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Innovation Diabetic Footpad to Reduce Plantar Pressure and Moisture

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***Abstract*—Foot care behavior of patients with diabetes is critical to prevent diabetic foot ulcers, one of them with the use of proper footpad. A right footpad must be able to reduce pressure on the plantar and decrease the moisture on the skin that can cause diabetic ulcers. Therefore, it is necessary to develop appropriate footpads for people with diabetes. The study aimed to create and analyze diabetic footpad for patients with diabetes to reduce plantar pressure and moisture. This research employed Research and Development (R&D). It consisted of 3 stages; phase I (literature study), phase II (product development), and phase III (product experiment). The literature study in phase I obtained materials used to create a diabetic footpad by solid viscoelastic foam, which has the advantage of being able to follow the shape of the foot. In the second phase of the research, designs and shapes were obtained. The results of the product experiment in the third phase of the study discovered that respondents felt more comfortable by the diabetic footpad. The statistical analyses determine the use of diabetes-specific footpad can evenly distribute the percentage of body weight to hallux, metatarsal, midfoot/arch, lateral heel, the center of heel, and medial heel and also does not increase moisture in the feet compared to the use of ordinary footwear. Diabetic footpad is useful to reduce plantar pressure and humidity for patients with diabetes.**

Keywords—Innovation, Diabetic, Footpad, Plantar Pressure

I. INTRODUCTION

The prevalence of diabetic foot ulcers globally is 6.3%; the highest prevalence experienced in men than women [1]. One effort to reduce the incidence of diabetic foot ulcers is by doing foot care. Many people with diabetes ignore the health of their feet, which impacts on the risk of diabetic ulcers. Foot care in patients with diabetes mellitus can be done by checking the condition of the feet regularly, maintaining the cleanliness of the feet, cutting the nails well, and choosing the right footwear. Proper foot care can prevent and reduce diabetic foot complications by up to 50% [2,3].

The use of footwear in patients with diabetes should be able to reduce pressure on the feet [4]. The use of inappropriate footwear increases the high pressure on the foot, so the risk of developing diabetic ulcers is greater than the proper one [5]. Other studies also found the incidence of diabetic ulcers was influenced by irregular foot care (OR = 16.9; 95% CI = 1.2-51.7) and inappropriate use of footwear (OR = 15.2; 95% CI = 1.4-50.7) [6].

Some studies of diabetic footwear only revolve around discussing the proper use of footwear in diabetic patients [4,6,7]. Research on select shoes for people with diabetes to reduce pressure on the feet has also been carried out [8]. Some types of shoes have been proven to reduce and prevent the incidence of diabetic ulcers [9,10]. However, when it is viewed from the perspective of its effective cost, special diabetic shoes are more expensive than ordinary ones; thus, this creates a dilemma for health workers to recommend the use of diabetic-special shoes to patients, as well as being an economic burden on patients [11].

The purpose of this study is to develop a special diabetic footpad that can reduce pressure on the feet and can maintain skin moisture. Patients do not need to buy diabetic-special shoes, but simply replace the footwear on existing shoes with diabetic-special footpads that will be developed in this study, thereby it will reduce the burden on patients.

II. METHODS

A. Study Design

This is a type of research that adopts Research and Development (R&D) design. This research consists of 3 phases, namely phase I (literature study), phase II (product development), and phase III (product experiment) [12,13]

B. Phase I (literature study)

At this stage, researchers looked for suitable materials used as materials for making diabetic-special footpad.

C. Phase II (product development)

At this stage, the researchers designed the footpad and made it from the materials collected in period I. Furthermore, shoe artisans did the manufacture of the diabetic-special footpad.

D. Phase III (product experiment)

1. Design.

The product experiment used a crossover design. Diabetic footpad has been tested and compared to ordinary footpad that already existed, and it was applied to the same patient [14].

Settings. The product experiment location is in the electrical engineering laboratory of Universitas Muhammadiyah Purwokerto

2. Population and sample

The research population in this stage was all patients suffering from diabetes mellitus with inclusion criteria not suffering from diabetic ulcers, standard leg shape or deformity, average body mass index. In contrast, the exclusion criteria were patients with severe peripheral neuropathy. The number of samples at this stage of the trial was 30 respondents [15].

3. Variable, Instrument, and Measurement.

The variables measured in this stage were plantar pressure and skin moisture of the feet. The plantar pressure variable was measured using the FSR 402 Sensor, and the skin moisture variable is measured using a Skin Moisture Meter. Plantar pressure measurement was done by placing 12 FSR 402 sensors on diabetes footwear that had been made, and by sensors putting in the hallux (interphalangeal joint and lesser toes), central foot (metatarsophalangeal joint (MPJ) 1-5), midfoot (lateral and medial midfoot), and heel (lateral, medial and central heel). The sensor would read the pressure in kilopascals (kPa) and indicated it into specific colors based on the weight of the load, blue with the lowest strength and red with the highest pressure. Measurement of skin moisture used a Skin Moisture Meter (≤33%: dehydrated skin; 34-37%: dry skin; 38-42%: healthy skin and 43-50%: moist skin) [16,17].

4. Experimental Procedure.

Plantar pressure variable measurement was conducted by asking the respondents to step on diabetic-special footpad and ordinary footpad that had been given sensors in turn; then, the sensor would read the results of these pressure measurements and presented the results into the monitor. Whereas in the analysis of skin moisture variable was done by asking respondents to use shoes with diabetic- special footpad and ordinary footpad alternately for 15 minutes and the skin moisture of the feet was measured from 0, 5, 10, and 15 minutes.

5. Data Analysis.

Plantar pressure and skin moisture data were then analyzed using an independent t-test [18].

III. RESULT AND DISCUSSION

The results of the literature study found that suitable materials for making diabetic-special footpad were synthetic rubber, memory foam, and microfiber cloths. Memory foam comes from solid viscoelastic foam which has the advantage of being able to follow the shape of the foot, durable, and anti-fungal so that it makes the patient feel comfortable beside it is easy to absorb sweat, the material is not hot and not stiff, smooth, and comfortable when used. Synthetic rubber was chosen because it has the advantages of heat resistance and strength as a cushion. While microfiber cloth has soft properties and can absorb liquid.

At the product manufacturing stage, diabetic- special footpad is created consisting of 3 parts, namely the bottom or base made from synthetic rubber, the middle section made from a memory foam material, and the upper part made from microfiber cloth (Figure 1).

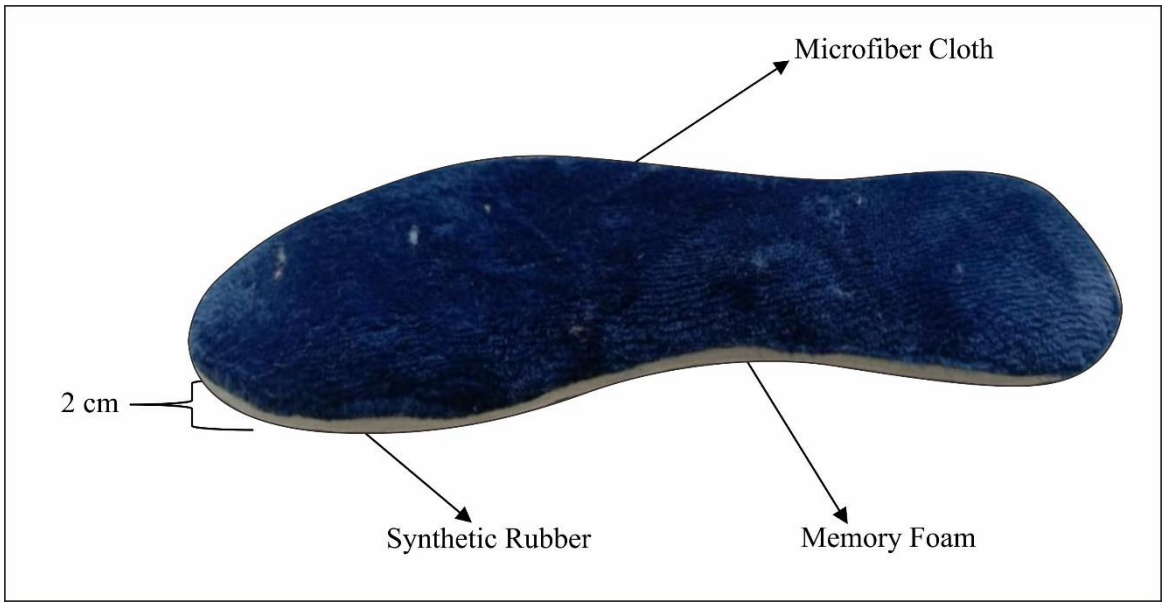

Fig. 1. Diabetic footpad

The mean of plantar pressure in each foot area of ordinary footwear is more significant than in the use of diabetic footpad (table 1). The way of plantar pressure decrease is by 15% in the use of diabetic-special footpad compared to ordinary footwear. Statistical analysis shows a significant difference in right and left foot plantar pressure in respondents who used diabetic-special footpad compared to the patients with a regular shoe, p <0.001 (table 2). In the use of diabetic-special footpad, the pressure is evenly distributed in each foot compared to the use of ordinary footwear (figure 2 and figure 3).

The diabetic-special footpad in this research proved to be able to reduce plantar pressure and to maintain skin moisture of the feet compared to the use of ordinary footwear with an average reduction of 15%. This is due to the plantar pressure inhibited by the memory foam material found in this special footpad and the presence of synthetic leather as a cushion. Memory foam material has the property to be able to follow the shape of the foot so that the body's burden can be distributed evenly on the sole [19]. Moreover, the memory foam material can withstand pressures of 200-300 kPa and will return 97-98% to its original form [20].

In ordinary footwear, plantar pressure becomes greater because there is no obstacle to reducing that pressure. Besides, the weight is not distributed evenly on the sole so that the area of the foot having excessive force is the hallux, central foot, and heel area, and they are prone to tissue death resulting in diabetic ulcers [21].

TABLE I. THE MEAN OF PLANTAR PRESSURE IN EACH AREA OF THE FOOT SOLE (N=30)

Region	Ordinary footwear		Diabetic footpad	
	Right	Left	Right	Left
Hallux				
Interphalangeal joint	243.21	235.81	206.73	201.53
Lesser toes	99.58	94.28	84.64	80.44
Central foot				
MPJ 1	249.78	247.58	212.31	208.71
MPJ 2	256.21	251.61	217.78	213.38
MPJ 3	239.82	238.62	203.85	200.75
MPJ 4	237.65	234.15	202.00	199.80
MPJ 5	231.24	226.64	196.55	193.05
Midfoot				
Lateral	249.77	247.67	212.30	209.10
Medial	187.21	184.11	159.13	156.93
Heel				
Lateral	256.33	251.03	217.88	213.78
Central	229.88	221.78	195.40	190.20
Medial	179.84	174.34	152.86	148.36
Total Mean	221.71 kPa	217.30 kPa	188.45 kPa	184.67 kPa

TABLE II. ANALYSIS OF DIFFERENCES IN PLANTAR PRESSURE BETWEEN ORDINARY FOOTWEAR AND DIABETIC FOOTPAD

Plantar Pressure (kPa)		Mean	Mean dif	% Reduce	p-value
Ordinary footwear V/S Diabetic footpad	Right	221.71	33.26	15.0	0.0001
	Right	188.45			
	Left	217.30	32.63	15.01	0.0001
	Left	184.67			

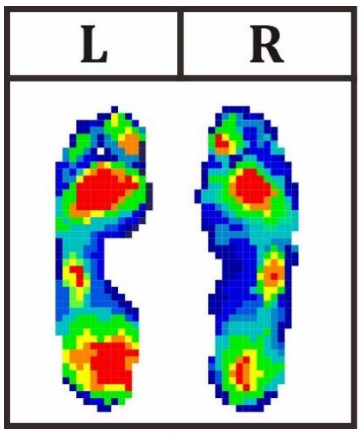

Fig. 2. Representation of plantar pressure distribution on ordinary footwear

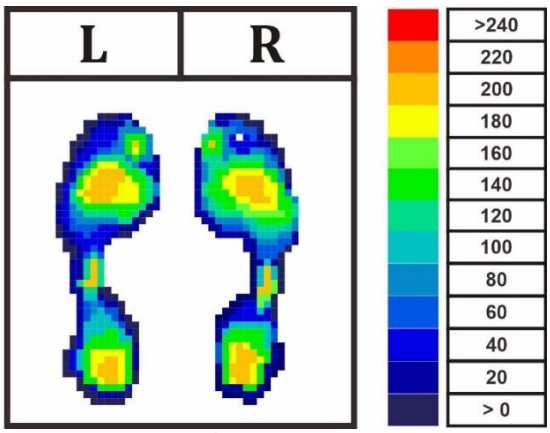

Fig.3. Representation of plantar pressure distribution on diabetic footpad

The results of the skin moisture level found a significant difference in foot skin moisture between the use of ordinary footwear and diabetic footpad on diabetic patients p <0.001. The use of regular footwear tends to increase skin moisture from an average of 40.97% at 0 minutes of use, over time, rising to 45.40% at 15 minutes after application, whereas the use of diabetic footpad tends not to increase the foot skin moisture (Figure 4).

The memory foam material has many pores that can regulate air circulation when walking, so it does not accelerate the increase of moisture in the feet skin. Research on memory foam towards moisture also found that the material can maintain humidity at 40% within 24 hours [22]. Microfiber cloth used in diabetic footpad also has water-absorbing properties, so the soles of the feet will remain dry because the sweat that appears is directly absorbed by the fabric [23]. revious studies have found that the microfiber cloth is effective in reducing the number of bacteria [24,25]. Therefore, the use of this material as diabetic special footpad is very appropriate because the high humidity in the skin of the foot will increase the growth of microorganisms in the foot due to excessive perspiration.

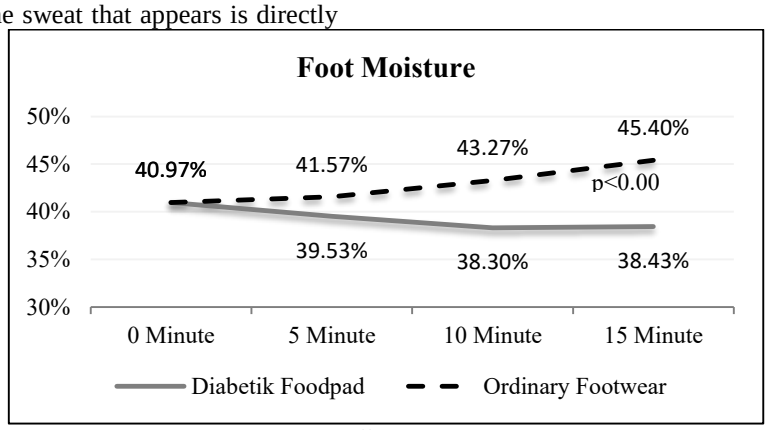

Fig. 4. The difference in skin moisture

IV. CONCLUSION

An innovation of diabetic footpad has been proven to reduce plantar pressure and reduce foot skin moisture in diabetic patients compared to ordinary footwear, which can have an impact on the onset of diabetes ulcers.

REFERENCES

[1] Zhang P, Lu J, Jing Y, Tang S, Zhu D and Bi Y 2017 Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis *Ann. Med.* **49** 106–16

[2] Pendsey S P 2010 Understanding diabetic foot *Int. J. Diabetes Dev. Ctries.* **30** 75–9

[3] Iraj B, Khorvash F, Ebneshahidi A and Askari G 2013 Prevention of diabetic foot ulcer *Int. J. Prev. Med.* **4** 373–6

[4] Raspovic A, Waller K and Wong W M 2016 The effectiveness of felt padding for offloading diabetes-related foot ulcers, at baseline and after one week of wear. *Diabetes Res. Clin. Pract.* **121** 166–72

[5] Bus S A 2016 The Role of Pressure Offloading on Diabetic Foot Ulcer Healing and Prevention of Recurrence. *Plast. Reconstr. Surg.* **138** 179S-87S

[6] Hastuti R T 2008 *Faktor-Faktor Risiko Ulkus Diabetika Pada Penderita Diabetes Mellitus (Studi Kasus di RSUD Dr. Moewardi Surakarta)* (Universitas Diponegoro Semarang)

[7] van Netten J J, Lazzarini P A, Armstrong D G, Bus S A, Fitridge R, Harding K, Kinnear E, Malone M, Menz H B, Perrin B M, Postema K, Prentice J, Schott K-H and Wraight P R 2018 Diabetic Foot Australia guideline on footwear for people with diabetes *J. Foot Ankle Res.* **11** 2

[8] Mrdjenovich D E 2011 Off-loading practices for the wounded foot: concepts and choices *J. Am. Col. Certif. Wound Spec.* **2** 73–8

[9] Busch K and Chantelau E 2003 Effectiveness of a new brand of stock “diabetic” shoes to protect against diabetic foot ulcer relapse. A prospective cohort study. *Diabet. Med.* **20** 665–9

[10] Chantelau E 2004 Effectiveness of diabetic therapeutic footwear in preventing reulceration: response to Maciejewski et al. *Diabetes Care* **27** 3024–6

[11] Brunner J E 2015 Does your patient need diabetic therapeutic footwear? (Where benefit, evidence, and bureaucracy collide) *Clin. Diabetes* **33** 51–3

[12] Rosander R 1988 [Working with research and development (R&D)]. *Jordemodern* **101** 258–60

[13] Yoshikawa H 2012 *Design Methodology for Research and Development Strategy Realising a Sustainable Society* (Japan: Center for Research and Development Strategy Japan Science and Technology Agency)

[14] Wellek S and Blettner M 2012 On the proper use of the crossover design in clinical trials: part 18 of a series on evaluation of scientific publications *Dtsch. Arztebl. Int.* **109** 276–81

[15] Charan J and Biswas T 2013 How to calculate sample size for different study designs in medical research? *Indian J. Psychol. Med.* **35** 121–6

[16] Schwartz D, Magen Y K, Levy A and Gefen A 2018 Effects of humidity on skin friction against medical textiles as related to prevention of pressure injuries *Int. Wound J.* **15** 866–74

[17] Wibowo D B 2018 Pengukuran Distribusi Beban Telapak Kaki Manusia Saat Berdiri Tegak Menggunakan Sensor FSR 402 *ROTASI* **20** 22–28

[18] Kim T K 2015 T test as a parametric statistic *Korean J. Anesthesiol.* **68** 540–6

[19] National Clinical Guideline Centre (UK) 2014 *The Prevention and Management of Pressure Ulcers in Primary and Secondary Care* (London: National Institute for Health and Care Excellence (UK))

[20] Singhal P, Rodriguez J N, Small W, Eagleston S, Van de Water J, Maitland D J and Wilson T S 2012 Ultra Low Density and Highly Crosslinked Biocompatible Shape Memory Polyurethane Foams *J. Polym. Sci. B. Polym. Phys.* **50** 724–37

[21] Fernando M E, Crowther R G, Lazzarini P A, Sangla K S, Wearing S, Buttner P and Golledge J 2016 Plantar pressures are higher in cases with diabetic foot ulcers compared to controls despite a longer stance phase duration *BMC Endocr. Disord.* **16** 51

[22] Yu Y-J, Hearon K, Wilson T S and Maitland D J 2011 The effect of moisture absorption on the physical properties of polyurethane shape memory polymer foams *Smart Mater. Struct.* **20** 85010

[23] Microfiber Wholesale Knowledge Base 2019 What Is Microfiber Cloth & How To Use It *Microfiber Wholes.*

[24] Smith D L, Gillanders S, Holah J T and Gush C 2011 Assessing the efficacy of different microfibre cloths at removing surface micro-organisms associated with healthcare-associated infections *J. Hosp. Infect.* **78** 182–6

[25] Trajtman A N, Manickam K and Alfa M J 2015 Microfiber cloths reduce the transfer of Clostridium difficile spores to environmental surfaces compared with cotton cloths *Am. J. Infect. Control* **43** 686–9