Comparison between Staheli Index on Harris Mat Footprint and Talar-First Metatarsal Angle for the Diagnosis of Flatfeet

Yanin Plumarom MD*,
Worarachanee Imjaijitt MA**, Nusorn Chaiphrom MD*

** Department of Orthopedics, Phramongkutklao Hospital and Phramongkutklao College of Medicine, Bangkok, Thailand*
*** Office of Research and Development, Phramongkutklao Hospital and Phramongkutklao College of Medicine, Bangkok, Thailand*

Background: *Flatfoot is practically diagnosed by physical examination, radiographs, or footprint. Talar first-metatarsal angle on a weight-bearing lateral radiograph provides an accurate measurement for the diagnosis of flatfoot and is frequently used by foot and ankle specialists. Staheli Index is also considered as a reliable method. However, there is no information of the sensitivity and specificity of this index compared to the talar-first metatarsal angle for the diagnosis of flatfoot.*
Objective: *To evaluate the usefulness of the Staheli Index on Harris mat footprint for the diagnosis of flatfoot.*
Material and Method: *The weight-bearing lateral radiographs were obtained from 157 patients (314 feet). The radiographs were examined for the talar-first metatarsal angle. Harris mat footprint was also obtained from each participant for the measurement of the Staheli Index. The sensitivity and specificity of the Staheli Index was calculated using the talar-first metatarsal angle as a gold standard. ROC curve was also performed to determine the cut-off point of the Staheli Index. Interobserver and intra-observer reliability was also tested.*
Results: *The cut-off point of the Staheli Index at 0.77 revealed the sensitivity of 70.2% and specificity of 73 %, and the accuracy value was 72% for the detection of flatfoot compared to the talar-first metatarsal angle. There was no significant difference of the area under the ROC curves performed by two physicians was found. The area under the ROC curves showed no difference when performed at two different times by the same physician.*
Conclusion: *The Staheli Index obtained from the Harris mat footprint could be considered as the screening or diagnostic method for flatfoot.*

Keywords: *Flatfoot, Harris mat footprint, Staheli index, Talar-first metatarsal angle, Sensitivity, Specificity*

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Flatfoot is one of the frequently encountered orthopedic conditions in both children and adult population. Prevalence of flatfoot varied among different groups. For example, Harris and Beath identified flatfeet in approximately 23% of 3,600 recruits in the Royal Canadian Army(1). Tareco et al found the prevalence of flatfoot at 6 % in patients with no history of foot problems using the single leg stance footprint(2). Michelson et al showed that the prevalence of flatfoot in 196 athletes was 15% using Harris mat footprints(3). Mosca showed the prevalence of 23% in 3,619 adults(4). In Thailand, information of flatfoot including the prevalence is lacking. Flatfoot was identified as the significant risk of injuries in athletes(3) and military training(5). This condition may show potential for other abnormalities such as twisted big toe (Hallux valgus)(6).

To date, there is no consensus on clinical or radiographic criteria for defining a flatfoot. However, diagnosis of flatfoot in the outpatient department is practically carried out using patients' information, physical examination, and radiographic evaluation. A few radiographic measurements have been used to evaluate flatfoot(7-9). Among these, talar-first metatarsal angle is one of the most familiar and useful measurements for flatfoot using a weight-bearing lateral radiograph(8). The talar-first metatarsal angle, defined by Meary(8), is the angle formed between the long axis of the talus and first metatarsal on a weight-bearing lateral view. Flatfoot is considered when the measured talar-first metatarsal angle is greater than 4° convex

Correspondence to:
Chaiphrom N, Department of Orthopedics, Phramongkutklao Hospital and Phramongkutklao College of Medicine, 315 Ratchawithi Road, Ratchathewi, Bangkok 10400, Thailand.
Phone: 0-2354-7600 ext. 93504, Fax: 0-2644-4940
E-mail: c_nusorn99@yahoo.com

downward. However, the radiograph based methods may not be inconvenient in some situations, for instance, overcrowded clinics or community settings. Alternatively, a few non-radiograph methods such as a footprint ration have been used as a predictive method for flatfoot. Measurement of footprint using Staheli Index is considered as a reliable method for evaluation of flatfoot(10). It has been used in both research and clinic settings because this method is easy to perform in less time and low cost(11-15). However, there was no comparative study between the non-radiographic and radiographic methods in order to determine its sensitivity and specificity.

The present study aimed to determine the sensitivity and specificity of the measurement of footprint using Staheli Index for the evaluation of flatfoot compared to the radiographic method, the talar-first metatarsal angle using a weight-bearing lateral radiograph.

Material and Method

The present study protocol was approved by the Ethical Committee of the Royal Thai Army Medical Department. The patients who visited the Outpatient Clinic of the Department of Orthopedics, Phramongkutklao Hospital were consecutively asked to participate in this study. Inclusion criteria included 1) patients age15-80 years old and 2) those who agreed to participate in the study and gave written informed consent. Exclusion criteria included 1) patients who had a broken foot or anklebone in the past 6 months, 2) those who underwent orthopedic surgery of the foot or ankle in the past 6 months, and 3) those who had a disease or disorder of the foot or ankle including rheumatologic diseases, arthritis and a diabetic foot. Written informed consent was obtained from all participants.

Methods for evaluation of flatfoot

Both feet of each subject were examined for flatfoot using the talar-first metatarsal angle, a radiographic method and Staheli Index on Harris mat footprint. The talar-first metatarsal angle was used as the gold standard for the measurement of flatfoot. This angle was calculated from the longitudinal axis of the talus (halfway point between the superior and inferior surfaces of the talus at the middle of the talus and the neck of the talus) which was the line across the lateral longitudinal axis of the first metatarsal (mid-diaphyseal reference points). The normal value was between -4° and +4°(8). These weight-bearing lateral radiographs were measured using Goniometer by the foot and ankle specialists.

The Harris mat footprint method was then performed in all subjects(16). Staheli Index is the ratio of the minimal distance in the mid-foot region to the maximal distance in the rear-foot region (Fig. 1)(10). Each distance was measured by a vernier caliper. Measurement of foot area for the calculation of Staheli Index was carried out twice with the interval of 1 month to determine the intra-observer reliability. Two different physicians who had never met or examined the participants before in order to determine the interobserver reliability also performed the measurement.

Statistical analysis

The talar-first metatarsal angle, a radiographic method was used as the gold standard. The sensitivity and specificity with 95% CI of Staheli Index was determined. Receiver Operating Characteristic (ROC) curves was generated using STATA/MP 12.

Results

Demographic data of all 157 participants are shown in Table 1. Among these participants, 97 (61.8%) were female. The average age was 33.1±15.9 and range

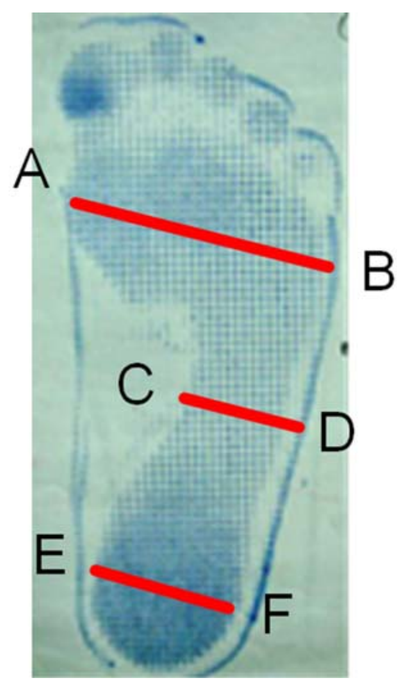

Fig. 1 Staheli Index, ratio of the minimal distance in the midfoot region to the maximal distance in the rearfoot region, CD/EF.

18-79 years old. The average weight and height was 63.1±14.6 kg and 163.1±9.2 cm, respectively. The average BMI was 23.7±4.8 kg/cm^2. A total of 314 feet were included for the radiographic evaluation, the talar-first metatarsal angle method. This method indicated flatfoot in 114 feet (36.3%). All feet were underwent the Harris mat footprint for the calculation of Staheli Index. This method showed flatfoot in 134 feet (42.7%). Compared to the talar-first metatarsal angle method, sensitivity and specificity of the Staheli Index was 70.2% and 73%, respectively (Table2). Positive predictive value was 59.7%, while, negative predictive value was 81.1%.

Fig. 2 showed the ROC curve for the Staheli Index compared to the talar-first metatarsal angle method measured by two physicians. A point on the ROC curve was selected as a cut-off point to give the appropriate value of sensitivity and specificity. When the authors used a cut-off point of 0.77, the sensitivity and specificity of the Staheli Index was 70.2% (95% CI: 60.9-78.4) and 73% (95% CI: 66.3-79.0), respectively. The accuracy of this test was 72%. The area under the ROC curve was 0.7882. Fig. 2 also showed the evaluation of intra-observer and interobserver reliability. There was no significant difference of the area under the ROC curve determined by two different physicians (p = 0.338). In addition, the area under the ROC curve determined by one physician at different time point showed no statistical difference (p = 0.328).

Table 1. Demographic data of the 157 articipants for the evaluation of flatfoot

	n (%)
Age (years), mean ± SD	33.1±15.9
<20	18 (11.5)
20-29	72 (45.9)
30-39	10 (6.4)
40-49	23 (14.6)
50-59	25 (15.9)
60-69	5 (3.2)
70+	4 (2.5)
Sex	
Male	60 (38.2)
Female	97 (61.8)
Body weight (kg), mean ± SD	63.1±14.6
Height (cm), Mean ± SD	163.1±9.2
Body mass index (BMI), Mean ± SD	23.7±4.8
Underweight	4 (2.5)
Normal	82 (52.2)
Overweight 1	26 (16.6)
Overweight 2	35 (22.3)
Obesity	10 (6.4)

Discussion

Radiographic parameters such as talar-first metatarsal angle, calcaneal pitch and talo-navicular coverage angle have been used to evaluate the flatfoot since a few studies showed they could discriminate flatfoot from normal foot[7-9,11,15]. Among these parameters, the talar-first metatarsal angle on weight-bearing lateral radiograph has been commonly used since increased talar-first metatarsal angle is one of the most discriminating measurements. Hence, this parameter was used as the gold standard in the present study. The prevalence of flatfoot diagnosed by the talar-first metatarsal angle was 36.3%, which was rather high compared to a few previous studies[1-4]. This could be due to the selective study population from Orthopedic Clinic.

Although a few studies showed a correlation between radiographic parameters and footprint measurement[11], the present study is the first to compare the Staheli Index and the talar-first metatarsal angle for the diagnosis of flatfoot in terms of sensitivity and specificity. Our study showed that the Staheli Index on the Harris mat footprint was 70.2% sensitive and 73% specific for the diagnosis of flatfoot compared to the radiographic method, the talar-first metatarsal angle measuring on a weight-bearing lateral radiograph. Our information supports a few recent studies showing the usefulness of the Staheli Index for the diagnosis of

Table 2. Detection of flatfoot by the Staheli Index on Harris mat footprint compared to the talar-first metatarsal angle method

Detection method staheli index at 0.77	Talar-first metatarsal angle method		Total
	Positive	Negative	
Positive	80	54	134
Negative	34	146	180
Total	114	200	314

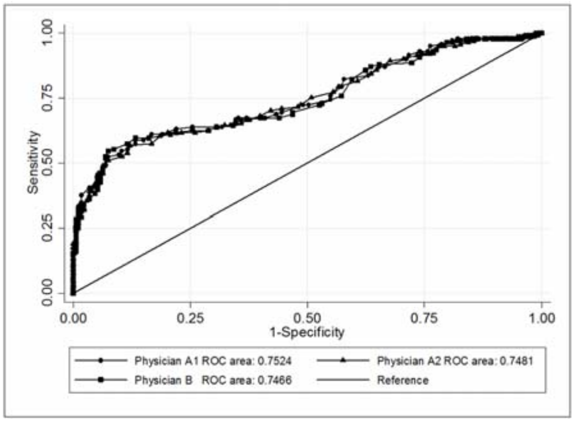

Fig. 2 ROC curve for staheli index method compared to Talar-first metatarsal angle method.

asymptomatic and symptomatic flatfoot[13,17].

According to the ROC curve, it was found that the appropriate cut-off point of 0.77 would give the sensitivity at 70.2% and the specificity at 73%. The accuracy was 72%. However, if the cut-off point of 0.3 is used, the sensitivity would be increased to 98.3%. This should be a good candidate method for screening of flatfoot in the field. Then the diagnosis has to be confirmed by other techniques since its specificity was as low as 4.0%. In contrast, if the cut-off point was 1.0, the specificity would be as high as 98.0%, the sensitivity would be equal to 45.6%. This could be helpful for the evaluation of flatfoot in the clinical settings.

Since radiographic evaluation for flatfoot may not be suitable in some situations such as an epidemiological survey of a large population. In addition, a recent study showed that the measurement of the talar-first metatarsal angle had the lowest interobserver reliability among 6 radiographic measurements for flatfoot. This might be due to the decision on important anatomical marks. The reliability was also shown to depend on physician's experience[18]. In the present study, the author showed that the measurement of Staheli Index on the Harris mat footprint was reproducible. The measurement was performed by the 1st physician, two times (intra-observer reliability) and no statistically significant differences were found. Results of the measured Staheli Index of 2 physicians were also compared (interobserver reliability). Again, no statistically significant differences were found.

The Staheli Index originally validated in young people so that it was suitable to preliminarily conduct the study in the young population with normal BMI like ours. False positive result of the Staheli Index might occur in overweight or adults who have more excessive soft tissue. Thus, validation of the Staheli Index in these populations should be further conducted.

Conclusion

Results from the present study demonstrated that measurement of the Staheli index on the Harris mat footprint is useful and convenient for the evaluation of flatfeet. This method is also simple, easy, inexpensive and reproducible.

Acknowledgement

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Potential conflicts of interest

None.

References

1. Harris RI, Beath T. Army foot survey. Ottawa: National Research Council of Canada; 1947.
2. Tareco JM, Miller NH, MacWilliams BA, Michelson JD. Defining flatfoot. Foot Ankle Int 1999; 20: 456-60.
3. Michelson JD, Durant DM, McFarland E. The injury risk associated with pes planus in athletes. Foot Ankle Int 2002; 23: 629-33.
4. Mosca VS. Flexible flatfoot and skewfoot. J Bone Joint Surg Am 1995; 77: 1937-45.
5. Wang X, Wang PS, Zhou W. Risk factors of military training-related injuries in recruits of Chinese People's Armed Police Forces. Chin J Traumatol 2003; 6: 12-7.
6. Nguyen US, Hillstrom HJ, Li W, Dufour AB, Kiel DP, Procter-Gray E, et al. Factors associated with hallux valgus in a population-based study of older women and men: the MOBILIZE Boston Study. Osteoarthritis Cartilage 2010; 18: 41-6.
7. Gamble FO, Yale I. Clinical foot roentgenology. Baltimore: Williams & Wilkins; 1966: 153.
8. Meary R. On the measurement of the angle between the talus and the first metatarsal. Symposium: Le pied creux essential. Rev Chir Orthop 1967; 53: 389-410.
9. Bleck EE, Berzins UJ. Conservative management of pes valgus with plantar flexed talus, flexible. Clin Orthop Relat Res 1977; (122): 85-94.
10. Staheli LT, Chew DE, Corbett M. The longitudinal arch. A survey of eight hundred and eighty-two

feet in normal children and adults. J Bone Joint Surg Am 1987; 69: 426-8.
11. Coughlin MJ, Kaz A. Correlation of Harris mats, physical exam, pictures, and radiographic measurements in adult flatfoot deformity. Foot Ankle Int 2009; 30: 604-12.
12. El O, Akcali O, Kosay C, Kaner B, Arslan Y, Sagol E, et al. Flexible flatfoot and related factors in primary school children: a report of a screening study. Rheumatol Int 2006; 26: 1050-3.
13. Chen KC, Yeh CJ, Kuo JF, Hsieh CL, Yang SF, Wang CH. Footprint analysis of flatfoot in preschool-aged children. Eur J Pediatr 2011; 170: 611-7.
14. Roth S, Roth A, Jotanovic Z, Madarevic T. Navicular index for differentiation of flatfoot from normal foot. Int Orthop 2013; 37: 1107-12.
15. Younger AS, Sawatzky B, Dryden P. Radiographic assessment of adult flatfoot. Foot Ankle Int 2005; 26: 820-5.
16. Jahss MH, Kummer F, Michelson JD. Investigations into the fat pads of the sole of the foot: heel pressure studies. Foot Ankle 1992; 13: 227-32.
17. Gross KD, Felson DT, Niu J, Hunter DJ, Guermazi A, Roemer FW, et al. Association of flat feet with knee pain and cartilage damage in older adults. Arthritis Care Res (Hoboken) 2011; 63: 937-44.
18. Sensiba PR, Coffey MJ, Williams NE, Mariscalco M, Laughlin RT. Inter- and intraobserver reliability in the radiographic evaluation of adult flatfoot deformity. Foot Ankle Int 2010; 31: 141-5.

การเปรียบเทียบระหว่างการวัดอัตราส่วนของสตาลี (Staheli Index) จากแผ่นพิมพ์ฝ่าเท้า แฮริสแมท ฟุตปริ้นและมุม talar-first metatarsal angle ในการวินิจฉัยภาวะเท้าแบน

ญาณินภ์ ปลื้มอารมย์, วรรัชนี อิ่มใจจิตต์, นุสรณ์ ไชยพรหม

ภูมิหลัง: *การวินิจฉัยภาวะเท้าแบนทำได้โดยการการตรวจร่างกายดูลักษณะของเท้าการวินิจฉัยจากภาพฉายรังสีและจากการพิมพ์ฝ่าเท้ามุม talar-first metatarsal angle ที่ได้จากการฉายภาพรังสีด้านข้างในท่ายืนลงน้ำหนักเป็นค่าที่มีความแม่นยำในการ วินิจฉัยภาวะเท้าแบนและใช้บ่อยในแพทย์ทางเท้าและข้อเท้าการวัดอัตราส่วนของรูปเท้า จากพิมพ์ฝ่าเท้าด้วยวิธีของสตาลี (Staheli Index) เป็นวิธีที่เชื่อถือได้แต่ยังไม่มีการศึกษาหาความไวและแม่นยำเมื่อเปรียบเทียบกับฉายภาพรังสีท่ายืนความจำเพาะของการวัดอัตราส่วนนี้กับมุม talar-first metatarsal angle ในการใช้การวินิจฉัยภาวะเท้าแบน*

วัสดุและวิธีการ: *ทำการฉายภาพรังสีท่ายืนลงน้ำหนักในผู้ป่วย 157 คน (314 เท้า) เพื่อวัดมุม talar-first metatarsal angle วัดอัตราส่วนด้วยวิธีของสตาลี (Staheli Index) จากแผ่นพิมพ์ฝ่าเท้าแฮริสแมทฟุตปริ้นความไวและความจำเพาะของการวัดอัตราส่วนด้วยวิธีของสตาลี (Staheli Index) ถูกคำนวนโดยใช้ talar-first metatarsal angle เป็นวิธีมาตรฐานนำข้อมูลที่ได้มาสร้าง ROC curve เพื่อคำนวนหาจุดตัดสำหรับการวัดอัตราส่วนด้วยวิธีของสตาลี (Staheli Index) ได้มีการทดสอบความน่าเชื่อถือภายใน (Interobserver reliability) และระหว่างบุคคล (intraobserver reliability)*

ผลการศึกษา: *เมื่อใช้จุดตัดที่ 0.77 พบว่าการวัดอัตราส่วนด้วยวิธีของสตาลี (Staheli Index) มีค่าความไวเท่ากับ 70.2% (95%CI: 60.9-78.4) ความจำเพาะเท่ากับ 73% (95%CI: 66.3-79.0) และค่าความแม่นยำเท่ากับ 72% ในการตรวจหาภาวะเท้าแบนเมื่อเทียบกับมุม talar-first metatarsal angle ไม่พบว่ามีความแตกต่างของพื้นที่ใต้ ROC curves เมื่อทำการวัดโดยแพทย์ 2 คน หรือเมื่อทำการวัดโดยแพทย์คนเดียวกัน 2 ครั้ง*

สรุป: *ค่า Staheli index จากการวัดอัตราส่วนของรูปเท้าจากแผ่นพิมพ์ฝ่าเท้าแฮริสแมทฟุตปริ้นเป็นวิธีที่มีประโยชน์ในการคัดกรองหรือวินิจฉัยภาวะเท้าแบน*