THE RELATIONSHIP BETWEEN BODY MASS INDEX AND PLANTAR PRESSURES OF THE ELDERLY

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This paper approaches the relationship between obesity and foot disorders, an important topic in designing and producing preventive or palliative strategies to improve the quality of life for the elders. In spite the growth of old people, they are constrained to accept the footwear that the market is offering, which doesn't meet their special requirements in case of feet parameters. The analyzed sample consisted in 67 women, aged between 52-84 years old. By comparing the values of body mass index for the analyzed group it is demonstrated that with age, the weight increases for a significant number of women, going from overweight to obese. The authors performed as well, a descriptive statistics and a Pearson correlation between the body mass index and several plantar footprints parameters obtained in a previous research. As an important instrument, the body mass index can be used by footwear producers to modify and customize the last and the elderly shoes. The results of this study are important in various stages of producing footwear, highly adapted to the needs of different pathologies for the elderly consumers.

Keywords: footwear, customization, plantar parameters correlation

INTRODUCTION

The loss of the ability to walk due to foot problem, not only produces physical limitations, but also has a significant impact on the persons's mental, social, and economic status (Helfand, 2015; Herghiligiu *et al*., 2016; Sarghie *et al*., 2016; Ionesi *et al*., 2014; Deselnicu *et al*., 2015). The world population is heading toward 10 billion people (Walker and Mesnard, 2009; Bougourd, 2015). While global population growth will bring its own challenges, aging is also unprecedented. Reports published by the United Nations (UN, 2009), Population Division suggests that in 1950, 200 million people were aged over 60 years; by 2000 they increased to 600 million; and predicts that by 2050 there will be 2 billion. During this period the median age increased in all of the EU Member States, the highest rising, by 5.4 years, being in Romania (*, **). According to national statistics, at the present in Romania are 3.4 million elderly, representing over 15% of the population (***).

In a study by Thaı's Rabiatti Aurichio and others (Aurichio *et al*., 2011) was demonstrated that as the weight increases, the foot flattens. In case of that particular study, the mechanism of evaluating the foot high arch index was possible using plantar footprints. In addition to structural changes due to aging, obesity is an important factor to be taken into account when assessing morphological changes of elders' feet. Tavares and Anjos (1999), Barreto *et al*. (2003), Santos and Sichieri (2005) have demonstrated that women are more prone to obesity than men.

METHOD

In a previous study (Mihai and Păştină, 2012; Păştină *et al*., 2012), it was determined the foot types, based on plantar footprints taken from 67 women, aged between 52-84 years old and weighing 45-70 kg, figure 1. The subjects were divided in

three categories, group 1: 52-59 years old, group 2: 60-64 years old and group 3: 65-84 years old. All subjects read and signed an informed consent before testing.

Figure 1. Taking plantar footprints and static plantar pressures using RSscan pressure plate

RESULTS

Body Mass Index

The body mass index is weight divided by height squared an individual thereof (kg / m^2), and it is a useful tool in the assessment of excess fat (Pinheiro *et al*., 2004). According to World Health Organization, normal BMI values are between 18.5 and 24.9; values below 18.5 represent underweight, and over 30, obese (WHO, 1997).

For all 67 women the BMI was calculated before taking plantar footprints and static and dynamic measurements. The results can be observed in table 1.

Table 1. Body mass index

BMI /Age	Group 1, 52-59 years old	Group 2, 60-64 years old	Group 3, 65-84 years old
Underweight (BMI<18.5)	2	0	2
Normal (BMI 18.5-25)	13	5	3
Overweight (BMI 25-30)	12	9	9
Obese (BMI >30)	2	4	5

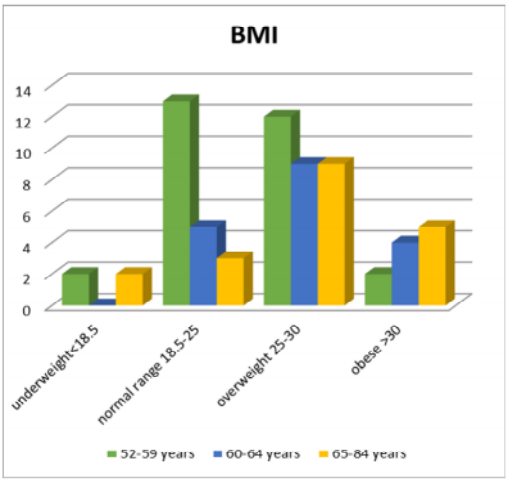

Figure 2. Body Mass Index, BMI

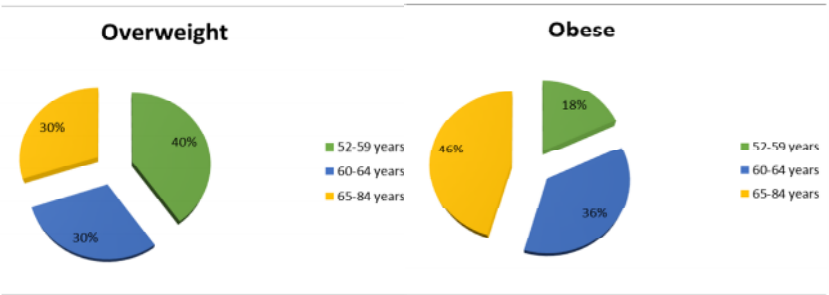

Figure 3. BMI grouped by age

By comparing the values of BMI for all three groups, it can be observed that the overweight percentage is higher for group 1, and obesity for groups 2 and 3. These values demonstrate that with age, the weight increases for a significant number of women, going from overweight to obese. The results are closely related to foot pain and disorders, which occur while ageing.

DISCUSSIONS

Based on plantar footprints from the previous study, the following parameters were obtained: Heel Width (HW), Minimum Width of Plantar Footprint (MWF), Toe Width (TW), Hallux-Valgus Angle (HVA), Chippaux-Simark Index (CSI).

Using the previous obtained data, BMI results and SPSS software, a descriptive statistics is performed, table 2.

Table 2. Descriptive statistics of foot parameters

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
BMI	67	19.67	17.63	37.30	26.3672	4.29880	18.480	-.031	.578
HW	67	18.00	45.50	63.50	53.8806	3.69796	13.675	-.250	.578
MWF	67	46.00	.00	46.00	25.1269	12.61173	159.056	-.333	.578
TW	67	27.50	72.50	100.00	88.9030	5.84214	34.131	-.420	.578
HVA	67	54.50	-19.00	35.50	6.3881	11.38041	129.514	-.001	.578
CSI	67	48.70	.00	48.70	27.9746	13.85177	191.872	-.297	.578
Valid N	67								

The statistically significant correlations between parameters were studied using Pearson correlation which is commonly used as a measure of the degree of linear dependence between two variables****. The results are available in table 3.

Table 3. Pearson Correlation of foot parameters

		BMI	HW	MWF	TW	HVA	CSI
BMI	Pearson Correlation	1	0.257*	0.293*	0.245*	-0.177	0.278*
	Sig. (2-tailed)		0.036	0.016	0.046	0.152	0.023
	Sum of Squares and Cross-products	1219.660	269.562	1048.924	406.207	-571.671	1090.822
	Covariance	18.480	4.084	15.893	6.155	-8.662	16.528
	N	67	67	67	67	67	67
HW	Pearson Correlation	0.257*	1	0.373**	0.399**	-0.014	0.343**
	Sig. (2-tailed)	0.036		0.002	0.001	0.912	0.004
	Sum of Squares and Cross-products	269.562	902.545	1148.015	568.724	-38.146	1160.197
	Covariance	4.084	13.675	17.394	8.617	-.578	17.579
	N	67	67	67	67	67	67
MWF	Pearson Correlation	0.293*	0.373**	1	0.399**	0.000	0.993**
	Sig. (2-tailed)	0.016	0.002		0.001	0.998	0.000
	Sum of Squares and Cross-products	1048.924	1148.015	10497.672	1938.075	-3.049	11444.616
	Covariance	15.893	17.394	159.056	29.365	-.046	173.403
	N	67	67	67	67	67	67
TW	Pearson Correlation	0.245*	0.399**	0.399**	1	0.214	0.304*
	Sig. (2-tailed)	0.046	0.001	0.001		0.082	0.012
	Sum of Squares and Cross-products	406.207	568.724	1938.075	2252.619	937.772	1623.535
	Covariance	6.155	8.617	29.365	34.131	14.209	24.599
	N	67	67	67	67	67	67
HVA	Pearson Correlation	-0.177	-0.014	0.000	0.214	1	-0.031
	Sig. (2-tailed)	0.152	0.912	0.998	0.082		0.803
	Sum of Squares and Cross-products	-571.671	-38.146	-3.049	937.772	8547.910	-323.690
	Covariance	-8.662	-0.578	-0.046	14.209	129.514	-4.904
	N	67	67	67	67	67	67
CSI	Pearson Correlation	0.278*	0.343**	0.993**	0.304*	-0.031	1

	BMI	HW	MWF	TW	HVA	CSI
Sig. (2-tailed)	0.023	0.004	0.000	0.012	0.803	
Sum of Squares and Cross-products	1090.822	1160.197	11444.616	1623.535	-323.690	12663.527
Covariance	16.528	17.579	173.403	24.599	-4.904	191.872
N	67	67	67	67	67	67

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Positive correlations are found between BMI and HW, MWF, TW and CSI and a negative correlation between BMI and HVA. The highest correlations are found to be between MWF and CSI (0.993) confirming a strong relation of those two parameters, the lower the plantar width, the higher arched foot.

CONCLUSIONS

Demonstrating the relationship between obesity and foot disorders in case of older people is important in designing and producing preventive or palliative strategies to improve the quality of the elders. The old people are constrained to accept the footwear that the market is offering, which doesn't meet their special requirements in case of feet parameters.

By comparing the values of BMI for the analyzed group it is demonstrated that with age, the weight increases for a significant number of women, going from overweight to obese. A good fit of the shoe on the foot involves customizing the last, but this can only be achieved under certain standards. As an important instrument, the body mass index can be used by footwear producers to modify and customize the last and the elderly shoes. The results of this study are important in various stages of producing footwear adapted to the needs of different pathologies of elderly consumer.

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