

## Foot dimensions in Thai diabetes

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**Background** : *A large number of diabetic patients wear ill-fitting shoes which may either have incorrect width or length. Custom-made shoes are the choice for diabetic patients because they are uniquely made for them. The authors aim to obtain the foot dimensions in Thai diabetes in order to find the foot sizes that they mostly have. The most common foot length sizes that they had were brought to compare with the sizes of health shoes provided by a Thai shoe manufacture.*

**Material and Method** : *Diabetic patients who could stand upright with weight bearing on both feet were recruited into the study. Four foot dimensions which were, namely: foot length, foot width, heel width and toe depth ball girth were measured while the patients were standing upright. All data were analyzed and presented as frequencies, means and standard deviations. The foot width and toe depth data were comparable to ready-made shoes in the market.*

**Results** : *This study recruited 144 diabetic patients who were 56 men and 88 women. Their average age was  $60.27 \pm 9.90$  years. Foot length, foot width and toe depth in men were 23.20-28.30cm ( $25.42 \pm 1.19$ ), 8.70 -12.30 cm ( $10.28 \pm 0.65$ ) and 1.6-2.8 cm ( $2.18 \pm 0.24$ ). Foot length, foot width and toe depth in women were 20.70-25.70cm*

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( $23.39 \pm 0.99$ ), 8.10 -11.00 cm ( $9.44 \pm 0.55$ ) and 1.35-2.5 cm ( $1.92 \pm 0.23$ ). Most Thai diabetic patients have foot lengths of 22.0-25.0 cm. There were 109 men (97.3%) and 120 women (68.5%) whose foot dimensions could be compared with those shoes. The results showed that 94.6% men had shoe-length size in number 4 - 8 whereas 68% of the women had shoe-length size in number 4 - 6. At the same length, diabetic patients' feet were wider and larger than their shoe 54.59% ( $n=125$ ) in men and 17.47% ( $n = 40$ ) in women, respectively.

**Conclusion** : Thai diabetic patients mostly have foot lengths of 22.0 to 27.0 cm. Women mostly have foot length of 22.0 to 25.0 cm (90.9%) whereas most men have foot length of 23.5 to 27.0 cm (91.9%). Various foot widths in each foot lengths were noted. More than half of the subjects had wider feet than their health shoes' counterparts. At same shoe length size should have various width sizes in order to provide more comfort for the patients. Extra-depth should be considered when therapeutic insole is added.

**Keywords** : Diabetes, Shoe, Foot.

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- วัตถุประสงค์** : ผู้ป่วยเบาหวานจำนวนมากสวมรองเท้าที่มีขนาดความกว้างหรือความยาวไม่เหมาะสม ซึ่งทำให้เกิดแผลเรื้อรังที่เท้า การใส่รองเท้าที่แคบกว่าปกติมีสาเหตุสองประการ ประการแรกรองเท้าที่มีอยู่ส่วนใหญ่มีหน้าแคบ ประการที่สองผู้ป่วยเบาหวานที่มีเส้นประสาทผิดปกติ ทำให้มีแนวโน้มสวมรองเท้าที่เล็ก ผู้ป่วยเบาหวานจะได้รับประโยชน์มากหากรองเท้าที่อยู่ในตลาดมีขนาดที่เหมาะสมกับผู้ป่วย ผู้วิจัยได้วัดมิติเท้าในผู้ป่วยเบาหวานไทยเพื่อที่จะหาขนาดรองเท้าที่เหมาะสมกับผู้ป่วย รวมถึงนำขนาดความยาวเท้าที่พบบ่อยมาเปรียบเทียบกับขนาดของรองเท้าสุขภาพที่ผลิตจากบริษัทรองเท้าของคนไทยแห่งหนึ่ง
- วิธีการศึกษา** : ผู้วิจัยศึกษาในผู้ป่วยเบาหวานที่สามารถยืนลงน้ำหนักบนเท้าทั้งสองข้าง ผู้วิจัยได้วัดมิติเท้า ได้แก่ความยาวเท้า ความกว้างเท้า ความกว้างของสันเท้า และขนาดของนิ้วเท้าในท่ายืนลงน้ำหนักบนเท้าสองข้าง ข้อมูลถูกวิเคราะห์และนำเสนอในรูปแบบความถี่ ค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐาน ความกว้างของเท้าและขนาดของนิ้วเท้า จะถูกนำมาเปรียบเทียบกับความกว้างของรองเท้าและความลึกของช่องนิ้วของรองเท้า (ความลึกของรองเท้า) ซึ่งข้อมูลขนาดความกว้างและความลึกของรองเท้าถูกนำมาจากบริษัทผลิตรองเท้าแห่งหนึ่ง
- ผลการศึกษา** : การศึกษานี้ได้ศึกษาผู้ป่วยเบาหวานจำนวน 144 คน เป็นชาย 56 คน และหญิง 88 คน มีอายุเฉลี่ยประมาณ  $60.27 \pm 9.90$  ปี ผู้ป่วยเบาหวานไทยส่วนใหญ่มีความยาวเท้าอยู่ระหว่าง 22.0 ถึง 25.0 ซม. ข้อมูลมิติเท้าของผู้ป่วยชายจำนวน 109 ราย (ร้อยละ 97.3) และหญิง 120 ราย (ร้อยละ 68.5) ถูกนำมาเปรียบเทียบกับขนาดของรองเท้า ผลการศึกษาพบว่าร้อยละ 94.6 ของผู้ชาย และร้อยละ 68 ของผู้หญิงที่มีความยาวเท้าตรงกับกับความยาวรองเท้าขนาดเบอร์ 4 ถึง 6 นอกจากนี้ผู้วิจัยพบว่าที่ความยาวเดียว ร้อยละ 85.15 ของผู้ป่วยเบาหวาน (จำนวน 195 ราย) มีขนาดเท้าที่กว้างกว่าความกว้างของรองเท้า และร้อยละ 17.47 ของผู้ป่วยเบาหวาน (จำนวน 40 ราย) มีนิ้วหัวแม่เท้าที่ใหญ่กว่าช่องนิ้วของรองเท้า

**สรุป** : ส่วนใหญ่ผู้ป่วยเบาหวานไทยมีความยาวเท้าอยู่ระหว่าง 22.0 ถึง 27.0 ซม. ร้อยละ 90.9 ของผู้หญิงมีความยาวเท้าอยู่ในช่วง 22.0 ถึง 25.0 ซม. ขณะที่ร้อยละ 91.9 ของผู้ชายมีความยาวเท้าอยู่ในช่วง 23.5 ถึง 27.0 ซม. ในแต่ละความยาวเท้ามีความหลากหลายของความกว้างของเท้า มีผู้ป่วยเบาหวานมากกว่าครึ่งที่มีเท้ากว้างกว่ารองเท้าสุขภาพที่นำมาเปรียบเทียบ ในรองเท้าที่ขนาดความยาวเดียวกันควรมีความกว้างหลากหลายเพิ่มขึ้น เพื่อให้ผู้ป่วยสวมใส่ได้อย่างสบาย หากต้องการใส่แผ่นรองเท้าเพื่อการรักษา ก็ควรคำนึงถึงรองเท้าที่มีความลึกเป็นพิเศษ

**คำสำคัญ** : มิติเท้า, เท้าเบาหวาน, รองเท้า, เบาหวาน.

Ill-fitting shoes are related to chronic diabetic foot ulcers.<sup>(1)</sup> Many diabetic patients wear shoes that have incorrect length or width.<sup>(2)</sup> There were study report that they have worn too narrow shoes.<sup>(2 - 4)</sup> Although diabetic patients are generally advised to wear appropriate shoes, it is difficult for them to follow the recommendation based on two reasons.<sup>(5)</sup> Firstly, finding a correct shoe size is problematic because shoe manufacturers usually design their shoes to catch up with the latest fashion styles and trends, rather than giving comfort to their customers. Most shoes which are available in the market have narrow ball design. These shoes are not recommended for diabetic patients. The shoes with wide ball design which is suitable for them are hardly found in the market. Furthermore, the size of right foot can possibly be different from the left if some patients have mismatched feet problem.<sup>(6,7)</sup> Secondly, diabetic patients with neuropathy usually select too small shoes because they perceive that the shoe sizes were correct for them.<sup>(8)</sup> Therefore, these incorrect shoe sizes and designs can induce pressure, especially on the forefoot area.

Custom-made shoes are best choices for diabetic patients because they need shoes that are uniquely made for them. Modification of over the counter shoes are another option that can be used for diabetic patients who have mild foot deformity. Diabetic patients will get proper shoes faster if proper shoe sizes are made available in the stock. However, the data concerning proper shoe sizing are not currently available especially for the Thai people.

The authors primarily aimed to obtain the foot dimensions in Thai diabetes having normal or mild foot deformity. These data is beneficial for Prosthetic-

Orthotic (PO) Unit, Division of Rehabilitation Medicine, King Chulalongkorn Memorial Hospital in preparing prefabricated shoes for this group of patients. This will shorten waiting time. Secondly, the most common foot length sizes were brought to be compared with health-shoe sizes provided by a Thai shoe manufacturer. The comparative data will confirm if the available comfortable shoe in the market could be compatible with our patients or not.

### Material and Method

A cross sectional descriptive study was done at the Division of Rehabilitation Medicine, King Chulalongkorn Memorial Hospital from February 2005 - 2006. As for the sample population, diabetic patients were recruited from King Chulalongkorn Memorial Hospital as well as the health centers under the Bangkok Metropolitan Administration.

The diabetic patients who could stand upright with weight bearing on both feet were recruited into the study. Written informed consent was obtained from each subject before their recruitment. Patients who had conditions such as fracture, Charcot arthropathy, severe pronated foot, severe hallux valgus, toe amputation and partial foot amputation were excluded because these conditions had effects on foot size parameters.

Three physiatrists measured four foot dimensions while patients were standing upright with weight bearing equally on both feet. The foot dimensions included foot length, foot width, heel width and toe depth. They were measured by the Chula Foot Calipers as shown in Figure 1.<sup>(9)</sup> The authors categorized the foot length based on the Japanese shoe sizing system because it is based on Asian

population and correlated to the International Mondopoint System.



**Figure 1.** Four foot dimensions were measured:  
 a. foot length; b. foot width; c. heel width;  
 d. toe depth.

All data were analyzed with SPSS software for Windows version 11.0. The data were presented as frequency, mode, mean and standard deviation. All data were shown in centimeters and categorized based on foot length. The foot width and toe depth data were matched to ready-made shoes that consider as comfortable and available in the market. The data of the inside shoe widths and depths were provided by a health shoe manufacturing company. As genders also have effect on foot shape, all data were separately analyzed and shown in the tables below. <sup>(10)</sup>

## Results

The enrolled diabetic patients in the study

were 56 men and 88 women. Their average age was  $60.27 \pm 9.90$  years. Their average age at the onset of diabetes and disease duration was  $50.92 \pm 10.55$  years and  $9.08 \pm 7.68$  years, respectively. Their average height and body mass index were  $1.50 \pm 0.08$  meters and  $26.61 \pm 4.62$  kg/m.<sup>2</sup> Foot length, foot width and toe depth in men were 23.20 - 28.30cm ( $25.42 \pm 1.19$ ), 8.70 -12.30 cm ( $10.28 \pm 0.65$ ) and 1.6-2.8 cm( $2.18 \pm 0.24$ ). Foot length, foot width and toe depth in women were 20.70-25.70cm ( $23.39 \pm 0.99$ ), 8.10 -11.00 cm ( $9.44 \pm 0.55$ ) and 1.35-2.5 cm ( $1.92 \pm 0.23$ ).The authors used foot length to categorize and display foot dimension data as shown in Table 1. Most men had foot length of 23.5 - 27.0 cm (n = 103, 91.9%) whereas most women 22.0 - 25.5 cm (n = 167, 95.4%). The authors aimed to compare foot width and toe depth with shoe width and depth. The shoe data provided by a health shoe manufacturer numbered of the shoes based on length, width and depth. The subjects were categorized again and compared in the same shoe length. There were 109 men's feet (97.3%) and 120 women's feet (68.5%) that could be compared with the shoes as shown in Table 2. The authors defined that a shoe is compatible when the shoe was equal or wider than foot 0.5 cm while the proper shoe depth is equal to or more than toe depth (shoe depth -toe depth difference was 0 cm or more). At the same length, 85.15% of diabetic patients' feet (n = 195) were wider than the ball of shoes. Moreover, 17.47% of diabetic patients' big toes (n = 40) were larger than the toe box of the shoes as shown in Table 3.

**Table 1.** Foot dimensions data were categorized based on length of foot size.

Men Foot Length (cm)	N	Foot Width (cm)				Heel Width (cm)				Toe Depth (cm)			
		Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
23.5	8	8.70	9.80	9.52	0.35	5.65	6.20	6.03	0.18	1.85	2.10	1.98	0.09
24.0	14	9.05	11.00	9.80	0.65	5.80	6.90	6.33	0.38	1.75	2.60	2.03	0.21
24.5	8	9.40	10.80	9.96	0.47	6.00	7.50	6.56	0.46	1.95	2.40	2.13	0.15
25.0	14	9.50	11.70	10.27	0.54	6.00	7.30	6.55	0.34	1.90	2.50	2.14	0.18
25.5	8	9.40	10.90	10.32	0.52	6.30	7.20	6.69	0.30	1.80	2.50	2.18	0.24
26.0	22	9.70	11.60	10.37	0.52	5.90	8.50	6.89	0.55	1.60	2.80	2.17	0.30
26.5	21	9.40	11.40	10.53	0.59	6.10	7.30	6.68	0.30	1.80	2.65	2.30	0.23
27.0	8	10.20	11.00	10.51	0.24	6.70	7.50	6.93	0.33	2.10	2.60	2.33	0.22
27.5	7	9.90	12.30	11.10	0.89	6.70	8.00	7.16	0.55	2.00	2.65	2.29	0.24
28.0	1	10.20	10.20	10.20		6.70	6.70	6.70		2.30	2.30	2.30	
28.5	1	10.70	10.70	10.70		7.50	7.50	7.50		2.40	2.40	2.40	

  

Women Foot Length (cm)	n	Foot Width (cm)				Heel Width (cm)				Toe Depth (cm)			
		Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
21.0	2	8.50	9.50	9.00	0.71	5.30	5.70	5.50	0.28	1.75	2.35	2.05	0.42
21.5	5	8.40	9.15	8.85	0.30	5.30	6.10	5.75	0.32	1.70	2.30	1.88	0.27
22.0	10	8.40	9.50	8.84	0.36	5.00	6.40	5.77	0.45	1.35	2.20	1.81	0.25
22.5	21	8.60	9.90	9.22	0.41	5.00	7.10	5.99	0.55	1.60	2.30	1.83	0.18
23.0	24	8.65	10.50	9.52	0.53	5.50	6.60	5.90	0.30	1.50	2.40	1.88	0.23
23.5	34	8.40	11.00	9.38	0.53	5.15	7.15	6.19	0.43	1.35	2.50	1.85	0.23
24.0	39	8.20	10.60	9.57	0.49	5.25	7.30	6.27	0.47	1.45	2.40	1.96	0.24
24.5	17	8.10	10.35	9.40	0.63	5.85	7.80	6.41	0.54	1.60	2.30	1.99	0.17
25.0	15	9.10	10.70	9.69	0.35	6.00	7.70	6.76	0.56	1.65	2.20	1.97	0.18
25.5	8	9.80	11.00	10.25	0.46	6.50	7.60	7.05	0.44	1.90	2.40	2.16	0.17
26.0	1	10.00	10.00	10.00		7.10	7.10	7.10		2.00	2.00	2.00	

**Table 2.** Number of diabetic patients' feet compared with each health shoe length.

Length (cm)	Shoe			Men (n)	Women (n)
	Width (cm)	Toe Depth (cm)	LengthSize		
23.82	89.5	2.20	4	15	65
24.67	92	2.30	5	18	34
25.50	9.46	2.30	6	17	20
26.30	9.71	2.40	7	40	1
27.20	9.96	2.40	8	16	0
28.00	10.20	2.50	9	3	0

**Table 3.** Number of diabetic patients' feet which were compared with health shoes.

Shoe Width and Foot Width	Men (n)	Women (n)	Total (n)
Narrower shoe	96	99	195
Compatible width	13	16	29
Wider shoe	0	5	5
Total	109	120	229

  

Shoe Depth and Toe Depth	Men (n)	Women (n)	Total (n)
Difference < 0	28	12	40
Difference = 0 cm or more	81	108	189
Total	109	120	229

## Discussion

Each foot length group had various foot widths whereas heel width and toe depth are more constant. This study did not compare diabetic patients' feet with their shoes because previous studies have already showed that diabetic patients frequently wore incorrect shoe sizes.<sup>(2-4)</sup> However, the authors aimed to compare diabetic patients' feet with health shoes which are already in the market. The authors chose a Thai shoe manufacturer that mainly made health shoes to compare with the foot

dimensions. The result showed that 94.6% of men had shoe-length size in number 4-8 whereas 68% of women had shoe-length size in number 4-6. The authors found that men may find the appropriate shoe length easier than women.

Although the comparative shoes were wide ball design but the study showed that about half of the subjects still had wider feet; having various foot-width sizes in the same foot length. Moreover extra depth is also needed if therapeutic insole



is prescribed. Therapeutic insoles have various thicknesses from 0.4-1.0 cm. These mean that most diabetic patients still need prefabricated shoe from PO unit.

The authors have found that the available health shoes provided by a Thai shoe manufacture were not compatible with the feet of some diabetic patients. This study had a limitation that it did not include data from other shoe manufacturers. The finding is beneficial for PO unit for prepare prefabricated shoes which could shorten the waiting time for proper size shoes.

### Conclusion

Foot length, foot width and toe depth in men were 23.20-28.30cm ( $25.42 \pm 1.19$ ), 8.70 -12.30 cm( $10.28 \pm 0.65$ ) and 1.6-2.8 cm ( $2.18 \pm 0.24$ ). Foot length, foot width and toe depth in women were 20.70-25.70cm ( $23.39 \pm 0.99$ ), 8.10 -11.00 cm ( $9.44 \pm 0.55$ ) and 1.35-2.5 cm ( $1.92 \pm 0.23$ ). In this study most Thai diabetic patients have foot lengths of 22.0 to 27.0 cm. Women mostly have foot length with in 22.0 to 25.0 cm (90.9%) whereas men mostly have foot length within 23.5 to 27.0 cm (91.9%). Various foot widths in each foot lengths were noted. When feet were compared to sample health shoes at the each length, compatible shoe length size were found in men greater than women. More than half of the subjects had wider feet vis-l-vis health shoes of the same length. Therefore, for shoe manufacturer, shoes of the same length size should have various width sizes in order to allow more comfort for the patients. Most subjects had toe depth which was compatible with shoe dept but extra-depth should be considered when therapeutic insole is added.

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