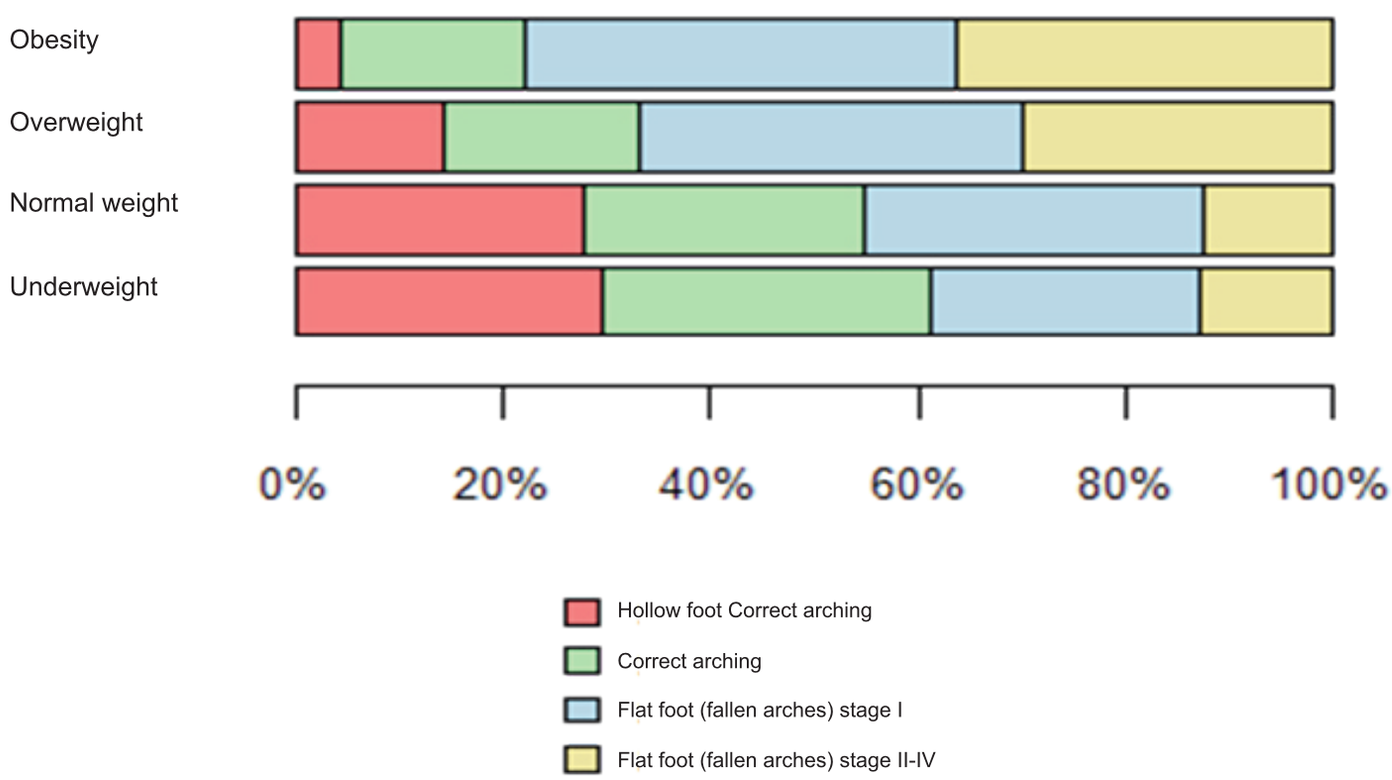

Fig. 4 The Wejsflog index depending on the BMI

The impact of the Wejsflog index on the intensity of pain, taking into account the value of the body mass index (BMI)

The analysis of the whole group

Pain intensity on the VAS scale, depending on the Wejsflog index is presented below. Pain intensity did not have a normal distribution in the groups analysed, as verified with the Shapiro-Wilk test so the Mann-Whitney test was used. The p value in the Mann-Whitney test was greater than 0.05 signifying that the evaluation of pain intensity is not highly statistically dependant on the Wejsflog index (Table 5, Fig. 5).

Table 5. The impact of the Wejsflog index on the level of pain, taking into account the value of the body mass index (BMI).

Wejsflog index	Pain on VAS scale					Mann-Whitney U-test
	Median	Min	Max	1st quartile	3rd quartile	
Transverse flat foot	5	1	9	3	7	W=9844.5
Correct transverse arch of the foot	5	0	10	3	7	p=0.586

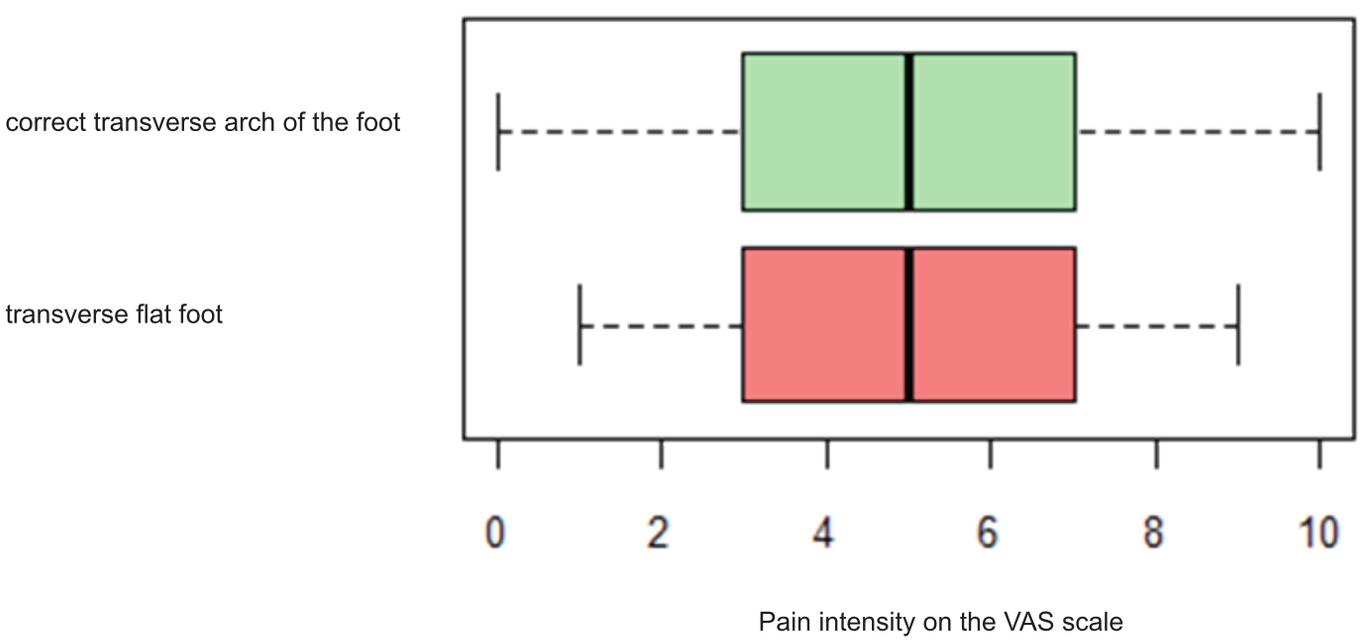

Fig. 5. The impact of the Wejsflog index on the level of pain, taking into account the value of the body mass index (BMI).

For underweight respondents
Correct arch of foot was observed in all underweight respondents.

For the respondents with normal weight
Pain intensity determined on the VAS scale, depending on the Wejsflog index is presented below. Pain intensity did not have a normal distribution in the groups analysed, which was verified with the Shapiro-Wilk test. Therefore, the Mann-Whitney test was used. The p value in the Mann-Whitney test was greater than 0.05 signifying that the evaluation of pain intensity by the respondents with normal weight is not highly statistically dependant on the Wejsflog index (Table 6, Fig. 6).

Table 6. Pain intensity determined on the VAS scale depending on the Wejsflog index

Wejsflog index	Pain on VAS scale					Mann-Whitney U-test
	Median	Min	Max	1st quartile	3rd quartile	
Transverse flat foot	5	1	9	3	6.5	W=564.5
Correct transverse arch of the foot	5	0	10	3	7	p=0.948

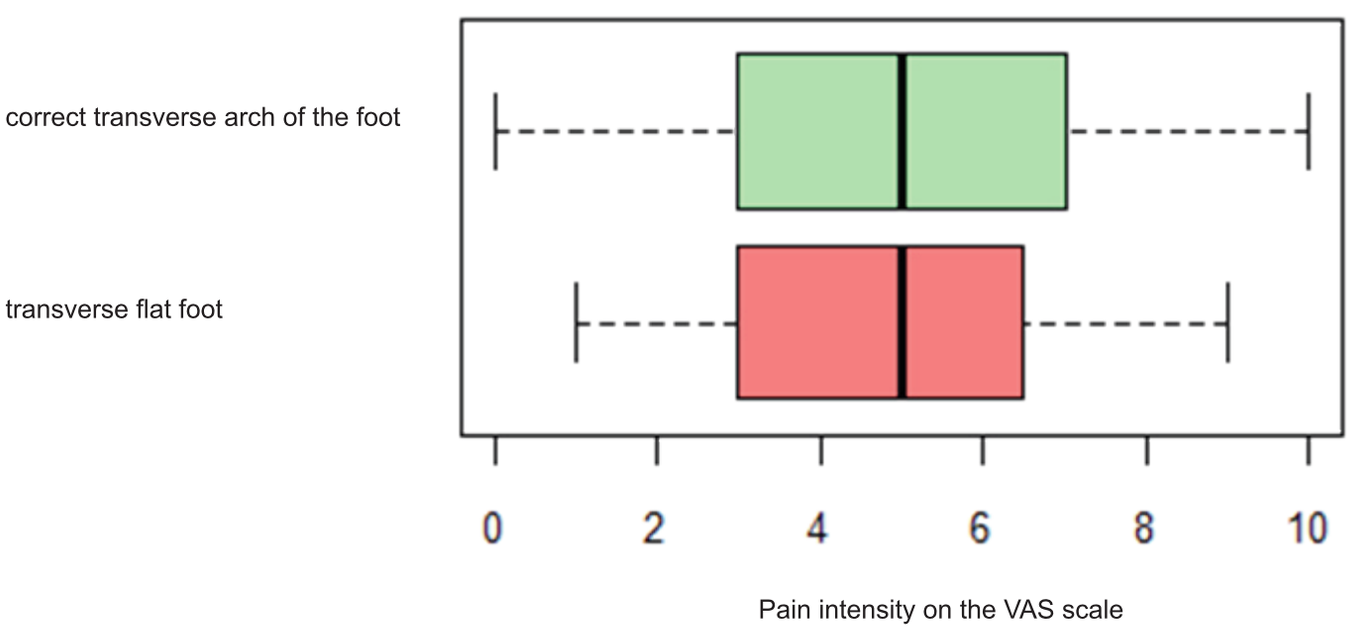

Fig. 6. Pain intensity determined on the VAS scale depending on the Wejsflog index

For overweight respondents

Pain intensity determined by the respondents on the VAS scale depending on the Wejsflog index. Pain intensity did not have a normal distribution in the groups analysed, which was verified with the Shapiro-Wilk test. Therefore, the Mann-Whitney test was used. The P value in the Mann-Whitney test was greater than 0.05 signifying that the evaluation of pain intensity by overweight respondents is not highly statistically dependant on the Wejsflog index (Table 7, Fig. 7).

Table 7. Pain intensity determined on the VAS scale depending on the Wejsflog index

Wejsflog index	Pain on VAS scale					Mann-Whitney U-test
	Median	Min	Max	1st quartile	3rd quartile	
Transverse flat foot	7	1	9	4	7	W=1531.5 p=0.077
Correct transverse arch of the foot	5	1	9	3	7	

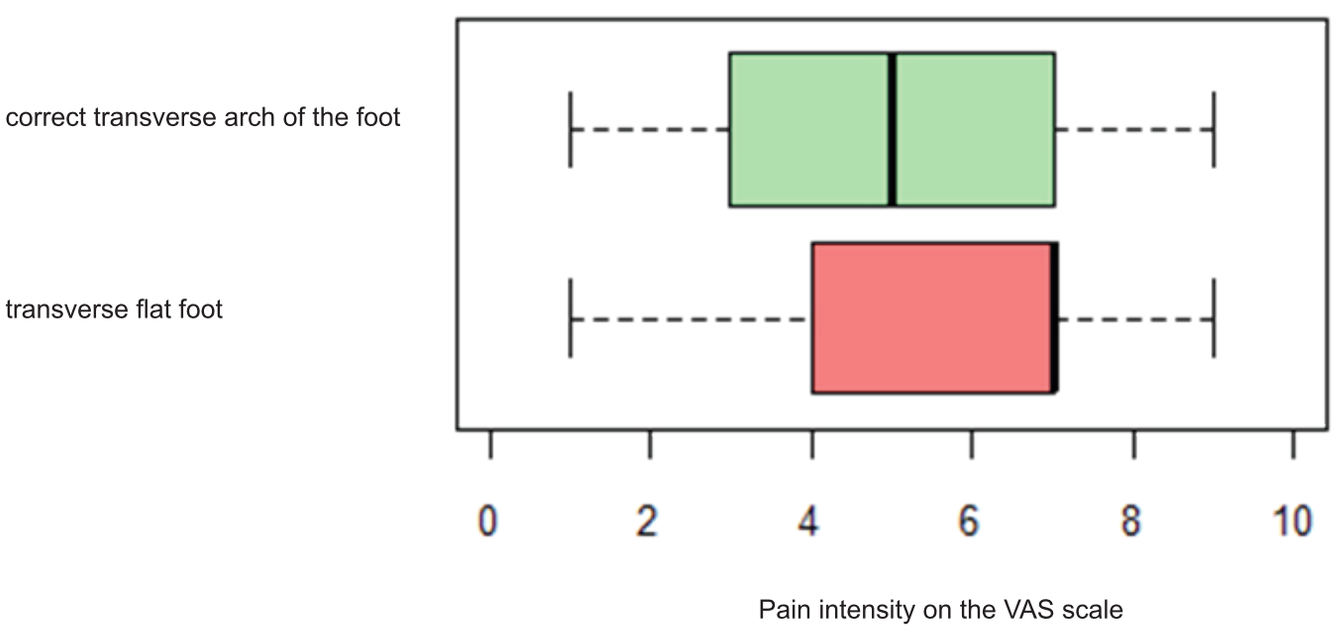

Fig. 7. Pain intensity determined on the VAS scale depending on the Wejsflog index

For obese respondents

Pain intensity determined by the respondents on the VAS scale depending on the Wejsflog index. Pain intensity did not have a normal distribution in the groups analysed, which was verified with the Shapiro-Wilk test. Therefore, the Mann-Whitney test was used. The P value in the Mann-Whitney test was greater than 0.05 signifying that the evaluation of pain intensity by obese respondents is not highly statistically dependant on the Wejsflog index (table 8, Fig. 8).

Table 8. Pain intensity determined on the VAS scale depending on the Wejsflog index

Wejsflog index	Ból w skali VAS / Pain on VAS scale					Mann-Whitney U-test
	Median	Min	Max	1st quartile	3rd quartile	
Transverse flat foot	5	1	9	2	5	W=670.5 p=0.145
Correct transverse arch of the foot	5	1	10	4	8	

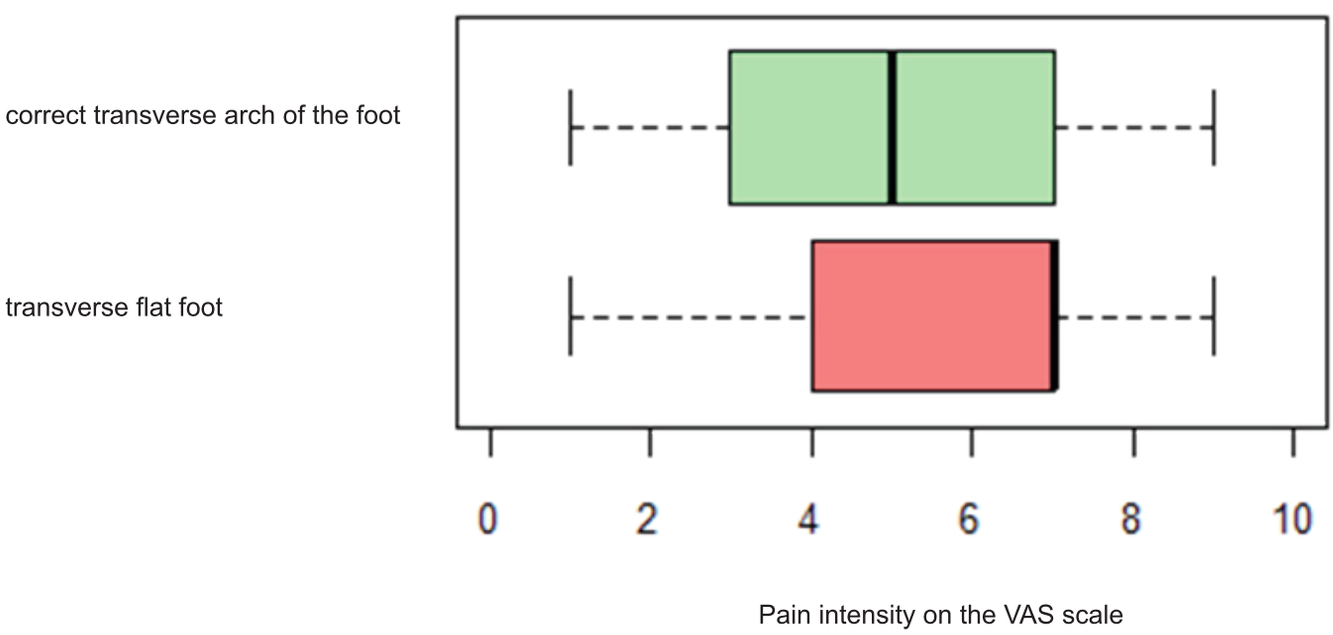

Fig. 8. Pain intensity determined on the VAS scale depending on the Wejsflog index

Discussion

The subject of the foot construction, its thorough examination and an attempt to define the standards is a research issue raised and discussed by many representatives of medical professionals, including medicine doctors focussed on the locomotor system, physiotherapists, anthropologists, biomechanics and orthopedic technicians. This subject has been discussed by numerous researchers [18, 19, 20, 21, 22, 23, 24, 25, 26]. Interestingly a multitude of publications on the assessment of child foot development are available whilst there are noticeably fewer scientific reports on the subject of mature foot assessment in terms of its structure and functioning. Scientific research is conducted using many, often diverse research methods, including simple plantograp hs and specialized hardware used for both static and dynamic examinations [27, 28, 29, 30, 31, 32].

Our own research focussed on attempting to analyse the measurement of the transverse arch of the foot using the Wejsflog index, taking into account the body weight and foot pain intensity. Bearing in mind data available on the use of different research methods and their sensitivity [33, 34, 35, 36], the decision was made to use an electronic podoscope. The research conducted by Hill CL. et al on a large number of respondents [37] indicates a relationship between the body mass

index (BMI) and the occurrence of foot pain and falling foot arches. The research conducted by Wearing S.C. et al. [38] indicates that there is no association between body weight and falling of the transverse arch of the foot. This study did not include the assessment of pain intensity. In our own research we examined 498 feet. The correlation between body mass index (BMI) and the fallen transverse arch of the foot has been demonstrated. By determining the Wejsflog index it has been proven that the higher the BMI the more common the occurrence of a fallen transverse arch of the foot ($p = 0.001$). It has been shown that in the group of of 54 respondents with a body mass index under 18.5, which signifies underweight, the ratio of correct transverse arches of foot was 100% and that, in the group, 143 respondents had a body mass index of 25.0-30.0 (overweight), the fallen arch of foot was observed in 10.62%, and in the group with a body mass index over 30.0 (obesity) the fallen transverse arch of the foot was observed in 14.41% of the respondents.

The higher the BMI, the more common the occurrence of fallen arch of foot. Based on our own research and studies conducted by other researchers it can be stated that increased body mass index constitutes an important risk factor for the falling of the transverse arch of the foot. The higher the BMI, the more probable the occurrence of flat foot, both transversely and longitudinally. Research conducted by Shibuya N. et al. [39] focussed on analysing the flat foot as a statistically significant risk factor and higher BMI values were also determined. Nielsen MD. et al. [40] conducted their research on a group of 64 adult respondents with acquired fallen longitudinal and transverse arches of foot. It showed that obesity constitutes a risk factor, given that 78.12% of respondents in the research group were classified as obese. Similarly, the study conducted by Faria , A. et al. [41] indicates an increased body weight in the research group of 81 women, constituted a significant risk factor for the fallen longitudinal and transverse arches of foot. The studies of Nguyen US. et al. [42] conducted on a group of 386 female and 214 male respondents in order to establish a correlation between the occurrence of hallux valgus and fallen longitudinal and transverse arches and the values of the body mass index (BMI), also took the age and gender of the respondents into consideration. The research indicates that there is no correlation between the BMI values and the occurrence of hallux valgus in women. For the male respondents the values of the body mass index (BMI) were correlated with the occurrence of hallux valgus. However, the author specifies high BMI values and wearing high-heeled shoes as primary risk factors of fallen longitudinal and transverse arches of foot and hallux valgus. The assessment of pain intensity did not present a correlation between the BMI values and the level of pain.

Conclusions

1. The correlation between body mass index (BMI) and the occurrence of fallen transverse arch of the foot measured with Wejsflog index has been proven.

2. Increased body weight, defined by the BMI index as overweight and obese is a significant risk factor of fallen transverse arch of the foot.
3. Increased body weight and fallen transverse arch of the foot measured with Wejsflog index do not correlate with the occurrence of foot pain.

corresponding author

dr n. med. Mateusz Curyło
mateusz_curylo@o2.pl, tel. 668-105-513
Krakowska Akademia im. A. F. Modrzewskiego,
Wydział Medyczny i Nauk o Zdrowiu
ul. Gustawa Herlinga-Grudzińskiego 1, 30-705 Kraków

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