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Mismated feet in diabetes

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Problem/background : *No two feet are exactly alike in size, shape, or proportions, but all pairs of shoes sold in the market are manufactured symmetrically. Mild discrepancy may not cause problems. However, normal people may need a period of adjustment with their new shoes, as severe discrepancy can cause certain degree of physical discomfort and some have to throw away their shoes. Unlike normal feet, insensitive feet of diabetic patients can tolerate ill fitting shoes for much longer period of time and subsequently develop foot ulceration which can lead to amputation.*

Objective : *To determine incidence of clinical significant of mismated feet in diabetes.*

Design : *Descriptive study*

Setting : *Diabetic clinic and Diabetic foot clinic King Chulalongkorn Memorial Hospital, Primary care unit of Thai Red Cross Society, Health Center Bangkok Metropolitan Administration.*

Material and Methods : *One hundred and eleven diabetic subjects were recruited into the study. Their foot dimensions (length, breadth and depth of great toe) were measured, and side to side comparison of individual feet was analyze by paired t – test.*

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Results : *There were 40 males and 71 females subjects recruited. Incidence of the difference in foot breadth at 5mm or more was 25 % and 11.3 % whereas the difference of foot length was 25 % and 12.7 % in men and women, respectively. The maximum discrepancy was 9 mm in breadth and 11mm in length. No discrepancy of the depth of great toe of more than 5mm detected in the male subjects. But 2.8 % of the female subjects had the discrepancy of the depth of great toe of 5 mm. When we compared side to side by paired t – test, there was statistic significant in foot breadth side to side comparison in male group (p = 0.024).*

Conclusion : *Ten to twenty - five percent of diabetic people have significant mismated feet which can cause foot injury. This information suggests that foot measurement should be considered in all diabetes when footwears or foot orthosis are prescribed.*

Keywords : *Diabetic foot, Foot breadth, Foot length, Foot dimension, Mismated feet.*

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ที่มา : *คนทั่วไปไม่มีใครมีเท้าที่รูปร่างและขนาดเท่ากัน แต่รองเท้าที่ขายในท้องตลาดนั้นจะมีรูปร่างและขนาดเท่ากัน หากมีความแตกต่างระหว่างเท้าทั้งสองข้างนั้นเพียงเล็กน้อย ความแตกต่างนี้อาจจะไม่ก่อให้เกิดปัญหาเพียงแต่ต้องใช้เวลาในการปรับตัวให้เข้ากับรองเท้าคู่ใหม่เท่านั้น แต่หากความแตกต่างมีมากถึงกับทำให้ใส่ไม่สบาย ผู้ใส่อาจหยุดการใช้รองเท้าคู่นั้น ผิดกับผู้ป่วยเบาหวานที่สูญเสียความรู้สึกที่เท้า ทำให้สามารถทนต่อความไม่สบายเท้าอันเกิดจากความแตกต่างดังกล่าวและสามารถทนใส่ได้เป็นเวลานาน ทำให้มีโอกาสเกิดแผลที่เท้าซึ่งเป็นสาเหตุหลักของการตัดขาในผู้ป่วยเบาหวาน*

วัตถุประสงค์ : *ต้องการศึกษาถึงอุบัติการณ์ของขนาดเท้าที่ต่างกันมากระหว่างเท้า 2 ข้างในผู้ป่วยเบาหวาน*

สถานที่ทำการศึกษา : *คลินิกเบาหวานและคลินิกเท้าเบาหวาน โรงพยาบาลจุฬาลงกรณ์สถานีกาชาด 2 สภากาชาดไทย ศูนย์บริการสาธารณสุข สำนักอนามัย กรุงเทพมหานคร*

รูปแบบการศึกษา : *การศึกษาเชิงพรรณนา*

วิธีการศึกษา : *วัดขนาดเท้าของผู้ป่วยเบาหวานจำนวน 111 คนด้วยเครื่องมือวัดขนาดเท้า โดยวัดความกว้าง ความยาวและความสูงของนิ้วหัวแม่เท้า เปรียบเทียบขนาดเท้าระหว่างข้างซ้ายและขวาด้วย paired t -test*

ผลการศึกษา : *มีผู้ป่วยเพศชาย 40 คน และหญิง 71 คน เมื่อพิจารณาที่ความแตกต่างที่ ≥ 5 มม.เป็นหลัก พบว่าประมาณร้อยละ 25 และ 11.3 ในเพศชายและหญิงตามลำดับที่มีความกว้างต่างกัน ขณะที่ประมาณร้อยละ 25 และ 12.7 ในเพศชายและหญิงตามลำดับที่มีความยาวต่างกัน โดยมีเท้ากว้างต่างกันมากที่สุดถึง 9 มม. และยาวต่างกันมากที่สุดถึง 11 มม. ไม่พบความสูงของนิ้วหัวแม่เท้าที่แตกต่างกัน ≥ 5 มม.ในเพศชาย แต่พบว่าประมาณร้อยละ 2.8 ในเพศหญิงมีความแตกต่างด้านความสูงของนิ้วหัวแม่เท้ามากที่สุดถึง 5 มม.เมื่อเปรียบเทียบแต่ละมิติระหว่างข้างซ้ายและขวาด้วย paired t –test พบว่าเพศชายมีความกว้างต่างกันอย่างมีนัยสำคัญทางสถิติ ($p = 0.024$).*

สรุป : *ร้อยละ 10 – 25 ของผู้ป่วยเบาหวาน มีขนาดเท้าสองข้างที่ต่างกัน ≥ 5 มม. ซึ่งจะทำให้เกิดการบาดเจ็บของเท้าได้ ข้อมูลที่ได้จากการศึกษานี้ชี้ให้เห็นว่า ควรวัดขนาดเท้าในผู้ป่วยเบาหวานทุกราย เมื่อมีการสั่งรองเท้าหรือกายอุปกรณ์เสริมรองเท้า*

คำสำคัญ : *เท้าเบาหวาน, ความกว้างของเท้า, ความยาวของเท้า, มิติเท้า, ความต่างระหว่างเท้า.*

Foot ulcer is primary cause of amputation in diabetes. About 40 – 80 % of diabetes related amputation had foot ulcer. And 15 – 50 % of them will have contralateral limb amputation within 5 years.[1] Apichart et al studied the incidence of amputation in Thai diabetes. This study reported incidence of amputation in diabetes with foot ulcer was 25 % with mortality rate 20 %. [2] Tanphiphat also found that of 144 cases of Thai diabetes, 86 cases (59.7%) were amputated.[3]

Boulton et al demonstrated that 62 – 87 % of diabetes had foot ulcer caused by the loss of protective feet sensation. These insensitive diabetic patients can tolerate inappropriate footwear for much a longer period of time which lead to injury and ulcer.[4] Appropriate footwear can reduce risk of ulceration.[5-6] Gregory et al found that 31% of diabetes wear shoes that are too narrow for their feet. Thirty – seven percent of this group also had previous foot problem especially the forefoot.[7] This exposes them to higher risk of abnormal pressure which can cause further complication such as foot ulcer and amputation.

Selecting a shoe of the right size is less complicated than selecting shoe of the right fit.[8] We knew that each side of foot could not of the same size and same shape in an individual. Rossi found that there is a high incidence of mismated feet among normal population.[8] Anyone can have problem with a new pair of shoes from mismated feet. Healthy persons could take off their foot if they had noxious pressure force, but diabetes could not due to their poor sensation of the feet.

We would like to find out incidence of clinical significant mismated feet in Thai diabetes. This information will determine how important it is to measure foot during our routine foot examination in diabetic foot clinic.

Material and Methods

This study protocol has been approved by the Ethics Committee of the Faculty of Medicine, Chulalongkorn University.

Subject

A total of 111 diabetic subjects were recruited from Diabetic Clinic and Diabetic foot clinic King Chulalongkorn Memorial Hospital, a primary care unit of the Thai Red Cross society and a health Center in Bangkok Metropolitan Administration. All subjects must be able to stand with weight bearing on both feet. The exclusion criteria were partial foot amputation or severe foot deformities such as Charcot's fracture, severe pronated feet and severe hallux valgus.

Methods

1. Foot measurement
   - Foot measurement was performed by using foot caliper. This instrument has been studied for its reliability analyzed by intraclass correlation coefficients (ICC) analyzed. The study showed high agreement between 3 interexaminers. (ICC more than 0.95).[9]
   - Subject stood with full weight bearing on their feet. Foot length, breadth and great toe depth were measured in both sides and recorded in millimeters.[10]
2. Sample size calculation
   - Ten of the male and female subjects were recruited in a pilot study for sample size calculation.

- Sample size was calculated by

$$N = \frac{(Z_{\alpha/2})^2 (\sigma)^2}{\Delta^2}$$

2. Data analysis
   - Side to side comparison of individual feet was measured and analyzed by pair t – test with statistic significant at $p < 0.05$.
   - Clinical significant of mismated is defined as difference in foot dimension at 5 mm or more. Frequency of mismated feet is reported and categorized in sex separately.

Results

A total of 111 diabetic patients were enrolled in the study. Most of them were female and their range of age was between 36 - 85 years old. The average duration of diagnosed diabetes was 9 years. More than 60 % of the subjects were overweight (Table 1 and 2).

The foot breadths of the male subjects revealed side to side difference with statistical significance (P = 0.024) whereas those of female did not (Table 3). About 25 % of the male and 10 % of the female have clinically significant mismated feet. (Chart 1 - 2). There was discrepancy of incidence between side to side difference of foot breadths and foot lengths (Table 4). Both the male and female have less side to side difference of the depth of great toe than foot breadth and foot length. Only 2.8 % of the female have the significant difference. The maximum difference is also reported to determine whether or not the subjects need to wear different shoe size (Table 5).

Table1. Demographic data showed in range (mean±SD).

Demographic data	Male	Female
Age (year)	36 – 80 (56.92 ± 9.416)	41 – 85 (62.03 ± 9.704)
Age at onset of DM (year)	27 – 67 (47.46 ± 10.239)	25 – 74 (52.92 ± 10.263)
Duration of DM (year)	1 – 31 (9.46 ± 7.608)	0 – 31(9.13 ± 7.312)
Body weight (kg)	60 – 105.7 (74.87 ± 10.062)	40 – 111.0 (63.75 ± 12.961)
Height (m)	1.56 –1.81(1.67 ± 0.053)	1.44 – 1.69 (1.54 ± 0.543)
Body Mass Index (kg/m^2)	21.87 – 36.77 (26.86 ± 3.062)	17.78 - 46.20 (26.914 ± 5.273)

Table 2. BMI Classification.

BMI Classification	Male	Female
Underweight (< 18.5 kg/m^2)	-	3 (4.8 %)
Normal Weight (18.5 – 24.99 kg/m^2)	12 (32.4 %)	19 (30.6 %)
Overweight (25 – 30 kg/m^2)	20 (54.1 %)	25 (40.3 %)
Obese (> 30 kg/m^2)	5 (13.5 %)	15 (24.2 %)

Table 3. Foot dimensions showed in range (mean±SD).

Foot dimension (mm)	Side	Foot breadth	Foot length	Great toe depth
Male	Right	103.6 ± 5.5	254.2 ± 11.44	21.6 ± 1.99
	Left	102.3 ± 6.2	254.7 ± 11.69	21.7 ± 2.42
Female	Right	94.3 ± 5.65	233.1 ± 10.29	19.2 ± 2.32
	Left	93.7 ± 5.9	232.9 ± 10.19	19.1 ± 2.43

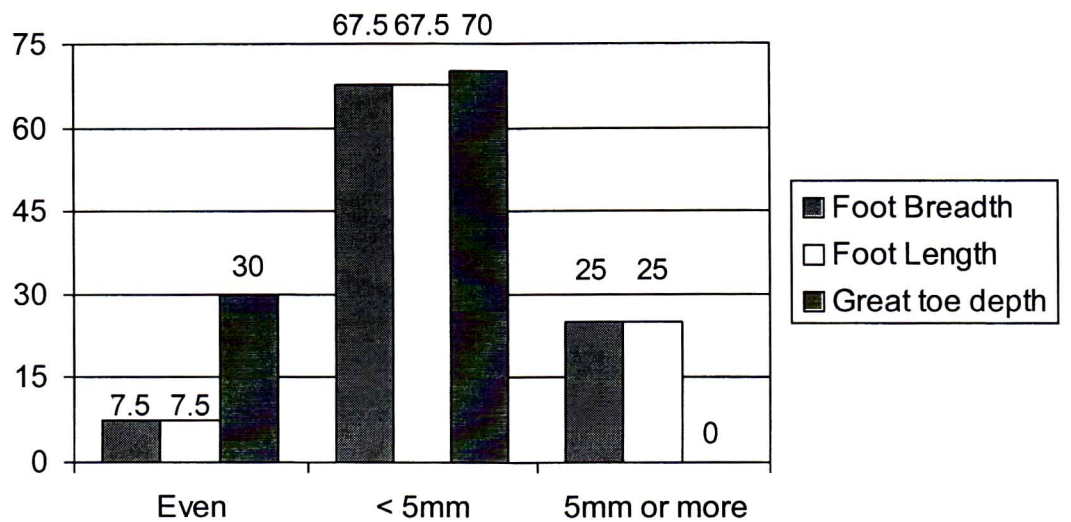

Chart 1. Incidence of side to side difference in male.

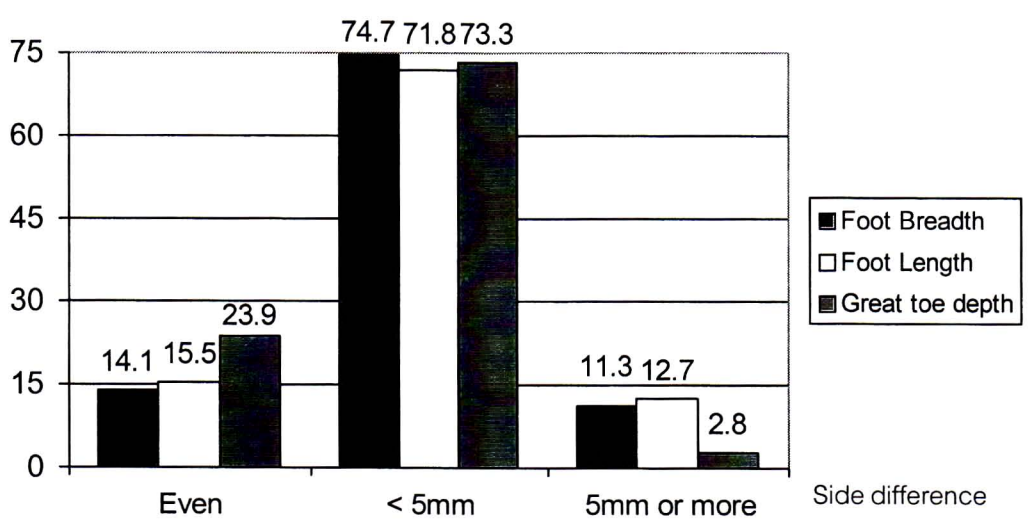

Chart 2. Incidence of side to side difference in female.

Table 4. Incidence of larger side in each parameter of foot dimension.

Foot dimension	Side	Incidence of larger side (%)		
		Foot breadth	Foot length	Great toe depth
Male	Right	62.5	37.5	32.5
	Left	30.0	55.0	37.5
Female	Right	56.3	42.3	46.5
	Left	29.6	42.3	29.6

Table 5. Mean and maximum difference in each parameter of foot dimension.

Foot Dimension(mm)	Male		Female	
	Mean difference	Maximum difference	Mean difference	Maximum difference
Foot breadth	0.31	9.0	0.22	8.0
Foot length	0.29	7.5	0.23	11.0
Great toe depth	0.12	3.5	0.13	5.0

Discussion

We separately reported mismate of the foot based on gender because there are statistically significant of difference in size between the male and female.[11,13] We found that more than 90 % of the male and 80 % of the female diabetes have asymmetrical feet. When we compared the difference of the dimension of foot side to side, we found no statistical significant difference between foot length and great toe depth in both sexes and foot breadth in the female subjects.There was statistical significance only of the foot breadth in the male subjects ($p = 0.024$).

Rossi studied in normal American feet and found that 60% of male subjects and 61.9% of female subjects have mismated feet. This study showed a higher incidence of difference in foot breadth when compared to the study of Rossi's.[8] Clinical significance of the mismate is defined as the difference in foot dimension at 5 mm or more. We used the cut point because there is variety in length difference (range between 3 – 7 mm) in each shoe length size (Table 6).[10] One of every four males and one of every ten in females have clinical significance of the mismate of foot breadth with the maximum difference of 9 mm. The difference of foot length is also important. We reported that about 25 % of the male and 12.7 % of the female have significant difference of foot length. The maximum difference of foot length is 11 mm. It is recommended to choose a shoe that allows a space of about ½ - ¾ inch beyond the longest toe to prevent distal contact through the gait cycle (Fig. 1).[14] If diabetic people chose their shoes based on their larger foot, the other foot will not fit in the shoe. Friction force could occur

in that side during the gait cycle. On the contrary, if they chose their shoes based on the smaller foot, there will be more pressure on the larger one. This can explain why about 30 % of diabetic people reported prior foot problem occurring in the forefoot.[7]

Table 6. International Standard ISO 9407:1991, Shoe sizes: Mondopoint system of sizing and marking.

System		Sizes															
Europe		**35**	**35 1/2**	**36**	**37**	**37 1/2**	**38**	**38 1/2**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46 1/2**	**48 1/2**
Japan	M	21.5	22	22.5	23	23.5	24	24.5	25	25.5	26	26.5	27.5	28.5	29.5	30.5	31.5
	W	21	21.5	22	22.5	23	23.5	24	24.5	25	25.5	26	27	28	29	30	31
U.K.	M	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	10	11	12	13 1/2
	W	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	9 1/2	10 1/2	11 1/2	13
U.S. &	M	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	10 1/2	11 1/2	12 1/2	14
Canada	W	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	10 1/2	12	13	14	15 1/2
Inches		9	9 1/8	9 1/4	9 3/8	9 1/2	9 5/8	9 3/4	9 7/8	10	10 1/8	10 1/4	10 1/2	10 3/4	11	11 1/4	11 1/2
Centimeters		22.8	23.1	23.5	23.8	24.1	24.5	24.8	25.1	25.4	25.7	26	26.7	27.3	27.9	28.6	29.2
Mondopoint		228	231	235	238	241	245	248	251	254	257	260	267	273			

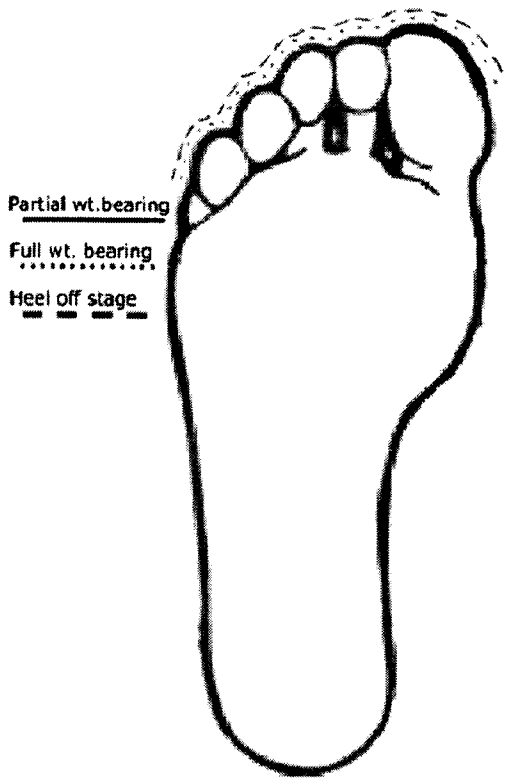

Figure 1. Natural elongation of the foot during gait cycle.

Although there is a lower incidence of the difference of the depth of great toe when compared to foot breadth and foot length, the information is significance. Since an insensitive foot needs an insole which is as thick up as 10 mm, the difference of the depth of great toe should be concerned if a special insole is prescribed.

Conclusion

Ten to twenty five percent of diabetic subjects have clinically significant mismated feet which can cause foot injury. This information suggests that foot measurement should be considered in all diabetes when foot wears or foot orthosis are prescribed.

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