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Quantitative Flatfoot Evaluation for Thais

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บทคัดย่อ:

วัตถุประสงค์: ในปัจจุบันยังไม่มีข้อสรุปในการประเมินลักษณะเท้าแบนอย่างชัดเจน โดยการประเมินลักษณะเท้าอย่างครอบคลุมต้องอาศัยลักษณะทางคลินิกและภาพถ่ายรังสีของเท้า การศึกษานี้ได้นำเสนอวิธีการประเมินลักษณะเท้าแบนของคนไทยในเชิงปริมาณที่ประกอบด้วยการประเมินทางคลินิกด้วยแรงกดเท้าจากค่า Arch Index (AI) และภาพถ่ายรังสีของเท้าในสองระนาบ ประกอบด้วยระนาบข้างและตัดขวาง

วัสดุและวิธีการ: การศึกษานี้ได้ประเมินค่า AI ของเท้าคนสุขภาพปกติ 100 ข้าง และทำการสุ่ม 35 เท้า จากเท้า 100 ข้าง มาประเมินภาพถ่ายรังสี ได้แก่ มุม calcaneal inclination angle (CIA), calcaneal-first metatarsal angle (C1MA) ในแนวระนาบข้าง และ talonavicular coverage angle (TNCA), talus-second metatarsal angle (T2MA) ในแนวระนาบตัดขวาง ช่วงค่าปกติสำหรับ

รับต้นฉบับวันที่ 14 มีนาคม 2559 รับลงตีพิมพ์วันที่ 3 ตุลาคม 2559

การประเมินจะกำหนดอยู่ในช่วงค่าเฉลี่ย±ส่วนเบี่ยงเบนมาตรฐาน สำหรับลักษณะเท้าแบนค่าประเมินดังกล่าวจะมีค่ามากกว่าหนึ่งค่าเบี่ยงเบนมาตรฐาน นอกจากนั้นการศึกษานี้ยังวิเคราะห์ความสัมพันธ์ระหว่างลักษณะทางคลินิกกับภาพถ่ายรังสีของเท้า
ผลการศึกษา: ค่าเฉลี่ยของ AI=0.2 (ส่วนเบี่ยงเบนมาตรฐาน=0.1) ค่าเฉลี่ย CIA=19.2 องศา (ส่วนเบี่ยงเบนมาตรฐาน=4.0) ค่าเฉลี่ย C1MA=135.1 องศา (ส่วนเบี่ยงเบนมาตรฐาน=6.9) ค่าเฉลี่ย TNCA=17.8 องศา (ส่วนเบี่ยงเบนมาตรฐาน=8.6) และค่าเฉลี่ย T2MA=19.4 องศา (ส่วนเบี่ยงเบนมาตรฐาน=10.0) ในการศึกษานี้พบว่าข้อมูลมีความสัมพันธ์อย่างมีนัยสำคัญระหว่างค่า AI และ CIA (r=−0.4, p−value=0.036) และ C1MA (r=0.5, p−value<0.010)
สรุป: การประเมินนี้สามารถนำไปใช้เพื่อประเมินลักษณะเท้าแบนในกลุ่มประชากรไทยเพื่องานศึกษาวิจัยด้านเท้าต่อไป

คำสำคัญ: การประเมิน, คนไทย, เท้าแบน, ภาพถ่ายรังสี

Abstract

Objective: At present, there is no consensus for a foot type classification method. A combination of clinical signs and foot radiographic measurements would provide comprehensive foot type determination. This study aimed to propose a flatfoot evaluation including footprint Arch Index (AI) and foot radiographs in two planes; sagittal and transverse planes.
Material and Method: The AIs of one hundred healthy adult feet were analyzed. Among these hundred feet, thirty five feet were randomly selected and evaluated for foot radiographic measurement. The calcaneal inclination angle (CIA) and calcaneal−first metatarsal angle (C1MA) were the radiographic measurements in the sagittal plane. The talonavicular coverage angle (TNCA) and talus−second metatarsal angle (T2MA) were the radiographic measurements in the transverse plane. Normative ranges of the assessment parameters were set by the range of mean±one standard deviation (S.D.). Flatfoot was diagnosed if these parameters were further than one S.D. from the mean. Correlations between clinical and radiographic measurements were also evaluated.
Results: The mean AI was 0.2 (S.D.=0.1). The means of the CIA and C1MA were 19.2 degrees (S.D.=4.0) and 135.1 degrees (S.D.=6.9), respectively. The means of the TNCA and T2MA were 17.8 degrees (S.D.=8.6) and 19.4 degrees (S.D.=10.0), respectively. The AI had significant correlations with the CIA (r=−0.4, p−value=0.036) and C1MA (r=0.5, p−value<0.010).
Conclusion: These foot classification criteria should be useful in determining foot type in Asians for future foot studies.

Key words: evaluation, flatfoot, radiograph, Thais

Introduction

At present, there are many methods for foot type classification. Currently used methods in clinical practice and research are visual observation, radiographic measurements and clinical measurements, such as subtalar joint axis location determination, medial longitudinal arch height, navicular bone displacement and footprint evaluation.[1−4] Clinical measurement is the easiest method to evaluate foot structure in clinical practice without radiation exposure. But the radiographic measurements provide the best visualization of bony alignments. In addition, there are wide variations in each method

and also among clinicians.[5] Furthermore, some criteria for foot type classification required subjective evaluation and need an experienced assessor.

A combination of clinical and radiographic assessments would provide more concise information on foot structure. From a literature review, only Murley's study proposed a guideline to use both clinical and radiographic measurements which included soft tissue and bone alignments to quantify normal foot and flatfoot in Caucasians.[4] They used the footprint arch index (AI) and/or normalized navicular height (NNH) as the first step in foot type screening. These clinical measurements were quantitative measurements and had moderate correlation with lateral view radiographic measurements.[6] Common angular radiographic measurements in the sagittal plane were included in Murley's protocol; namely calcaneal inclination angle (CIA) and calcaneal-first metatarsal angle (C1MA). Since flatfoot is a multi-planar deformity, there is a lack of consensus on the best presentation plane of flatfoot.[4] Murley's study also included two angular radiographic measurements in the transverse plane: talonavicular coverage angle (TNCA) and talus-second metatarsal angle (T2MA). However, the foot morphologies varied in different ethnicities.[7,8] The normative references of flatfoot identification parameters in each ethnicity were also different. From previous studies, there has only been flatfoot identification in the sagittal plane in the Asian foot.[3,9,10] This study aimed to propose quantitative flatfoot evaluation for the Thais' foot which include both clinical and radiographic measurements and also two planes of foot assessments: the sagittal and transverse planes.

Material and Method

Participants

Subjects were recruited randomly from students and staff population in a university in southern Thailand. The subjects were healthy adults who were aged 18-50 years old and had a body mass index (BMI) less than 25. All subjects provided written informed consent. The Institutional Review Board approved this study (EC: 55-299-25-6-3).

Procedures

The evaluation in this study was proposed in a modified Murley's protocol which had quantitative measurements and included two planes of foot assessments.[4] As the AI had higher reliability compared with NNH6, this study used only the footprint AI as the first step for the evaluation. The AI was printed via ink on size A4 paper with PedoPrint® (Bauerfeind Company, Germany) and it was calculated as the ratio of the mid foot area to the total area of the foot without the toes (Figure 1). Each area was determined by our developed computer algorithm. The second step was a radiographic measurement using SYNAPSE® version 3.2.0 (FujiFlim Medical Systems, USA). Four angles from two views of each set of foot radiographs were measured by an experienced musculoskeletal radiologist (Figure 2). The foot in the sagittal plane was evaluated with a radiograph in the lateral view f or the CIA and C1MA. The foot in the transverse plane was evaluated with a radiograph in the anterior-posterior view for the TNCA and T2MA. The CIA is the angle formed by a horizontal line and a line along the inferior cortex of the calcaneus. The C1MA is the angle between a line along the inferior surface of the calcaneus and a line parallel to the dorsum of the first metatarsal. The TNCA is the angle between the surface of the distal talus bone and the surface of the proximal navicular bone. The T2MA is formed by the bisection of the second metatarsal and a line perpendicular to a line connecting the surface of the distal talus bone.

Data analysis

One hundred feet of healthy subjects were recruited and the footprint AIs were evaluated. To

minimize the radiation exposure to subjects, a number of sample size was based on Leslie and Greenberg's' study.[11] From the 100 feet of healthy subjects, 35 right feet were randomly selected using a random numeric table to take the foot radiographs. All parameters were evaluated for distribution using skewness and kurtosis tests. The normative range was set in a range of mean± one standard deviation (S.D.) which is the normal limit of human anthropometric data.[12] To classify a normal foot, all five parameters (AI, CIA, C1MA, TNCA and T2MA) were in the normative range. For the flatfoot type, the AI was above the normative range and the CIA together with the C1MA or the TNCA together with T2MA were above the normative range, whereas the CIA was lower the normative range.[4] Pearson's correlation coefficients among the clinical and radiographic measurements were also evaluated. The statistical analysis was done with SPSS version 16.0 (SPSS Inc. Chicago, Illinois, USA) and the significance level was set at p-value<0.05.

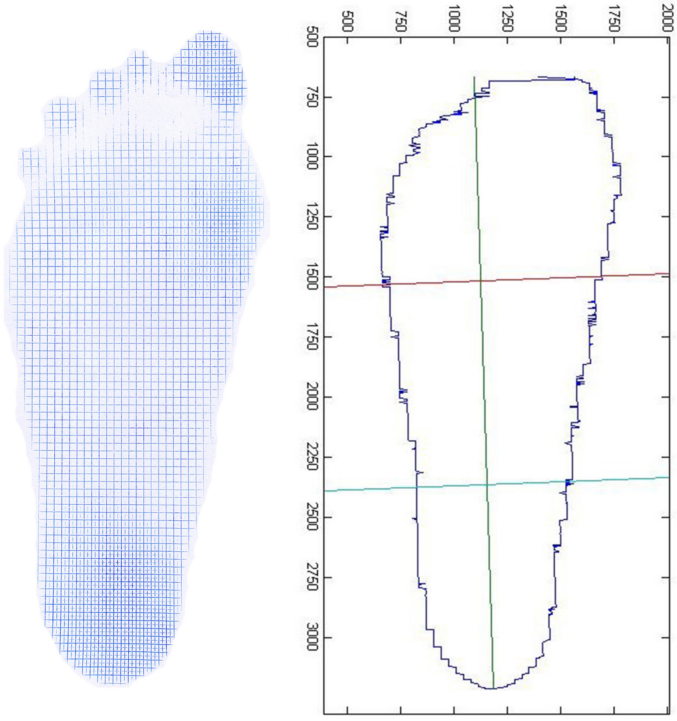

Figure 1 Footprint Arch Index (AI) result. (Left) an original footprint (Right) a contour of foot for AI calculation. The AI in this patient was 0.3628.

CIA=calcaneal inclination angle, C1MA=calcaneal-first metatarsal angle, TNCA=talonavicular coverage angle, T2MA=talus-second metatarsal angle

Figure 2 Example of radiographic measurements by experienced radiologist. (Above) Anterior-posterior view. (Below) Lateral view.

Results

The mean age and mean BMI of the subjects were 28.3 (S.D.=9.3) years old and 21.4 (S.D.=2.3) respectively. The 35 randomly selected right feet were 15 males and 20 females. All parameters distributed normally (Figure 3). The mean AI was 0.2 (S.D.=0.1). The mean CIA was 19.2 degrees (S.D.=4.0). The mean C1MA was 135.1 degrees (S.D.=6.9). The mean TNCA was 17.8 degrees (S.D.=8.6). The mean T2MA was 19.35 degrees (S.D.=10.0). The results of normative range values and the values to define flatfoot are presented in Table 1.

The AI had a significantly negative correlation with CIA (r=-0.4, p-value=0.036) but there was a positive correlation with C1MA (r=0.5, p-value<0.010). However, there were non-significant correlation between the AI and radiographic angles in transverse plane; TNCA (r=-0.2, p-value=0.930), T2MA (r=-0.2, p-value=0.927). The CIA had a significantly negative correlation with C1MA (r=-0.9, p-value<0.010). The TNCA had a significantly positive correlation with T2MA (r=0.9, p-value<0.010).

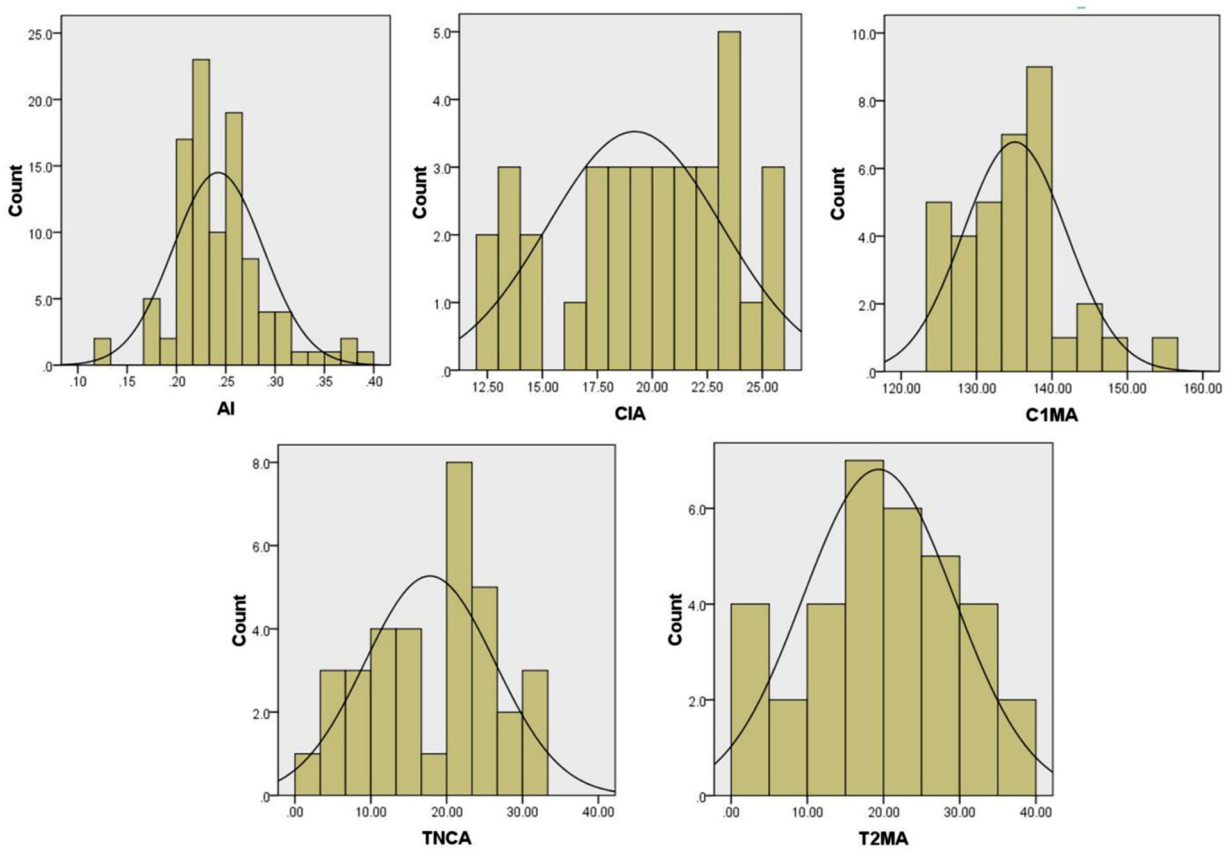

Figure 3 The normal data distribution of the Arch Index (AI), the calcaneal inclination angle (CIA), the calcaneal–first metatarsal angle (C1MA), the talonavicular coverage angle (TNCA) and the talus–second metatarsal angle (T2MA)

Table 1 Foot type classifying criteria

Parameters	Normal foot	Flatfoot
AI	0.2–0.3	>0.3
CIA	15.2–23.2	<15.2
C1MA	128.2–142.0	>142.0
TNCA	9.2–26.4	>26.4
T2MA	9.4–29.3	>29.3

AI=Arch Index, CIA=calcaneal inclination angle, C1MA=calcaneal–first metatarsal angle, TNCA=talonavicular coverage angle, T2MA=talus–second metatarsal angle.

Discussion

The results of this study showed a similar trend with the previous studies of the Asian foot (Table 1).[3,9,10] The AI result in this study was the parameter most consistent with the Xiong study.[3] Xiong and colleagues characterized arch of foot in healthy Hong Kong Chinese adults and found the mean AIs in the males and females were 0.2 (S.D.=0.1) and 0.24 (S.D.=0.0), respectively. Chu and colleagues also determined the range of AI in healthy Chinese adults and they found the mean AIs in the males and females were 0.2 (S.D.=0.1) and 0.2 (S.D.=0.1),

respectively.[9] Chu's study had a smaller number of female (n=14) and younger (23.4±3.1 years old) subjects compared with this study. This may cause a difference in the mean values of the AI from this study. Both studies also found that the AI had a significantly high correlation with arch height.[3,9] Kaewpornsawan and colleague evaluated the foot in healthy Thai adults using radiographic measurements.[10] They found that the mean value of CIA was 17.5 degrees (S.D.=4.6) for the right foot which was a smaller compared with this study. The different result may be related to the different demographic data. In comparison to the Caucasian foot, this study had the normal value of the AI, CIA and C1MA which are in agreement with Murley's study4 but the TNCA and T2MA had different ranges. In order to determine flatfoot in Thais, this study had smaller AI and CIA values, and higher C1MA, TNCA and T2MA values compared with the Murley's study.[4]

Significant correlations in this study were found only between the AI and the radiographic measurements in the sagittal plane, the CIA and C1MA angles, which were at mild to moderate level. No study has evaluated the correlation between the clinical and radiographic measurements in the Asian foot. Murley and colleagues found a significantly moderate correlation between the AI and the radiographic angles in the sagittal plane (CIA: r=-0.6 and C1MA: r=0.7) and a significantly mild correlation between the AI and the radiographic angles in the transverse plane (TNCA: r=0.4 and T2MA: r=0.2) in the healthy Caucasian foot.[4] Most of the subjects in Murley's study had greater BMIs compared with the subjects in this study. This possibly led to the significant correlation between the AI and the radiographic measurements in the transverse plane. Because a large amounts of fat mass increased fat tissue wihtin foot and midfoot area, and also diminish the foot posture control in transverse plane.[13]

There was a limitation in this study. The assessments evaluated only two planes of the foot. As flatfoot is a three-dimensional deformity, the third plane (frontal plane) should be added into the flatfoot evaluation. Despite that, this quantitative flatfoot evaluation could be useful in studies of the Thais foot.

Conclusion

Flatfoot can be classified by clinical and radiographic measurements. The normative ranges of these measurements, with some limitations, developed in this study could provide benefits for further Thais foot studies.

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