Reliability of Foot Caliper

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Objectives: *To determine the reliability of foot caliper.*
Design: *Descriptive study.*
Setting : *Rehabilitation Medicine Out patient Department, King Chulalongkorn Memorial Hospital.*
Subject: *Fifteen volunteers were recruited from Rehabilitation residents and health care professionals of Department of Rehabilitation Medicine, King Chulalongkorn Memorial Hospital.*
Material and Method: *The authors created 3 sets of simple Foot Caliper and measured foot dimension including foot width, foot length and toe depth while subjects stood with equal weight bearing to both feet. The authors set 3 examiners to measure foot dimension by the same method.To determine reliability of 3 sets of foot caliper, one examiner was assigned to measure foot dimension of 30 feet with all calipers. To determine the reliability of examiners, all examiners measured foot dimension of the same 30 feet. All parameters were recorded in millimeters.The data was analyzed and presented as intraclass correlation coefficients (ICC) with 95%CI.*
Results: *There were fifteen volunteers(8 men and 7 women).The average age was 28.6 ± 4.11years(range22 - 39). Average foot width,length and great toe depth (millimeters)were 9.64 ±0.63,24.17 ±1.10 and 1.91±0.24 respectively. For reliability analysis of 3 sets of foot caliper, the intraclass correlation coefficients (ICC) with 95%CI were 0.985(0.972-0.992), 0.996(0.992-0.998) and 0.982(0.968-991) for foot width, length and great toe depth, respectively. For Inter-examiner reliability , intraclass correlation coefficients (ICC) were 0.941(0.864-0.969),0.850(0.746-0.920)and 0.834(0.721-0.910) for foot width, length and great toe depth, respectively. These results showed high agreement of data.*
Conclusion: *These simple foot calipers have high reliability for foot measurement.These devices are appropriate for clinical use.*

Keywords: *Foot dimension, Diabetic foot, Foot caliper*

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The most common cause of non-traumatic lower extremity amputation is diabetes related. Many factors that contribute to develop diabetic foot ulcerations including peripheral neuropathy, peripheral vascular disease, biomechanical and structural abnormalities of foot, and trauma[1-6]. Multidisciplinary approach by diabetic foot care team to identify the foot at risk and management based on risk categories including patient education about proper foot care and foot wear, early detection and effective management of foot problems, and schedule follow up, has achieved an impressive 40% to 80% decrease in amputation rates[7-9]. Therapeutic shoes with offloading technique can prevent ulceration, promote wound healing and prevent recurrence of ulcer[10,11]. However ill fitting footwear is the most common precipitating factor for foot ulceration[12-14]. Chantelau E (2002)[15] found that most elderly people have feet that broader than general footwear sold in the market. Therapeutic footwear is usually are expensive and custom made shoes are time consuming. Patients may have new ulcer while waiting for new shoes. Making mass product shoes with proper size has lower cost and is time consuming. These shoes will be more appropriate for modification than general off-the-shelf shoes. Accurate foot dimension data is important for making these shoes. Until now, there is no standard method for foot dimension measurement.

The authors created three sets of simple foot

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calipers to measure foot dimension for making these shoes at our department. The authors designed the present study to determine the reliability of these foot calipers before using them in clinical practice.

Material and Method

A descriptive study was conducted at the Department of Rehabilitation Medicine, King Chulalongkorn Memorial Hospital. The present study was approved by the Ethics Committee of the Faculty of Medicine. All subjects were informed and written consents were obtained.

Subjects

Fifteen volunteers (8 men and 7 women) were recruited from rehabilitation residents and health care professionals at King Chulalongkorn Memorial hospital. The exclusion criteria were foot abnormalities which affected foot dimension such as amputation, severe foot deformities ,malunion after fracture, severe pronated feet ,and severe hallux valgus .

Material

The authors created 3 sets of foot calipers which were made from standard metal rulers. Each set was composed of 2 pieces, piece No.1 was used for foot width and length measurement and piece No.2 was used for great toe depth measurement. Each piece was composed of a nonmovable lever arm (axis A), a movable lever arm (axis B) and the longest lever arm with measurement scale in millimeters (axis C) (Fig. 1, 2).

Method

Foot dimension including width, length and toe depth were measured while the subjects stood with

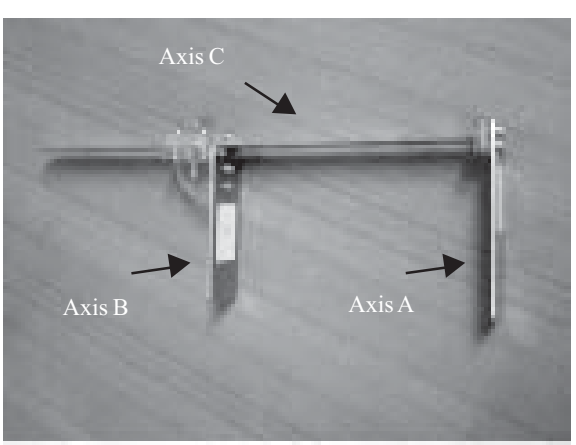

Fig. 1 Piece No1

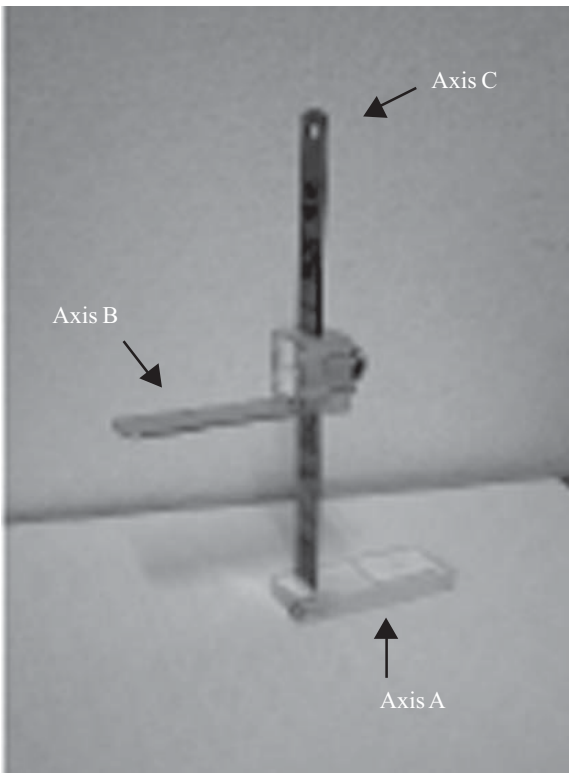

Fig. 2 Piece No 2

Fig. 3 Foot width

symmetrical weight bearing. Foot width and length were measured by caliper piece No.1 and toe depth was measured by caliper piece No.2. The authors set 3 examiners to measure foot dimension in the same method. Foot Length was measured by set rear surface of the heel at the axis A and medial side of the foot at the axis C then slide the axis B to contact tip of the longest toe(Fig. 4). Foot width was measured by set

Fig. 4 Foot Length

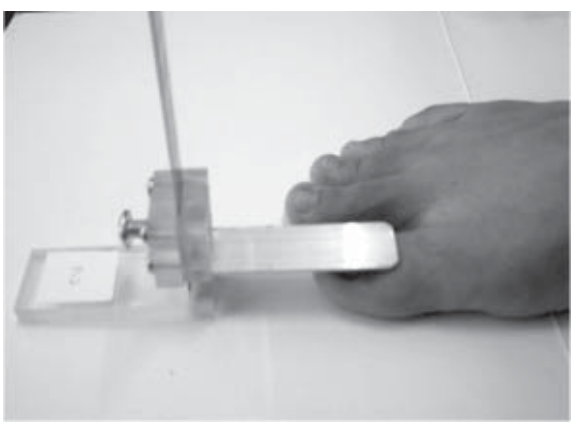

Fig. 5 Great toe depth

medial surface of the 1st metatarsophalangeal joint at axis A and slide axis B to contact lateral surface of the 5th metatarsophalangeal joint (Fig. 3). Toe depth was measured by set axisC in front of great toe and slide axis B to contact interphalangeal joint of the big toe (Fig. 5). All parameters were read on axis C and recorded in millimeters.

To determine reliability of 3 sets of foot caliper, one examiner was assigned to measure foot dimension of 30 feet with all sets of calipers at the same time of each foot. To determine the reliability of measurers, 3 examiners measured foot dimension of 30 feet at the same time of each foot.

Statistic analysis

The data was analyzed by using the SPSS program. The demographic data was shown as mean $\pm$ SD. The reliability between devices and between examiners were analyzed and shown as intraclass correlation coefficients (ICC) with 95% confidence interval.

Results

There were fifteen volunteers (8 men and 7 women). The average age was 28.6 $\pm$ 4.11years (range 22 - 39). The foot dimension data is shown in Table 1.

Reliability of 3 sets of Foot caliper

All parameters of 30 feet dimension measured by one examiner were analyzed and the intraclass correlation coefficients (ICC) were 0.985 (0.972-0.992), 0.996 (0.992-0.998) and 0.982 (0.968-0.991) for foot width, length and great toe depth, respectively (Table 2). This result showed high agreement of data from all devices.

Reliability of 3 examiners

All parameters of 30 feet dimension measured by 3 examiners were analyzed and the intraclass correlation coefficients (ICC) were 0.941(0.864-0.969), 0.850 (0.746-0.920) and 0.834 (0.721-0.910) for foot width, length and toe depth, respectively (Table 3). the present result showed a high agreement of data from all examiners.

Discussion

There are many studies about effects of footwear in prevention of ulceration, promote ulcer

Table 1. Foot dimension data

	Minimum	Maximum	Mean	Std. Deviation
Foot width	8.50	11.00	9.6423	0.62980
Foot Length	21.05	26.60	24.1737	1.09900
Great toe depth	1.50	2.40	1.9140	0.24470

Table 2. Reliability of 3 sets of foot calipers

Parameter	ICC	95% Confidence Interval	
		Lower Bound	Upper Bound
Foot width	0.985	0.972	0.992
Foot Length	0.996	0.992	0.998
Great toe depth	0.982	0.968	0.991

Table 3. Reliability of 3 examiners

	ICC	95% Confidence Interval	
		Lower Bound	Upper Bound
Foot width	0.941	0.864	0.969
Foot Length	0.850	0.746	0.920
Great toe depth	0.834	0.721	0.910

healing and prevent ulcer recurrence in diabetic patients[16-19]. The main key of footwear is pressure relief underneath the foot. Footwear must have proper size matched to the feet and have enough room for proper insole modification. Most shoes sold in the market do not have size matched to the foot and do not have extra depth for insole modification.

Working in our diabetic foot clinic, the authors hardly ever find off- the- shelf shoes that have proper size and are cheap for the patients so the authors would like to make mass products of shoes like off- the- shelf shoes to minimize time and cost for patients. Accurate foot dimension is important for making proper size shoes. Up till now, there is no standard foot dimension measurement. Shoe sellers use the Brannock device for foot sizes measurement. This instrument is easy for shoes size selection in US size. There are many other systems of shoes size such as the UK, French, Japanese and European but no standard size for Thai people. Rossi[20]used simple ruler flat on the floor with another ruler as a vertical marker to fall on the first ruler. Chantelau[15]use electric motor device and Cheung[21] used 3-D scan for foot dimension measurement . The last two method are more expensive but the first one is easier to make an error. None of them reported about reliability of the device. In Thailand, Techakampuch used the "No MESS" foot impression system to analyze foot prints. This foot print device is also expensive and the foot print will be larger than the actual foot size.

The authors designed and created the new simple foot calipers made from a simple standard metal ruler (Fig. 1, 2) The authors made 3 sets of devices for the convenience of use at our diabetic foot clinic. These foot calipers were cheap (500baht/set), user friendly and portable. The data were analyzed and reported as intraclass correlation coefficients (ICC) which showed a very high agreement of result .

Conclusion

These simple foot calipers have high reliability for foot measurement.These devices are appropriate for clinical use.

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ความน่าเชื่อถือของเครื่องมือวัดขนาดเท้า

ศิริพร จันทร์ฉาย, ณัฏฐิยา ตันติศิริวัฒน์

วัตถุประสงค์: *เพื่อศึกษาความน่าเชื่อถือของเครื่องมือวัดขนาดเท้า*
รูปแบบการวิจัย: *การศึกษาเชิงพรรณนา*
สถานที่ทำการศึกษา: *ห้องตรวจผู้ป่วยนอก ฝ่ายเวชศาสตร์ฟื้นฟู โรงพยาบาลจุฬาลงกรณ์*
กลุ่มที่ทำวิจัย: *อาสาสมัคร15 คน จากแพทย์ประจำบ้านและบุคลากรทางการแพทย์ ฝ่ายเวชศาสตร์ฟื้นฟู โรงพยาบาลจุฬาลงกรณ์*
วัสดุและวิธีการ: *คณะผู้วิจัยออกแบบและทำการผลิตเครื่องมือวัดขนาดเท้าอย่างง่ายขึ้น จำนวน3ชุด ใช้วัดขนาดเท้าทั้งความกว้าง ความยาว และความสูงของนิ้วหัวแม่เท้าขณะอาสาสมัครยืนตรงลงน้ำหนักเท้า2 ข้างเท่ากัน โดยกำหนดและทำการฝึกผู้วัดขึ้น3คนให้วัดด้วยวิธีเดียวกัน กำหนดให้ ผู้วัด1 คน วัดขนาดเท้าด้วยเครื่องมือวัดขนาดเท้าในกลุ่มเท้าตัวอย่างจำนวน 30 ข้าง ด้วยเครื่องมือทั้ง 3 ชุด เพื่อศึกษาถึงความน่าเชื่อถือของเครื่องมือ และ ผู้วัด 3 คนวัดขนาดเท้า ในกลุ่มเท้าตัวอย่างเดียวกันจำนวน 30 ข้าง เพื่อศึกษาหาความน่าเชื่อถือของผู้วัด บันทึกค่าที่วัดได้เป็นมิลลิเมตรและนำค่าที่ได้มาวิเคราะห์หาความน่าเชื่อถือแสดงผลเป็น Intraclass correlation coefficients (ICC)*
ผลการศึกษา: *อาสาสมัคร15 คนเป็นเพศชาย8 คน หญิง 7 คน อายุเฉลี่ย 28.6 $\pm$ 4.11ปี (22 - 39) วัดขนาดเท้าได้ความกว้าง ยาว และ สูง เฉลี่ย (มิลลิเมตร) เท่ากับ 9.64 $\pm$ 0.63, 24.17 $\pm$1.10 และ 1.91$\pm$0.24 ตามลำดับ จากการศึกษาเพื่อหาความน่าเชื่อถือของเครื่องมือ ทั้ง 3 ชุด เมื่อวิเคราะห์ด้วย Intraclass correlation coefficients (ICC) พบว่า ค่าความกว้าง ความยาวและความสูงของนิ้วหัวแม่เท้า, มีค่า 0.985 (0.972-0.992), 0.996 (0.992-0.998) และ 0.982 (0.968-991) ตามลำดับ ซึ่งมีความสอดคล้องกันอย่างสูง (95%CI) และ เมื่อศึกษาหาความน่าเชื่อถือของผู้วัด 3 คนเมื่อวิเคราะห์ด้วย Intraclass correlation coefficients (ICC) พบว่า ค่าความกว้าง ความยาวและความสูงของนิ้วหัวแม่เท้า มีค่า 0.941 (0.864-0.969), 0.850 (0.746-0.920) และ 0.834 (0.721-0.910) ตามลำดับ ซึ่งมีความสอดคล้องของข้อมูลอย่างสูงเช่นกัน*
สรุป: *เครื่องมือวัดขนาดเท้าอย่างง่ายนี้มีความน่าเชื่อถือสูงในการวัดขนาดเท้า สามารถนำมาประยุกต์ใช้ได้ในทางคลินิก*