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Original Article

The effect of age and body mass index on plantar cutaneous sensation in healthy women

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Abstract. [Purpose] This study was conducted to examine the effects of age and body mass index on plantar cutaneous sensation in healthy women. [Subjects and Methods] Two hundred and three healthy female volunteers over the age of 20 were included in the study. The statistical analyses were performed by considering the age and body mass index values of the individuals. The individuals were divided according to their ages and body mass index values. Foot pain was measured with a visual analogue scale and plantar cutaneous sensation using Semmes-Weinstein monofilaments. [Results] Fifty-six (27.5%) of the participants had normal weights, 67 (33%) were overweight, and 80 (39%) were obese. Statistical analysis revealed that as age and body mass index values increased, plantar sensitivity decreased and the frequency and severity of pain increased. [Conclusion] It is possible that healthy women may experience a decrease in foot plantar sensation with increasing weight and age. If women do not have any health problems, proprioception and sensory training must be focused on in order to prevent balance and falling problems.

Key words: Ageing, Body mass index, Cutaneous sensation

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INTRODUCTION

Walking and maintenance of balance in human beings depend on the complex integration of information coming from the visual, vestibular, and somatosensory systems[1–3)]. Precise somatosensory feedback is extremely important for controlled movement patterns[2–4)]. Plantar cutaneous receptors located on the plantar side of the foot provide somatosensory information for the body[4, 5)]. The stimuli coming from the bottom of the foot are important in terms of preventing balance problems and sustaining healthy walking[1)].

In recent studies, it has been determined that the obesity prevalence has increased in children and adults to a serious level[6)]. One of the concerns with the high prevalence of obesity is its association with an increased risk of falling. Each year, obese adults fall almost twice as frequently (27%) as their nonobese counterparts (15%)[7)]. An important reason for falling in obese people is the loss of balance due to the disrupted plantar sensitivity of the foot[8)]. The feet provide important sensorial information for balance and walking and help to sustain stability. The proprioceptive system is extremely important in ensuring the necessary balance control for standing and walking. This system includes cutaneous mechanoreceptors that detect pressure and skin deformations. The sensorimotor system uses the information coming from foot arches, joint capsules, intrinsic muscles, and cutaneous mechanoreceptors on the plantar surface of the feet to regulate the motor movement. Situations that cause problems in the functioning of this information may influence sensorimotor organization in a negative manner[9, 10)].

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Obesity influences the plantar pressure distribution[10–12]. These effects caused by obesity are explained by the effect of the weight on the foot structure. There are studies in the literature reporting that excessive weight and increased body mass index are related to a decrease in the *arch of the foot* and *pes planus*, decrease in the joint movement distance, chronic heel pain, nonspecific foot pain, tendonitis, changes in the plantar fat pad, biomechanical changes in the feet, and increased plantar pressure while standing and walking[13, 14].

Gender and age, as well as increases in weight are important factors influencing the functioning of the somatosensory mechanism. The plantar surface cutaneous sense, which is extremely important in ensuring static and dynamic balance control, may lead to a decrease in the functioning of the sensory systems with increasing age[9]. Similarly, it has been demonstrated that there are differences between foot morphology and plantar pressure in women and men[10, 15]. Although there are studies in the literature showing how plantar pressure characteristics in children and the elderly are influenced, there are few studies on how the plantar sense is influenced in different age groups and those that have been done have had limited numbers of cases in them. Similarly, the studies that have examined the effects of an increase in weight on plantar sensitivity in different age groups are extremely insufficient.

This study had two aims. The first aim was to demonstrate how plantar sense is influenced in women with different body mass indices. The second aim of the study was to demonstrate the change in plantar sensation in healthy women according to age. This study is important because it was conducted to show the change in plantar surface cutaneous sensation (tactile sensitivity) in healthy individuals over the age of 20. Our hypothesis was that plantar sensation decreases to an important level in healthy women with increasing age and weight.

SUBJECTS AND METHODS

Healthy female volunteers who accompanied patients to family clinics in the county of Mudurnu in the province of Bolu formed the population of the study. In a strength analysis performed to determine the sample size, it was determined using the Epi Info™ 7 (7.1.1.14) software that at least 100 women needed to be included in the study to obtain a strength rate of 80% with a confidence limit of 95% and an error rate of 0.05.

The criteria for being included in the study were being over the age of 20, being female, having no communication problems, and volunteering to participate in the study. The criteria for not being included in the study were having a foot plantar area dermatologic disease having edema in the feet; having a neurological, cardiopulmonary and/or musculoskeletal disease having a disease related to diabetes or peripheral neuropathy; or having a foot injury in the past year.

The Ethics Committee of Düzce University (Düzce University Clinical Research Ethics Committee, Decision Number: 2015/36) approved this research. All volunteers signed an informed consent form.

The individuals who were included in the study were assessed with a form. The demographic characteristics of the patients (age, height, weight, gender, body mass index (BMI)) were recorded. The heights of the patients were measured with a wall strip when they were standing in bare feet. The weights of the patients were measured using a Fakir Hercules scale after they removed as much clothing as possible. BMI was calculated based on weight/height^2 (kg/m^2). Statistical analyses were performed by considering the age and BMI values of the individuals. The individuals were divided into 3 groups according to their BMI values as fallows; normal weight (BMI: 18.5–24.9 kg/m^2), overweight (BMI: 25–29.9 kg/m^2), as follows: and obese (BMI: 30 and over kg/m^2). Similarly, the individuals were also divided into 3 groups according to their age distributions 20–44 years old (n=50, 24.6%), 45–64 years old (n=115, 56.6%), and 65 years old and over (n=38, 18.7%). All subjects were questioned regarding their level of education, marital status, chronic diseases, current use of tobacco, and current use of alcohol.

Foot pain was examined in the subjects with a visual analog scale (VAS). A VAS is a pain severity measurement scale with demonstrated reliability. The individuals were asked to evaluate their level of pain on a 10-cm line with numbers indicated on it from 0 to 10 at 1-cm increments. Zero (the left point) represented no pain, 10 (far right point) represented the most severe pain, and the middle represented mild pain. The point where the individual marked was measured with a ruler, and the value was recorded as the pain score.

In order to assess plantar cutaneous sensation (tactile sensitivity), nylon Semmes-Weinstein monofilaments were used. Semmes-Weinstein monofilaments apply bending stress to the skin and create a sense of pressure, and the amount of pressure they apply is indicated by numbers ranging from 1.65 to 6.65. The highest monofilament value is the hardest filament, which can only be bent with difficulty. Monofilaments with thickness values of 4.17 and 5.07 were used in this study. The individuals were asked to lie on their backs with their feet bare and their eyes open. A researcher, who was a physiotherapist, stood by the individual and applied the monofilament at a 90-degree angle for 1.5 seconds (s) to 7 areas on the plantar surface of the foot where the load was applied on the individual and which was inclined to ulceration (first toe, fifth finger, first and fifth forefoot, hindfoot, medial and lateral sides of the foot (mid-foot)), and the patient was asked whether she felt it or not. This was repeated for both feet with each monofilament in all areas (Fig. 1)[12, 16].

Statistical analyses were performed using the PASW Statistics (ver. 18) software. The definitive statistics were determined by using average and standard deviation values for continuous variables; for categorical variables, frequency and percentage values were used. Data normality was checked using the Shapiro-Wilk test. The age groups of the individuals included in the study (22–44 years old, 45–64 years old, 65 years old and over), BMI groups (normal, overweight, obese), frequency of

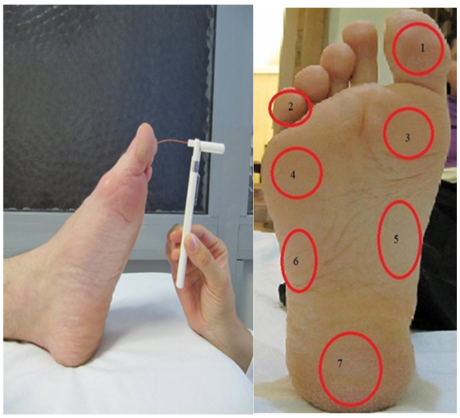

Fig. 1. Planter are sensory test with a monofilament

Table 1. Sociodemographic characteristics of the subjects

N=203		X ± SS	
Age (years, x ± ss)		52.5961 ± 13.05	
Height (m, x ± ss)		1.5836 ± 0,06	
Weight (kg, x ± ss)		73.0409 ± 13.51	
Body mass index (kg/m^2, x ± ss)		29.01 ± 5.63	
		n	%
BMI Groups	Normal	56	27.59
	Overweight	67	33
	Obese	80	39
Age Groups	25–44	50	24.6
	45–64	115	56.6
	65 and over	38	18.7
Profession	Not working	11	5.4
	Officer	13	6.4
	Employee	13	6.4
	Freelance	4	2
	Housewife	160	78.8
	Other	2	1
Educational level	Primary	137	67.5
	Secondary school	9	4.4
	High school	8	3.9
	University	18	8.9
	Other	9	4.4
	Illiterate	22	10.8
Current use of tobacco	Yes	22	10.3
	No	181	89.2
Current use of alcohol	Yes	4	2
	No	139	68.5
Cholesterol	Yes	16	7.9
	No	186	91.6

pain, and relations between monofilament thicknesses in different areas were evaluated with the relevant chi-square analysis. The Kruskal-Wallis test was used in comparing the BMI and age groups in terms of VAS scores, and differences between the groups were examined with the Dunn's test.

Values were accepted as statistically significant when $p<0.05$.

RESULTS

The average age of the individuals who participated in the study was 52.59 ± 13.05 years, the average BMI value was 29.0 ± 5.63 (kg/m^2). Fifty-six (27.5%) of the individuals had normal weights, 67 (33%) were overweight, and 80 (39%) were obese. The majority of the individuals (78.8%) were housewives, and the educational levels were low (67.5%). Tobacco and alcohol use were extremely low (%10 and %2 of the individuals reported tobacco and alcohol use, respectively). Sixteen (7.9%) individuals had cholesterol complaints, while 186 (91.6%) individuals did not (Table 1).

The frequency of pain was 9 (23.7%) in the 25–44 age group, 37 in the 45–64 age group (54.4%), and 16 (51.6%) in the individuals who were over the age of 65. When the age groups were compared in terms of the frequency of pain, the pain frequencies of the age groups comprising individuals 45 years old and over were similar; however, the frequencies were significantly high when compared with that for the 44 years old and below age group ($p<0.05$). In addition, the pain frequency was 38.7% (12 people) in the normal weight group, 44.4% in the overweight group (20 people), and 49.02% (30 people) in the obese group. No significant differences were determined between the BMI groups in terms of the frequency of pain ($p>0.05$). However, when the BMI groups were compared in terms of VAS scores, there was a significant difference only between normal and obese individuals ($p<0.05$). The severity of pain in obese individuals was higher than that in normal weight individuals ($p<0.05$). When the age groups were compared, the severity of pain (VAS) in 44 years old and below age group was significantly lower ($p<0.001$); however, no significant differences were found in the age groups comprised of

Table 2. The level of pain according to age and BMI group distribution

	BMI groups			Age groups		
	Normal weight (n=35)	Overweight (n=55)	Obese (n=59)	22–44 (n=36)	45–64 (n=86)	65 and over (n=27)
VAS	X ± SD (min-max)	X ± SD (min-max)	X ± SD (min-max)	X ± SD (min-max)	X ± SD (min-max)	X ± SD (min-max)
	1.42 ± 1.71** (0–6)[a]	1.92 ± 1.64** (0–7)[a]	2.38 ± 1.89** (0–7)[b]	0.88 ± 1.66* (0–6)[a]	2.40 ± 1.67* (0–7)[b]	2.14 ± 1.74 * (0–7)[b]

*p<0.001, Kruskal-Wallis test. **p<0.05, Kruskal-Wallis test. VAS: visual analogue scale

Table 3. Pain frequency and distribution according to monofilament thickness and area

Monofilament measurement area	Monofilament thickness	Foot pain			
		Yes		No	
Right foot		n	%	n	%
Area 1	4.17	57	45.6	68	54.4
	5.07	5	41.7	7	58.3
Area 2**	4.17	51	42.1	70	57.9
	5.07	11	68.8	5	31.3
Area 3	4.17	53	45.7	63	54.3
	5.07	9	42.9	12	57.1
Area 4	4.17	47	43.9	60	56.1
	5.07	15	50.0	15	50.0
Area 5	4.17	52	43.3	68	56.7
	5.07	10	58.8	7	41.2
Area 6	4.17	50	44.6	62	55.4
	5.07	12	48.0	13	52.0
Area 7	4.17	28	41.2	40	58.8
	5.07	34	49.3	35	50.7
Left foot		n	%	n	%
Area 1*	4.17	40	37.0	68	63.0
	5.07	22	75.9	7	24.1
Area 2	4.17	50	42.4	68	57.6
	5.07	12	63.2	7	36.8
Area 3	4.17	52	45.2	63	54.8
	5.07	10	45.5	12	54.5
Area 4	4.17	44	43.1	58	56.9
	5.07	18	51.4	17	48.6
Area 5	4.17	51	44.0	65	56.0
	5.07	11	52.4	10	47.6
Area 6	4.17	49	44.1	62	55.9
	5.07	13	50.0	13	50.0
Area 7	4.17	28	45.2	34	54.8
	5.07	34	45.3	41	54.7

*p<0.001, χ^2 test. **p<0.05, χ^2 test

individuals over 45 years old and older (p>0.05, Table 2).

When the relation between the frequency of pain and the monofilament thicknesses was examined, the frequency of pain in the individuals who felt the 5.17 monofilament only in right monofilament area 2 and left monofilament area 1 was significantly higher (p<0.05), and there were no significant differences between the 4.17 and 5.07 monofilaments in terms of the frequency of pain in the other right and left areas (p>0.05, Table 3).

The sensation frequencies of all right and left plantar areas showed significant changes according to age group for both monofilament thicknesses (p<0.05). In the statistical analysis, the frequency of feeling the thinner 4.17 monofilament (i.e.,

Table 4. Plantar sensory distribution according to age group

Monofilament measurement area	Monofilament thickness	Age groups					
		25-44		45-64		65 and over	
Right foot		n	%	n	%	n	%
Area 1*	4.17	50_a	100.0	105_b	91.3	32_b	84.2
	5.07	0_a	0.0	10_b	8.7	6_b	15.8
Area 2*	4.17	49_a	98.0	94_b	81.7	28_b	73.7
	5.07	1_a	2.0	21_b	18.3	10_b	26.3
Area 3*	4.17	48_a	96.0	97_b	84.3	27_b	71.1
	5.07	2_a	4.0	18_b	15.7	11_b	28.9
Area 4*	4.17	48_a	96.0	91_b	79.1	20_c	52.6
	5.07	2_a	4.0	24_b	20.9	18_c	47.4
Area 5*	4.17	48_a	96.0	95_b	82.6	28_b	73.7
	5.07	2_a	4.0	20_b	17.4	10_b	26.3
Area 6*	4.17	48_a	96.0	93_b	80.9	27_b	71.1
	5.07	2_a	4.0	22_b	19.1	11_b	28.9
Area 7*	4.17	37_a	74.0	61_b	53.0	14_b	36.8
	5.07	13_a	26.0	54_b	47.0	24_b	63.2
Left foot		n	%	n	%	n	%
Area 1*	4.17	48_a	96.0	70_b	60.9	20_b	52.6
	5.07	2_a	4.0	45_b	39.1	18_b	47.4
Area 2**	4.17	47_a	94.0	$98_{a. b}$	85.2	27_b	71.1
	5.07	3_a	6.0	$17_{a. b}$	14.8	11_b	28.9
Area 3*	4.17	49_a	98.0	98_b	85.2	26_c	68.4
	5.07	1_a	2.0	17_b	14.8	12_c	31.6
Area 4*	4.17	46_a	92.0	82_b	71.3	23_b	60.5
	5.07	4_a	8.0	33_b	28.7	15_b	39.5
Area 5*	4.17	49_a	98.0	94_b	81.7	24_c	63.2
	5.07	1_a	2.0	21_b	18.3	14_c	36.8
Area 6*	4.17	47_a	94.0	$95_{a. b}$	82.6	26_b	68.4
	5.07	3_a	6.0	$20_{a. b}$	17.4	12_b	31.6
Area 7*	4.17	39_a	78.0	60_b	52.2	10_c	26.3
	5.07	11_a	22.0	55_b	47.8	28_c	73.7

*p<0.0001, χ^2 test. **p<0.05, χ^2 test. Different superscripts indicate statistically significant differences (a vs. b, a<0.05).

the plantar sensation), showed a significant decrease in right plantar area 4 and left plantar areas 3, 5, and 7. with increasing age (p<0.05). The frequency of feeling the 4.17 monofilament in the other right and left plantar areas was the best in the 25–44 age group when compared with the other groups (p<0.05, Table 3). However, no difference was determined in terms of plantar cutaneous sensation in the 45–65 years old age group and the 65 years old and over age group (p>0.05, Table 3).

When the BMI and plantar sensation relation was examined, the individuals whose BMI values were higher in right foot area 7 and left foot area 1, 4, and 7. felt the thicker 5.07 monofilament, (p<0.05, Table 4). In other areas of both the right and left foot plantar surfaces (right foot areas 2–6, and left foot areas 2, 3, 5, and 6, respectively), there were no significant relations detected between an increase in BMI and the plantar sensation (p>0.05, Table 4). In other words, no statistical difference was determined in the forefoot areas of the foot except the mid-foot and area 1 (metatarsal head) in terms of plantar sensitivity (p>0.05). It was determined that the probability of the overweight and obese individuals feeling the monofilament in areas where a statistical difference was determined was lower and equal to that of normal individuals (Table 5).

DISCUSSION

The results of our study showed that, supporting our hypothesis, plantar sensation decreased in healthy women as age and BMI values increased. Similarly, it was also determined that the frequency and severity of pain in the feet increased as age increased, and that the severity of pain (VAS) was higher in individuals who were obese when compared with normal weight individuals. Differences have been observed in tactile sensitivity and proprioceptive sensation with increasing age[17–19]. Discriminative touch (i.e., 2-point sensation) has been found to be compromised with aging[20, 21]. The decrease in tactile

Table 5. Plantar sensory distribution according to BMI group

Monofilament measurement area	Monofilament thickness	BMI Group					
		Normal weight		Overweight		Obese	
Right foot		n	%	n	%	n	%
Area 1	4.17	55	98.2	59_{b}	88.1	$73_{a.\ b}$	91.3
	5.07	1_{a}	1.8	8_{b}	11.9	$7_{a.\ b}$	8.8
Area 2	4.17	50_{a}	89.3	55_{a}	82.1	66_{a}	82.5
	5.07	6_{a}	10.7	12_{a}	17.9	14_{a}	17.5
Area 3	4.17	51_{a}	91.1	54_{a}	80.6	67_{a}	83.8
	5.07	5_{a}	8.9	13_{a}	19.4	13_{a}	16.3
Area 4	4.17	46_{a}	82.1	55_{a}	82.1	58_{a}	72.5
	5.07	10_{a}	17.9	12_{a}	17.9	22_{a}	27.5
Area 5	4.17	50_{a}	89.3	51_{a}	76.1	70_{a}	87.5
	5.07	6_{a}	10.7	16_{a}	23.9	10_{a}	12.5
Area 6	4.17	49_{a}	87.5	56_{a}	83.6	63_{a}	78.8
	5.07	7_{a}	12.5	11_{a}	16.4	17_{a}	21.3
Area 7*	4.17	38_{a}	67.9	$39_{a.\ b}$	58.2	35_{b}	43.8
	5.07	18_{a}	32.1	$28_{a.\ b}$	41.8	45_{b}	56.3
Left foot		n	%	n	%	n	%
Area 1*	4.17	47_{a}	83.9	36_{b}	53.7	55_{b}	68.8
	5.07	9_{a}	16.1	31_{b}	46.3	25_{b}	31.3
Area 2	4.17	50_{a}	89.3	57_{a}	85.1	65_{a}	81.3
	5.07	6_{a}	10.7	10_{a}	14.9	15_{a}	18.8
Area 3	4.17	51_{a}	91.1	55_{a}	82.1	67_{a}	83.8
	5.07	5_{a}	8.9	12_{a}	17.9	13_{a}	16.3
Area 4*	4.17	49_{a}	87.5	$50_{a.\ b}$	74.6	52_{b}	65.0
	5.07	7_{a}	12.5	$17_{a.\ b}$	25.4	28_{b}	35.0
Area 5	4.17	50_{a}	89.3	53_{a}	79.1	64_{a}	80.0
	5.07	6_{a}	10.7	14_{a}	20.9	16_{a}	20.0
Area 6	4.17	49_{a}	87.5	58_{a}	86.6	61_{a}	76.3
	5.07	7_{a}	12.5	9_{a}	13.4	19_{a}	23.8
Area 7*	4.17	38_{a}	67.9	40_{a}	59.7	31_{b}	38.8
	5.07	18_{a}	32.1	27_{a}	40.3	49_{b}	61.3

*$p<0.05$, χ^2 test. Different superscripts indicate statistically significant differences (a vs. b, a<0.05).

sensitivity, together with the decreasing stimuli coming from the foot and ankle area, may lead to serious postural stability problems and falling[19]. It is an undeniable fact that tactile sensitivity is clinically important and has an important influence on quality of life. A degradation of tactile acuity in aging may be clinically meaningful in that a recent study identified that the loss of 2-point sensation in the plantar aspect of the toe (in the sole) was significantly greater in fallers than in nonfallers[22]. The afferent signals coming from the sole cutaneous receptors influence balance and stability and ensure temporal and spatial information[23]. These signals play important roles when compensatory actions are needed to maintain continuity of the erect posture. Toledo and Barela[19] observed that the more the proprioceptive system is impaired in elderly subjects, the greater the oscillations of the center of pressure, which reinforced the idea that balance is influenced by the proprioceptive information of the sole of the foot. Franco et al.[24] conducted a study and reported that they could not detect or define any peripheral diseases; however, they observed a lower ability to discriminate two-point pressure in the sole in the elderly when compared with young individuals. Stevens et al. conducted a study on 60 healthy older adults (65 years old and over) and in 19 young adults (18–28 years old) in which they assessed 2-point gap discrimination in 5 body areas (volar forearm, upper and lower surfaces of the forefinger, and plantar and dorsal surfaces of the forefoot) and reported that there were important losses in older adults when compared with young people in tactile acuity, and the loss was greater[25]. Perry conducted a study on 95 older adults (63–75 years old) and on 7 other adults (23–26 years old) and reported that the monofilaments were beneficial when used for assessing age-related insensitivity and that the older adults had plantar-surface insensitivity at an important level when compared with the young adults[9]. In our study, plantar surface sensation decreased with increasing age, which is consistent with the studies conducted so far. Furthermore, the measurements for right and left foot plantar sensitivity were better in individuals in the 25–44 years old group; however, there was no statistically significant difference between the individuals from the 45–65 years old and over 65 years old groups. There were also important decreases in the sensing the 4.17 monofilament in the rear-foot areas of the foot (area 7), forefoot (especially right area 4 and left area 3), and mid-foot (left area 5). We also agree that the monofilaments are beneficial in evaluating age-related insensitivity, which was reported in the study conducted by Perry[9]. It is possible that there might be decreases in plantar cutaneous sensitivity due to different health problems as age increases (visual losses, hearing losses, foot problems, neuropathy, etc.)[21, 26]. As a matter of fact, the frequency and severity of pain in the foot increased with increasing age in the present study. The frequency and severity of the pain were higher in the individuals who were 45 years old and over. Although no statistically significant differences were observed, the severity of pain of the individuals who were 45–64 years old was higher than that of those who were 65 years old and over. We consider that this result may stem from the fact that this age group is more active when compared with individuals who are 65 years old and over. It is possible that the social participations and performance of activities that require standing and walking decrease with increasing age due to retirement or various health problems. This situation may also be observed due to the lower extremity pain occurring for any reason or a decrease in mobility. Complaints of the pain may also influence the everyday activities of an individual. Tactile inputs in the skin of the foot are important for body posture awareness[27]. The ability to sense them is considered a function that has to be cared for, especially at older ages, and must be regained. For this reason, proprioception exercises that can be performed, especially by young adults and adults, and whether an individual has any health problems or not are of great importance in terms of protecting the quality of life of an individual. Similarly, we think that the pain score must be evaluated in individuals who are 45 years old and over, as pain has an important influence on foot functions and proprioception.

In the studies conducted so far, it was observed that increased body weight influenced postural stability in a negative way and increased the risk of falling and injuries. An increase in body weight in obese people influences the functioning of the mechanoreceptors on the bottom of the foot with the increase in load during standing and walking in a negative way, and these results in proprioception loss. In other studies, it was determined that high plantar pressure was related to obesity and that plantar pressure was related to plantar sensitivity[7]. Similarly, it was reported that obesity and an increase in weight in children and adults was related to musculoskeletal pain especially that involving the lower extremity (knee, feet, and hip pains), and led to disability[28]. In our study, it was determined that there was a relation between the BMI value and plantar sensation and that plantar sensitivity decreased as BMI increased in healthy adults (especially in forefoot (areas 1 and 4) and hindfoot areas (area 7)). However, no relations were determined between the BMI and in the mid-foot area of the foot (areas 5 and 6). Similarly, foot pain increased with the increase in weight, and there was a significant relation between foot pain and plantar sensitivity. In our study, the frequency and severity of pain in obese individuals were higher when compared with those of normal weight individuals. Cimolin et al.[29] conducted a study and determined that the contact areas of the forefoot and mid-foot (only the medial area) areas of the foot with the ground were bigger in obese people when compared with those who were not obese, and there were no statistically significant differences in the hindfoot areas. Our results show that the load on the feet increased with the increase in weight in healthy individuals especially around the first toe and heel, and this led to a loss of sensitivity in the areas where excessive load was placed. It was also observed that plantar sensitivity was influenced negatively by foot pain in obese people. Foot pain may influence the distribution of the load on the bottom of the feet in an individual. For this reason, determination of musculoskeletal system problems of the feet in individuals who gain weight-even if they are healthy- is important. It is also important to apply exercises that will increase proprioception together with assessments for loss of sensation. The lack of detailed evaluation of the load on the feet is the important limitation of our study. There is a need for more studies on how an increase in body weight influences plantar pressure and plantar sensitivity.

The important limitation of our study was the fact that the distributions of the load on the feet were not assessed by using different methods. If the relation between the distribution of the load on the feet, especially in individuals who gained weight, and plantar sensitivity was assessed, the relation between foot pain, the distribution of the load on the feet, and plantar sensitivity could be assessed better. In obese individuals with higher levels of pain severity in particular, determination of the distribution of the plantar load on the feet might be important in terms of observing what kind of changes occur when compared with normal weight individuals. More studies must be conducted in which the relation between the distribution of the load on the feet and plantar sensitivity in individuals with different BMI values is investigated. Another limitation of our study was the examination of the pain as *foot pain*. The localization of the foot pain in individuals was not examined. Examination of the localization of the foot pain would facilitate determination of the areas of plantar sensation losses and ensure better interpretation of the relations between them. Since the determination of these relations was not the primary purpose of our study, the fictionalizing of the study was made on foot pain. However, there is need for further studies in which foot pain is determined locally and the plantar relations are examined. Determining the influence of pain on plantar sensation will be important in terms of determining and preventing losses of sensations and the balance and walking problems stemming from them in individuals who have foot pain due to various reasons.

The results of our study demonstrate that although an individual may be healthy, there might be increases in foot pain and decreases in foot plantar cutaneous sensation as age and body mass index increase. When the importance of the relations between foot sensation and mobility and falling is considered, provision of plantar sensation training is considered to be important for individuals to maintain their quality of life and decrease the risk of injuries. There is a need for further studies in which different methodologies are used to examine this issue.

CONFLICT OF INTEREST

The authors declare that they have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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