RESEARCH ON FOOT ANTHROPOMETRY AND COMPLICATIONS OF WOMEN WITH DIABETES IN VIETNAM

Van-Huan BUI*, Duy-Nam PHAN

Faculty of Textile – Leather and Fashion, School of Materials Science and Engineering, Hanoi University of Science and Technology, No. 1, Dai Co Viet, Hai Ba Trung, Hanoi, Vietnam

Received: 18.03.2024 Accepted: 11.06.2024 https://doi.org/10.24264/lfj.24.2.5

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ABSTRACT. Diabetes is a dangerous, chronic disease that frequently causes foot complications. Diabetes patients are at risk for amputation due to the serious complications of foot ulcers. Shoes made specifically for people with diabetes might greatly reduce this issue. It is crucial to wear shoes that are specifically made for the patient based on their anthropometric measurements and the evaluation of foot damage. The foot anthropometric and foot damage study results of 295 female diabetic patients at Khoai Chau District Medical Centre, Hung Yen Province, and the National Hospital of Endocrinology of Vietnam are presented in this research. The results showed that there were differences in measurements of height, width, and foot circumference between the two groups of patients. This discrepancy, which is independent of age, is caused by the level of problems or injuries to the feet. Women with diabetes often experience worsening foot injuries over the course of the illness. According to the level of foot complications, up to 96.69% of female patients with diabetes require "Extra Depth Diabetic Shoes"; 17.9% of patients needed "Custom Molded Inlays/insoles"; 3.1% of patients need to use "Custom Molded Diabetic Shoes" and "Custom Molded Inlays".

KEY WORDS: diabetic foot, foot anthropometry, therapy shoes, custom diabetic shoes

CERCETĂRI PRIVIND ANTROPOMETRIA PICIORULUI ȘI COMPLICAȚIILE APĂRUTE LA FEMEILE CU DIABET DIN VIETNAM

REZUMAT. Diabetul este o boală cronică periculoasă, care provoacă frecvent complicații la nivelul picioarelor. Pacienții cu diabet sunt expuși riscului de amputare din cauza complicațiilor grave ale ulcerului piciorului. Încălțămintea fabricată special pentru persoanele cu diabet ar putea reduce foarte mult această problemă. Este esențială purtarea de încălțăminte fabricată special pentru pacient, pe baza măsurătorilor antropometrice și a evaluării leziunilor piciorului. În această cercetare sunt prezentate rezultatele studiului antropometric și de evaluare a leziunilor piciorului la care au participat 295 de femei cu diabet, paciente ale Centrului Medical Districtual Khoai Chau, provincia Hung Yen și ale Spitalului Național de Endocrinologie din Vietnam. Rezultatele au arătat că au existat diferențe în măsurătorile înălțimii, lățimii și circumferinței piciorului între cele două grupuri de pacienți. Această discrepanță, care este independentă de vârstă, este cauzată de gradul leziunilor la nivelul picioarelor. Femeile cu diabet se confruntă adesea cu leziuni care se agravează pe parcursul bolii. În funcție de nivelul complicațiilor piciorului, până la 96,69% dintre pacienții de sex feminin cu diabet au nevoie de „Încălțăminte pentru diabet cu adâncime suplimentară"; 17,9% dintre pacienți au avut nevoie de „Inserții/Branțuri personalizate"; 3,1% dintre pacienți trebuie să folosească „Încălțăminte personalizată pentru diabetici" și „Inserții personalizate".

CUVINTE CHEIE: picior diabetic, antropometria piciorului, încălțăminte ortopedică, încălțăminte personalizată pentru diabetici

RECHERCHE SUR L'ANTHROPOMÉTRIE DU PIED ET LES COMPLICATIONS CHEZ LES FEMMES DIABÉTIQUES AU VIETNAM

RÉSUMÉ. Le diabète est une maladie chronique dangereuse qui entraîne fréquemment des complications au niveau des pieds. Les patients diabétiques courent un risque d'amputation en raison des complications graves des ulcères du pied. Des chaussures spécialement conçues pour les personnes diabétiques pourraient réduire considérablement ce problème. Il est essentiel de porter des chaussures spécialement conçues pour le patient en fonction de ses mesures anthropométriques et de l'évaluation des lésions du pied. Les résultats de l'étude anthropométrique du pied et des lésions du pied portant sur 295 patientes diabétiques du centre médical du district de Khoai Chau, province de Hung Yen, et de l'Hôpital National d'Endocrinologie du Vietnam sont présentés dans cette recherche. Les résultats ont montré qu'il existait des différences dans les mesures de taille, de largeur et de circonférence du pied entre les deux groupes de patients. Cet écart, indépendant de l'âge, est dû au niveau de problèmes ou de lésions du pied. Les femmes atteintes de diabète subissent souvent des lésions aux pieds qui s'aggravent au cours de la maladie. Selon le niveau de complications du pied, jusqu'à 96,69 % des patientes diabétiques ont besoin de « chaussures pour diabétiques avec une profondeur supplémentaire » ; 17,9 % des patientes avaient besoin de « inserts/semelles moulées sur mesure » ; 3,1 % des patientes doivent utiliser des « chaussures pour diabétiques moulées sur mesure » et des « inserts moulées sur mesure ».

MOTS CLÉS : pied diabétique, anthropométrie du pied, chaussures orthopédiques, chaussures sur mesure pour les patients diabétiques

* *Correspondence to: Van-Huan BUI, Department of Textile – Leather and Fashion, School of Materials Science and Engineering, Hanoi University of Science and Technology, No. 1, Dai Co Viet, Hai Ba Trung, Hanoi, Vietnam, huan.buivan@hust.edu.vn*

INTRODUCTION

According to data from the Ministry of Health of Vietnam [1], in Vietnam, there will be seven million diabetics by 2023. Remarkably, more than 55% of patients experienced complications; 34% were cardiovascular complications, 39.5% were ocular and neurological complications, and 24% were kidney complications. Over 17% of people have prediabetes [1].

Diabetics usually have dangerous complications such as coronary artery disease, cardiovascular diseases, neurologic diseases, kidney diseases, blindness diseases, etc. The feet of people with diabetes are very susceptible to damage due to a reduction in or loss of feelings, poor blood flow, etc. Dry skin, cracked skin, calluses, and ulcers are the most common complications. An extremely high risk of amputation results from foot injuries, particularly ulcers, which are extremely difficult to cure because of a lack of oxygen, nutrition, and lowered antibodies [1–3]. Different results for the types of foot damage in individuals with diabetes have been shown in previous published publications [4–15]. This is dependent upon the location, attributes, and quantity of patients under investigation. According to Abbas and Archibald [4], 40% of diabetic patients in Africa experience foot issues like blisters, sores, ulcers, and scrapes. According to Ahmed, O. *et al.*, the risk of foot ulcers rises with disease duration, more than ten years, for up to 18.1% of diabetic patients in Sudan [5]. Foot ulcers can affect as many as 44.5% of diabetic individuals in Bangladesh. Men are more at risk (45.6%) than women are, and those who live in rural regions are more at risk (45.5%) than those who live in cities [6]. In Nigeria, according to Tagang [7], the feet of female patients were more damaged than those of male patients. With a percentage of up to 36% for women and 27% for men, lesions on the plantar of the feet are most common in the area between the second and fifth toes. The rate of damage to the entire metatarsophalangeal joint is up to 35% for women and 27% for men. At the heel position, this rate is 32% for female patients, and 16% for male patients. Gopi Chellan and colleagues' research [8] indicates that the following rates of foot injuries occur in India: 11.9% in the big toe, 7.5% in the mid-foot, 15.5% in the forefoot and remaining toes, 4.2% in toe deformities, 37.4% in muscle, and 6.4% in bone.

By 2012, Cynthia Formosa *et al.* [9] determined that the highest rate of lesions on diabetic feet in Malta was in the big toe joints, accounting for 49.4%. Next is the hallux, accounting for 39%, and the metatarsal head, accounting for 24%. Research by S.O. Oyibo *et al.* [10] in Manchester states that 86.7% of patients had foot ulcers. Forefoot ulcers make up 76.7% of them. 2.1% comes from Charcot feet. 11.2% of patients needed specific foot care and amputation surgery. The majority of patients only have one foot ulcer, while 16% of patients have more than one. As to the 2011 National Institutes of Health data from the United States [11], approximately thirty percent of individuals with diabetes who are 40 years of age or older experience decreased sensation in their feet. Big toe joint ulcers account for 27% of all ulcers, according to research by Waaijman *et al.* [12]. A study conducted in Vietnam in 2002 by Bui, M.D. [13] revealed the prevalence of foot ulcers among people with diabetes. In particular, the toe tips account for 31.5 percent, while the instep, heel, and space between the toes each have a 9.3 percent share. The percentage of common foot ulcers in diabetes patients was found by Dang, T.M.T. [14] in 2011 to be as follows: 15.6% in the heel, 17.7% in the plantar, and 28.9% in the toes. In order to investigate the external sources of foot ulcers, Le, B.N. [15] studied 58 male and 36 female diabetes patients in Vietnam in 2018. These studies have only focused on: 1) determining the rate and causes of foot ulcers for treatment, not evaluating other types of foot damage; 2) carry out a survey in a single place; 3) a small-scale survey of diabetic foot patients; 4) not paying attention to foot measurements for the purpose of designing shoes and insoles.

Research on anthropometry and foot damage to design and produce shoes for diabetic patients is still relatively new in Vietnam. There are no diabetic-specific or

therapeutic shoes available in Vietnam. Numerous anthropometric investigations on diabetic patients' feet have been conducted recently [16–19], as has the design of shoe lasts for male diabetic patients [20]. However, comprehensive research on evaluating foot damage is lacking, particularly in the case of female diabetic feet. Therefore, in this study, we concentrated on measuring the feet and evaluating the pathology or damage of the feet in female diabetic patients in different locations in Vietnam to serve as a basis for designing shoes and insoles for patients.

EXPERIMENTAL

Subjects and Methods

Subjects

We concentrate on diabetic patients over 40 in this study. To be able to measure the feet of diabetic patients with different levels of complications, we selected two medical locations as follows:

1) Khoai Chau district medical central, Hung Yen province. At this Center, diabetic patients, usually patients with mild disease, periodically come for examination and get medicine and referred to as patients' group 1.

2) Department of Endocrinology – National Hospital of Endocrinology. This is a leading hospital specializing in diabetes treatment. At this hospital, there are not only patients living in Hanoi but also patients living in the Northern provinces of Vietnam, who come for examination and treatment. Patients here suffered from various foot complications, with a higher risk of ulceration compared to group 1 and referred to as patients' group 2.

In total, 295 female diabetic patients' feet were examined at these 2 locations; group 1 consisted of 116 individuals, and group 2 consisted of 179 individuals.

Measurement Method

In this study, we used the same foot measurement method as demonstrated in the previously published foot study of male diabetic patients [19]. We directly measured both bare feet in an upright position. The foot measuring device includes a soft narrow tape measure, a caliper with a 1 mm scale, and a footprint device. Measurement time is from 9 am to 11 am on weekdays. Foot measurements are as follows [19]:

Lf – Foot length;
Lmb – Length to medial ball;
Llb – Length to lateral ball;
L5toe – Length to the end of 5^{th} toe;
Lh – Length to the widest point of the heel
Rmb – Width of medial ball;
Rlb – Width of lateral ball;
Rb – Width of ball;
Rh – Width of heel;
Vmb – Medial ball girth;
Vlb – Lateral ball girth;
Vb – Ball girth;
Vw – Waist girth;
Vins – Instep girth;
Vh – Heel (cross) girth;
Va – Ankle girth;
C1toe – Height at 1^{st} toe;
Cmb – Medial ball height;
Cmd – Height at midfoot point;
Cins – Instep height;
Cla - Height at lateral ankle center;
α – Angle of the big toe.

H - Longitudinal arch factor. This is one of several indexes to help classify feet into 3 groups, as follows: subjects with normal, *pes cavus* (high arched), *pes planus* (flat) [21], or into 4 groups, i.e. one more group of *hallux-valgus* foot [22, 23].

Assessing Foot Damage Method

Along with measuring the feet, the patient's foot damage/pathology is recorded according to symptoms [24]:

- Normal feet without complications and losing protective sensation;
- Foot pain and swollen metatarsophalangeal joints;
- Skin changes (dry, cracked skin);
- Corns;
- Deformity of the foot, big toe bending outward/twisting;
- Foot ulcers;
- Loss/ impairment of protective sensation;
- Amputation.

The patient's foot lesions were recorded by observing them, interviewing the patient, reviewing medical examination results, and taking photos of the damaged feet with a digital camera.

Analyzing Measurement Data

The maximum, minimum, mean and standard deviation values of the left and right foot measurements are determined and compared. A Student Samples T-Test was conducted in order to find statistical significance of left and right foot measurements. The difference between the average values of foot measurements of the two groups of patients were calculated. We compared the average values of foot measurements according to age groups with each other, specifically age groups: 41-50, 51-60, 61-70 and 71-80 years old. The statistical significance of these comparisons was also found using the Student Samples T-Test [23].

Statistics on Foot Injuries/Pathologies

The actual condition of the feet of women with diabetes according to each type of injury is statistically and evaluated. From there, it is possible to initially determine the number/proportion of feet that need to use different types of therapeutic shoes [22]:

1) "Extra Depth Diabetic Shoes" and "Diabetic Inlays" (A5500) are for patients whose feet do not have loss of sensation, deformity, or a history of foot ulcers.

2) "Extra Depth Diabetic Shoes" and "Custom Molded Inlays" (A5512) are for patients who have lost protective sensation in the foot, have no deformity/mild deformity in the foot, or have a history of plantar ulceration.

3) "Custom Molded Diabetic Shoes" and "Custom Molded Inlays" (A5513) are for patients with loss of protective sensation in the foot with deformity or a history of sole ulceration or amputation.

To be able to design custom molded insoles for patients, in addition to assessing foot damage, it is necessary to determine the pressure distribution on its plantar [22].

RESULTS AND DISCUSSIONS

Female Diabetes Patients' General Information

Table 1: Female diabetes patients' information

Information	Patients group 1			Patients group 2		
	Min	Max	Average	Min	Max	Average
Height, cm	140	171	156.2 ± 4.6	138	170	154.1± 5.1
Weight, kg	35	81	53.7 ± 8.2	35	78	54.7± 7.3
Age, year	37	75	58.9 ± 6.9	39	91	65.8±8.4
Year of diabetes, year	1	18	4.5 ± 3.2	1	41	10.6±8.1

The average height of studied female patients is 154.1 – 156.2 cm, which is the average height of Vietnamese women, the average of weight is 53.7 – 54.7 kg, BMI about 22.6 indicates the normal body. According to age and number of years of diabetes, patients in group 1 have less age (58.9 years) and number of years of diabetes (4.5 years) than patients in group 2 (65.8 years) and 10.6 years.

Table 2 presents statistical results about the age distribution of patients at two medical locations. It shows that, in patients' group 1, the age group of 51 to 60 years old accounts for a large portion (up to 50.9%); the age group of 50 years accounts for 19%, while the age group of 71 to 80 years contributes a small proportion (about 2.6%). Group 1 has no patients over 80 years old. Meanwhile 43.6% of patients in group 2 are aged from 61 to 70 years old; patients aged from 51 to 60 and from 71 to 80 also account for a large proportion, 22.9% and 25.7%, respectively. The number of patients up to 50 years and over 80 years accounts for a small proportion of about 3.9%. This is reasonable because patients' group 2 is from central hospital,

which frequently examines and treats critical cases sent from medical station in addition to treating patients in Hanoi. Meanwhile, diabetes often tends to get worse over with duration or patient's age.

Table 2: Number of patients according to age group

	Patients group 1					
Group of age, year	≤50	51÷60	61÷70	71÷80	>80	Total
Quantity, people	22	59	32	3	0	116
Rate, %	19.0	50.9	27.6	2.6	0	100
	Patients group 2					
Quantity, people	7	41	78	46	7	179
Rate, %	3.9	22.9	43.6	25.7	3.9	100

Table 3: Female diabetes patients' job

Job	Officers	Workers	Farmers	Others	Total
	Patients group 1				
Quantity	11	19	60	26	116
Rate (%)	9.5	16.4	51.7	22.4	100
	Patients group 2				
Quantity	36	49	65	28	179
Rate (%)	20.2	27.6	36.4	15.8	100

The highest number of patients' group 1 patients are farmers (51.7%), workers (16.4%), officials (9.5%) and others (22.4%). The number of patients in group 2 who are officials and workers is higher, reaching 20.2% and 27.6%, respectively, while the number of patients who are farmers decreased significantly to 36.4% (Table 3).

Female Diabetes Patients' Foot Measurement

Table 4: The difference between the average of left and right foot measurements in 2 group patients

Foot measurement	Patients group 1								Patients group 2							
	Foot measurement values, mm					Deviation, mm			Foot measurement values, mm					Deviation, mm		
	Left	Right	Difference	Difference Max	p(two-tailed)	Left	Right	Difference	Left	Right	Difference	Difference Max	p(two-tailed)	Left	Right	Difference
Lf	230.8	230.4	0.4	5.0	0.556	8.6	8.7	-0.1	227.5	228.4	-0.9	9.0	0.315	9.6	9.6	-0.1
Lmb	168.5	168.6	-0.1	5.0	0.409	6.9	6.9	-0.1	163.2	163.1	0.1	11.0	0.860	8.4	8.2	0.2
Llb	150.0	149.9	0.1	5.0	0.271	6.2	6.2	0.0	145.0	146.6	-1.6	11.0	***0.015***	8.0	7.8	0.2
L5toe	193.8	193.5	0.3	9.0	0.618	7.6	7.8	-0.2	188.2	189.6	-1.4	7.0	0.091	8.3	8.4	-0.2
Lh	39.3	40.0	-0.7	8.0	0.548	7.8	7.8	0.0	38.5	38.8	-0.3	7.0	0.312	8.8	8.3	-0.5
Rmb	93.6	93.3	0.3	7.0	0.095	5.2	5.2	0.0	88.6	89.4	-0.8	13.0	0.170	5.8	5.6	0.2
Rlb	89.1	89.0	0.1	9.0	0.146	5.2	4.9	0.3	84.9	86.3	-1.5	10.0	***0.007***	5.9	6.4	-0.5
Rb	101.7	102.5	0.4	9.0	0.547	5.5	5.2	0.4	92.7	92.2	0.5	10.0	0.415	6.1	5.9	0.2
Rh	61.0	60.7	0.3	5.0	0.378	3.8	3.9	-0.1	58.6	59.0	-0.4	9.0	0.274	4.8	4.9	0.0
C1toe	19.7	20.1	-0.4	2.0	0.096	1.7	1.8	-0.1	18.3	18.9	-0.5	4.0	***0.005***	1.9	2.1	-0.2
Cmb	31.1	30.8	0.3	3.0	0.129	2.9	3.1	-0.2	29.8	30.7	-0.9	8.0	***0.007***	3.2	3.2	0.0
Cmd	44.1	43.7	0.4	3.0	0.167	4.7	4.5	0.2	52.1	52.8	-0.7	10.0	0.153	4.3	4.3	0.0
Cins	60.0	59.8	0.2	3.0	0.333	5.0	4.9	0.0	63.2	63.3	-0.1	10.0	0.847	4.5	4.4	0.1
Cla	59.4	59.4	0.0	3.0	0.726	3.3	3.1	0.1	56.3	57.6	-1.3	9.0	***0.000***	4.4	4.6	-0.2
Vmb	210.2	210.1	0.1	3.0	0.678	10.1	10.8	-0.7	206.5	207.6	-1.1	19.0	0.333	13.1	13.1	0.1
Vlb	212.4	212.3	0.1	10.0	0.618	9.9	10.2	-0.3	210.6	210.3	0.3	13.0	0.787	13.2	13.1	0.1
Vb	223.7	223.7	0.0	5.0	0.582	11.5	11.9	-0.5	219.0	219.3	-0.3	20.0	0.793	11.9	12.0	0.0

Foot measurement	Patients group 1								Patients group 2							
	Foot measurement values, mm					Deviation, mm			Foot measurement values, mm					Deviation, mm		
	Left	Right	Difference	Difference Max	p(two-tailed)	Left	Right	Difference	Left	Right	Difference	Difference Max	p(two-tailed)	Left	Right	Difference
Vw	217.5	217.5	0.0	5.0	0.682	13.6	13.7	-0.1	215.2	215.1	0.2	24.0	0.907	12.9	12.9	0.0
Vins	242.0	242.6	-0.6	5.0	0.572	13.0	13.0	0.0	238.7	240.5	-1.8	20.0	0.189	14.4	14.0	0.4
Vh	292.9	292.8	0.1	5.0	0.733	13.1	13.5	-0.5	289.1	289.5	-0.4	20.0	0.784	19.2	19.2	0.0
Va	190.1	190.2	0.0	3.0	0.742	17.0	16.7	0.3	192.7	192.9	-0.3	19.0	0.875	15.5	15.5	0.0
α	4.9	9.9	5.0	18.0	0.058	8.3	8.2	0.0	7.8	9.8	-1.8	25.0	***0.029***	5.3	5.5	-0.2
H	0.7	0.7	0.0	0.6	0.058	0.2	0.1	0.1	0.8	0.8	0.0	0.6	***0.033***	0.2	0.2	0.0

The two patient groups' average values for the length, width, and height of their right and left feet (Table 4) differ by no more than 1.3 mm, whereas the group's circumference measures show a maximum variation of 2 mm. The results of Levene's Test and T test for left and right foot both found p-value and p(two-tailed) value greater than 0.05. This confirms that there is no difference in the left and right foot of group 1.

There are differences in some measurements for patients in group 2, including thumb height C1toe, medial ball height Cmb, height at lateral ankle center Cla, angle of the big toe α, and longitudinal arch factor H ($p<0.05$ and p(two-tailed) <0.05). When experiencing varying levels of foot damage, this also indicates larger variability in the diabetic foot measurement values. This is also consistent with the maximum difference of the left and right feet of group 2. This difference value is often larger than the corresponding values of group 1 (Table 4).

The left and right foot measurements of the two patient groups have standard deviations that are similar to the foot value, typically being less than 1 mm. The feet of individuals without the disease resemble this [25].

There is a maximum 5 mm difference in the average value of the foot measures between patients in groups 1 and 2. Patients in group 1 were 2.6 mm longer in the foot than patients in group 2 (Table 5). This is reasonable because group 1 patients are on average 2.1 cm taller than group 2 patients. Similarly, the ball girth Vb and the ball width Rb are bigger by 4.5 mm and 2.7 mm, respectively.

Patients in group 2 have smaller big toe angles in their feet than patients in group 1, which can be attributed to the patients' tendency to push their big toes outward as a result of their diabetes. The same goes for the foot arch coefficient. This value (0.8) in group 2 patients' feet is larger than that of group 1 patients' feet (0.7), indicating that diabetic patients' foot arches tend to lower with the course of their condition. This demonstrates how beneficial it is for diabetes people to use diabetic or customized molded insoles.

The results of the T Test in Table 5 confirm that there is no difference between the foot length measurements Lf of the two groups of patients ($p>0.05$, p(two-tailed)=0.0860>0.05). Meanwhile, there were differences in all remaining foot measurements between patients in groups 1 and 2 ($p<0.05$, p(two-tailed) < 0.05). The standard deviation value of foot measurements at two medical facilities also clearly shows this. Compared with the corresponding standard deviation of foot measurements in group 1 patients, the majority of foot measurements in group 2 patients have higher standard deviations. The significant variation in parameter values in the feet of group 2 patients is also indicated by high standard deviation values.

Table 5: The difference between the average of foot measurements of group 1 and group 2

Foot measurement	Foot measurement values, mm				Deviation, mm		
	Group 1	Group 2	Difference	p(two-tailed)	Group 1	Group 2	Difference
Lf	230.6	228.0	2.6	0.0860	9.6	8.7	0.9
Lmb	168.6	164.2	4.4	0.0000	8.3	6.9	1.4
Llb	150	145.8	4.2	0.0000	7.9	6.2	1.7
L5toe	193.7	188.9	4.7	0.0000	8.3	7.7	0.6
Lh	39.5	38.6	0.9	0.0000	8.5	7.8	0.7
Rmb	93.5	89.0	4.4	0.0000	5.7	5.2	0.5
Rlb	89.1	85.6	3.5	0.0000	6.2	5.1	1.1
Rb	95.1	92.4	2.7	0.0000	6.0	5.4	0.6
Rh	60.9	58.8	2.1	0.0000	4.9	3.8	1.1
C1toe	19.9	18.6	1.3	0.0020	2.0	1.7	0.3
Cmb	31	30.3	0.7	0.0041	3.2	3.0	0.2
Cmd	53.9	52.5	1.4	0.0096	4.3	4.6	-0.3
Cins	59.9	62.2	-2.7	0.0100	4.4	5.0	-0.6
Cla	59.4	57.0	2.4	0.0005	4.5	3.2	1.3
Vmb	210.2	207.0	3.1	0.0000	13.1	10.5	2.6
Vlb	212.4	210.5	1.9	0.0001	13.2	10.0	3.2
Vb	223.7	219.2	4.5	0.0001	12.0	11.7	0.3
Vw	217.5	215.1	2.4	0.0493	12.9	13.7	-0.8
Vins	242.3	239.6	2.7	0.0478	14.4	13.0	1.4
Vh	292.9	289.3	3.5	0.0046	16.2	13.3	2.9
Va	190.2	192.8	-2.7	*0.6560*	15.5	16.8	-1.3
α	7.4	8.8	-1.4	0.0023	7.2	5.4	1.8
H	0.7	0.8	-0.1	*0.1700*	0.2	0.2	0.0

In order to assess how age affects foot parameter values, we examined the average foot measurement values across three age groups, which together account for a large proportion of the patients in each group (Tables 6 and 7).

Table 6: The average of the feet of patients in group 1 according to three age groups

Foot measurement	Average, mm	Foot measurement values by age group					
		41-50 (n=20)		51-60 (n=59)		61-70 (n=35)	
		Value, mm	Difference	Value, mm	Difference	Value, mm	Difference
Lf	*230.6*	*232.1*	*-1.5*	*230.1*	*-0.5*	*230.0*	*-0.60*
Lmb	168.6	171.3	*-2.7*	167.7	-0.9	168.1	-0.60
Llb	150.0	152.8	*-2.8*	149.4	-0.4	148.9	-1.00
L5toe	193.7	194.1	*-0.4*	191.3	-0.7	191.9	-0.10
Lh	39.5	40.0	*-0.5*	39.1	-0.4	39.0	-0.50
Rmb	93.5	92.9	*0.6*	93.0	0.2	92.2	-0.50
Rlb	89.1	90.5	*-1.4*	89.3	0.2	87.9	-1.20
Rb	*95.1*	*96.4*	*-1.3*	*94.8*	*-0.3*	*95.0*	*-0.10*
Rh	60.9	61.0	*-0.1*	60.9	0.4	59.6	-0.90
C1toe	19.9	19.1	*0.8*	19.0	-0.1	19.2	-0.10
Cmb	31.0	31.6	*-0.6*	30.9	-0.1	31.0	0.00
Cmd	53.9	52.0	*1.9*	44.5	-0.6	45.0	-0.10
Cins	58.9	60.9	*-2*	60.1	-0.3	60.5	0.10
Cla	59.4	57.2	*2.2*	58.5	0.2	58.5	0.20

Foot measurement	Average, mm	Foot measurement values by age group					
		41-50 (n=20)		51-60 (n=59)		61-70 (n=35)	
		Value, mm	Difference	Value, mm	Difference	Value, mm	Difference
Vmb	210.2	212.2	*-2*	211.7	-0.8	209.5	2.90
Vlb	212.4	216.1	*-3.7*	214.2	-0.7	211.7	2.80
Vb	*223.7*	*226.3*	*-2.6*	*223.1*	*-0.2*	*221.0*	*1.80*
Vw	217.5	220.2	*-2.7*	215.3	-0.7	213.6	1.50
Vins	242.3	244.8	*-2.5*	241.9	-0.4	240.4	0.10
Vh	292.9	295.8	*-2.9*	293.7	-0.1	289.8	4.00
Va	190.2	192.4	*-2.2*	191.4	-0.8	189.6	1.40
α	7.4	6.2	*1.2*	7.8	0.4	8.5	1.10
H	0.7	0.6	*0.1*	0.7	0.0	0.8	0.10

Table 7: The average of the feet of patients in group 2 according to three age groups

Foot measurement	Average, mm	Foot measurement values by age group					
		51-60 (n=41)		61-70 (n=78)		71-80 (n=46)	
		Value, mm	Difference	Value, mm	Difference	Value, mm	Difference
Lf	*228.0*	*228.4*	*-0.4*	*228.8*	*-0.8*	*226.3*	*1.6*
Lmb	163.2	162.5	0.6	163.8	-0.6	162.5	0.7
Llb	145.8	145.7	0.0	146.1	-0.4	145.1	0.7
L5toe	188.9	188.4	0.5	189.4	-0.5	188.6	0.3
Lh	38.6	38.0	0.7	39.0	-0.4	38.4	0.2
Rmb	89.0	88.8	0.2	89.1	-0.1	88.7	0.3
Rlb	85.6	85.6	0.0	85.7	-0.1	85.3	0.3
Rb	*92.4*	*92.1*	*0.3*	*92.5*	*-0.1*	*92.3*	*0.2*
Rh	58.8	58.4	0.4	58.9	-0.1	58.4	0.4
C1toe	18.6	18.5	0.2	18.7	-0.1	18.5	0.1
Cmb	30.3	30.2	0.0	30.4	-0.2	30.1	0.2
Cmd	52.5	52.8	-0.3	52.4	0.1	53.0	-0.5
Cins	63.2	63.4	-0.2	63.0	0.2	64.0	-0.8
Cla	57.0	57.4	-0.5	57.4	-0.4	56.0	1.0
Vmb	207.0	206.1	0.9	208.1	1.0	206.0	1.0
Vlb	210.5	210.4	0.0	211.2	-0.7	209.5	1.0
Vb	*219.2*	*218.6*	*0.5*	*219.8*	*-0.6*	*218.2*	*1.0*
Vw	215.1	215.6	-0.5	214.8	0.4	215.1	0.1
Vins	239.6	239.8	-0.2	240.0	-0.4	239.2	0.4
Vh	289.3	287.7	1.6	290.1	-0.8	288.6	0.7
Va	192.8	191.1	1.7	192.5	0.3	192.1	0.7
α	8.8	7.5	1.3	8.6	0.2	9.1	-0.3
H	0.8	0.8	0.0	0.7	0.0	0.8	0.0

The results shown in Tables 6 and 7 indicate that there is no large difference between the foot measurement average value of the group and the foot measurement values for each age group. In particular, based on three primary measures, the ball girth Vb is not greater than 2.6 mm, the ball width Rb is not greater than 1.3 mm, and the foot length Lf difference is 1.5 mm (group 1) and 1.6 mm (group 2).

We conducted Independent Samples T-tests to find the statistical significance of the results comparing feet between groups by age; the feet of each age group were compared with the average value of each group (Table 8). For the feet of group 1, all p-values of Levene's Test and p(two-tailed) values of T test have values greater than 0.05. This confirms that there is no difference in main foot measurements according to age group of group 1.

Group 2 had similar results to group 1, except the p(two-tailed)-value for groups 51–60-year-old and 71–80-year-old reached lower than 0.05, showing that the initial hypothesis is no longer valid.

Table 8: p(2-tailed)-value of the independent Samples T-test for the main measurements of the foot, comparing age groups

Comparing groups	p(two-tailed)-value		
	Lf	Rb	Vb
Group 1			
Groups of 41-50 and 51-60 years old	0.056	0.053	0.061
Groups of 41-50 and 61-70 years old	0.058	0.062	0.071
Groups of 51-60 and 61-70 years old	0.984	0.055	0.132
41–50-year-old group and average value of group 1	0.060	0.161	0.057
51–60-year-old group and average value of group 1	0.992	0.887	0.908
61–70-year-old group and average value of group 1	0.989	0.351	0.076
Group 2			
Groups of 51-60 and 61-70 years old	0.800	0.149	0.592
Groups of 51-60 and 71-80 years old	0.227	***0.029***	0.844
Groups of 61-70 and 71-80 years old	0.142	0.421	0.466
51–60-year-old group and average value of group 2	0.778	0.135	0.834
61–70-year-old group and average value of group 2	0.514	0.830	0.693
71–80-year-old group and average value of group 2	0.241	0.269	0.648
2 age groups of 2 groups of patients			
2 groups 51-60 years old	0.192	0.000	0.014
2 groups 61-70 years old	0.334	0.000	0.046

We continue to compare the values of foot measurements of two groups of patients aged 51-60 years and 61-70 years old (Table 9). Independent Samples T-tests were performed for these comparisons (Table 8). The results showed that there was no difference in foot length Lf (p values>0.05), but there were differences in width Rb and toe joint circumference Vb according to age groups of the 2 groups of patients (p values < 0.05).

Table 9: Comparison of foot measurements by two age groups of two patient groups

Foot measurements	Foot measurement values by age group, mm					
	51-60			61-70		
	Group 1	Group 2	Difference	Group 1	Group 2	Difference
Lf	230.1	228.4	1.7	230.0	228.8	1.2
Lmb	167.7	162.5	5.2	168.1	163.8	4.3
Llb	149.4	145.7	3.7	148.9	146.1	2.8
L5toe	191.3	188.4	2.9	191.9	189.4	2.5
Lh	39.1	38.0	1.1	39.0	39.0	0.0
Rmb	93.0	88.8	4.2	92.2	89.1	3.1
Rlb	89.3	85.6	3.7	87.9	85.7	2.2
Rb	94.8	92.1	2.7	95	92.5	2.5
Rh	60.9	58.4	2.5	59.6	58.9	0.7
C1toe	19.0	18.5	0.5	19.2	18.7	0.5
Cmb	30.9	30.2	0.7	31	30.4	0.6
Cmd	44.5	50.8	-6.3	45	50.4	-5.4
Cins	60.1	63.4	-3.3	60.5	63.0	-2.5
Cla	58.5	57.4	1.1	58.5	57.4	1.1
Vmb	211.7	206.1	5.6	209.5	208.1	1.4
Vlb	214.2	210.4	3.8	211.7	211.2	0.5
Vb	223.1	218.6	4.5	223.0	219.8	3.2
Vw	215.3	215.6	-0.3	213.6	214.8	-1.2

Foot measurements	Foot measurement values by age group, mm					
	51-60			61-70		
	Group 1	Group 2	Difference	Group 1	Group 2	Difference
Vins	241.9	239.8	2.1	240.4	240	0.4
Vh	293.7	287.7	6.0	289.8	290.1	-0.3
H	0.7	0.8	-0.1	0.6	0.7	-0.1

Consequently, it is evident that the level of foot damage mostly determines the variation in the average measurements of a patient's foot rather than age. It is obvious from this that determining the level of damage to the feet is essential in order to identify which feet require the use of specific shoe types [24].

Diabetic Women's Feet Damaged Condition

In addition to fitting properly, diabetes patients' shoes and insoles must also lower body pressure on the foot plantar and lower peak pressure, which can lead to foot ulcers. As a result, while designing and producing shoes or shoe insoles for diabetes patients, consideration must be given to both foot measurements and the many forms of foot injury. Diabetes patients who are female generally have large calluses on their ankles and metatarsophalangeal joints; the big toe joint is frequently enlarged and slightly deformed; some have a history of ulcers on the plantar of their feet; and there are minor ulcers on their ankle flexors. Numerous patients' feet have two or more different kinds of injury. Table 10 lists the percentage of patients' feet with various injuries.

The diabetes status of patients' group 1 is basically still mild, as shown by the number of patients with undamaged feet accounting for 50.9%. The number of female patients with pain and swollen metatarsophalangeal joints is relatively large, accounting for 26.7%. The number of patients with dry foot skin, cracked skin and calluses is almost equal proportions, roughly 18.1%. The number of patients with foot ulcers accounted for 4.3% and no patients had to have a foot amputated. Patients in group 2 have more serious diabetes than those in group 1. The percentage of patients with normal feet dropped to 32.3%, indicating this, whereas the percentage of feet with damage of all kinds sharply climbed. Eight percent of feet have ulcers or a history of ulcers, and two individuals had a portion of one foot amputated. More than 62.1% of patients had two different forms of foot injuries, which is a rather high percentage.

Table 10: Damaged feet conditions of female diabetes patients

Foot conditions	Group 1		Group 2		Type of shoes [24]
	Rate, %	Duration of diabetes, year	Rate, %	Duration of diabetes, year	
Normal feet without complications and losing protective sensation	50.9	3.8 ± 2,8	32.3	4.68 ± 2.5	A5500
Foot pain and swollen metatarsophalangeal joints	26.7	4.16 ± 2,1	33.5	5.90 ± 2.7	A5500; A5512*
Skin changes (dry, cracked skin)	18.1	4.39 ± 2,8	29.6	6.80 ± 3.9	A5500; A5512*
Corns	15.5	5.23 ± 3,8	27.9	6.50 ± 4.4	A5500; A5512*
Deformity of the foot, big toe bending outward/twisting	13.8	5.46 ± 4,1	22.4	8.80 ± 5.9	A5512; A5513*
Foot ulcers	4.3	5.82 ± 4,3	8.4	8.58 ± 5.1	A5512; A5513**
Loss/ impairment of protective sensation	4.6	6.97 ± 5,5	7.9	7.91 ± 6.8	A5512; A5513**
Amputation	0	0	0.1	15 ± 9.8	A5513
Total	133.9		162.1		

Note: * cases of ulcers on the soles of the feet and impaired/loss of sensation.
** cases where the foot is deformed and loses protective sensation

The percentage of shoe types required for each female patients has been preliminary determined based on the US Medicare Program's guidelines for utilizing therapeutic shoes/shoe insoles in doctor's prescriptions [24]. The results are displayed in Table 11.

Table 11: Preliminary statistical results of research on shoe types for women with diabetes

Type of shoes	Patients group 1	Patients group 2	Both groups
A5500, %	87.4	70.5	79.0
A5512, %	11.5	24.4	17.9
A5513, %	1.1	5.1	3.1
Total, %	100	100	100

Consequently, up to 96.9% of female patients with diabetes require "Extra Depth Diabetic Shoes"; of these, 79.0% utilize "Diabetic Inlays", 17.9% require "Custom Molded Inlays", "Custom Molded Diabetic Shoes" and "Custom Molded Inlays".

CONCLUSIONS

Women with diabetes who experience foot issues typically get worse over time. Variations in foot measurements of height, width, and circumference depend on damage or pathology and are independent of age. As a result, it is not possible to create and produce one type of shoes for feet with the wide range of difficulties associated with diabetic feet. In order to design and manufacture shoes for individuals with diabetes, it is necessary to examine the foot dimensions and shape as well as gauge the extent of the patient's foot damage.

According to the research on foot damage in women with diabetes, up to 96.9% of female patients need to use "Extra Depth Diabetic Shoes"; 17.9% of patients needed "Custom Molded Inlays"; 3.1% of patients need to use "Custom Molded Diabetic Shoes" and "Custom Molded Inlays". Therefore, it is essential to create and produce customized shoes and shoe insoles for diabetes patients in addition to conducting "Extra Depth Shoes" research on the mass production of shoes for these individuals. Conclusions of this study serve as the foundation for developing and producing shoes and insoles for diabetic Vietnamese women based on their anthropometric characteristics and foot issues.

Acknowledgements

This research is funded by Hanoi University of Science and Technology (HUST) under project number T2023-PC-051. The authors are grateful to the Health Centers of Hung Yen Province and Department of Endocrinology, National hospital of Endocrinology in Vietnam for supporting the implementation of this study.

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