Calculation of arch index from footprint of male medical students in Bangladesh: A cross- sectional study

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Abstract

Background: Foot dimension has great use in anatomy, physiology, ergonomics, forensic science, plastic surgery, radiology, podiatry, archaeology, anthropology, nutrition science and diagnostic knowledge between patient and normal population. The data of foot dimensions of Bangladeshi male is essential for the anatomist for normative reference, to the radiologist and podiatrist for diagnosis of diseases in their respective fields.

Objective: This cross sectional analytic study was planned to determine the arch index of foot from the footprint of Bangladeshi male medical students.

Methods: Two hundred (200) male medical college students of 18-25 years of age were selected from different medical colleges of Dhaka city and their age was determined by their national ID cards. Both feet of the same individual were painted with ink with the help of the brush. After ensuring that toes and sole were inked properly, footprints were taken at the same time for both feet while the ink was still wet. The footprints were scanned after putting a graph paper on top which was photocopied on a transparent paper. Arch index was calculated from the footprints superimposed by a transparent photocopied centimeter calibrated graph paper. Calculations were done by counting the big boxes first (1 cm^2) then the small boxes in the centimeter calibrated graph sheet which was scanned along with the footprint.

Results: In the present study, normal foot arch was found in 41 % and 39.5% individuals on the right and left foot respectively. High arch was observed in 22% and 23% on right and left foot respectively while low arch on right and left foot were found in 37% and 37.5% individuals respectively.

Conclusion: On calculation of the arch index, maximum distribution of foot arch was normal (41% on the right foot and 39.5% on the left foot) in type, the low foot arch type was 37% on the right foot and 37.5% on the left foot and the high foot arch showed minimum distribution (22% on the right foot and 23% on the left foot) among adult Bangladeshi male medical students.

Keywords: Arch index, foot print, male medical students

Introduction:

The foot dimensions derived from footprint can provide definitive information on many physical characteristics of

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the individual as morphology of human foot shows variations due to the combined effects of heredity, lifestyle and climatic factors. The partial or complete footprints can be found on rain covered areas, newly waxed floors, freshly cemented surfaces, moistened surfaces, in dust, mud, sand, oil, paint and can be left in blood at the crime scenes.

Arch-height estimation though practiced usually in supine posture; is neither correct nor scientific as referred in literature, which favour for standing x-rays or arch index as yardstick. In fact, the standing x-rays can be excused for being troublesome in busy OPD, but an ink-footprint on simple graph-sheet can be documented, as it is easier, cheaper and requires almost no machineries and expertisation.[1]

Measurement of the height of the arch of foot deserves immense importance so far its clinical aspects are concerned and for this purpose since middle of the past century several methods were used by pioneer researchers. Practically the height of the medial longitudinal arch provides acceptable outlook of the arch-height. Some researchers have classified the foot arch type by only visual impression, which was quite practiced till the end of last

century.[2-4] On the other hand a few of them carried on such a classification based on palpation of the navicular tuberosity.[5] In late nineties researchers approached with the help of radiography in parallel with footprint. Radiographically parameters like the 'taller height', 'navicular height' and recently the 'normalized navicular height' obtained from standing weight bearing lateral view x-ray of foot, were accepted as yardsticks to predict the arch height.[6-9]

Procurement of, and processing the footprint being easier and cheaper, is more acceptable for the patient than radiography. Hence, in spite of the fact that radiography is still important in establishing the arch height, footprint procedures are preferred to it.[10-11] It was previously disclosed that the foot-print obtained on a graph sheet by conventional ink is better that the electronic foot-print obtained by special soft-ware system, so far determination of the sole contact area was concerned.[12] This can be conveniently taken on a graph paper and the Arch Index can be calculated thereafter to ascertain the height of the arch of foot. The concept of Arch Index was first described by Cavanagah et al. (1987) as the ratio of the area of the middle third of the foot to the entire foot area excluding the toes. An arch index of less than 0.21 has been said to be indicative of a cavus foot, while it greater than 0.26 is indicative of planus foot whereas Arch Index between 0.21~0.26 corroborates normal arch height. Importance of "arch-index" as a sensitive podographic indicator was later on confirmed in different studies[13]. Later it has been established that arch index, derived from footprint to show a significant negative correlation with the navicular height.[9, 14-16] But unfortunately almost no studies have inter-related mathematically the foot-print derived arch-index values with the radiographically[17] evaluated standing arch-height measurements with an acceptable equation, by which one can interpret directly the standing navicular or taller height with the help of arch index without proceeding through actual maneuver. Especially such information lacks in pertinent literature so far.

The values of different dimensions of foot of Bangladeshi males may be helpful to the anatomists for a normative reference. For the radiologist and the podiatrists the normative values may be helpful in diagnosis of diseases in their respective fields. This knowledge of different foot dimensions and its correlation with the arch of foot is of extreme importance for the forensic scientists to establish the identity of an individual. For proper designing of a prosthetic foot by the ergonomists and for surgical reconstruction by the plastic surgeons foot dimension data is essential.

With the above perspective, the present study was carried out to give the overview of foot dimensions of Bangladeshi males and to calculate the arch index of foot of the same age group of Bangladeshi males.

Materials and Methods:

This cross sectional analytic study was carried out at Department of Anatomy of Dhaka Medical College, Dhaka from July 2012 to June 2013. The study was performed on 200 male Bangladeshi medical students of age ranging from 18-25 years' individuals with congenital anomaly of feet, any deformity of feet from any disease, endocrine diseases like acromegaly, gigantism, those who have encountered any road traffic accident or burn injury affecting feet and tribal population were excluded from the study.

The feet of the individual were washed with liquid soap before inking. Feet were washed in order to remove oily or greasy substance and dirt from the foot. The feet were then wiped with a towel. Two legal size white papers were fixed on a clip board with double clips to take print of right and left foot which was placed on an even floor as footprints of both feet were collected at the same time. A small amount of ink was poured into a clean and dry flat box with a wide base. The individual was asked to sit on a chair and rest his legs on a low stool with extended knee so that his feet were placed beyond the stool for proper painting of the soles. A wide paint brush was moved in the ink over flat surface of the wide based box until the ink spread thinly and homogenously in the brush.

The right and left foot were painted with ink with the help of the brush. After ensuring that toes and sole were inked properly, footprints were taken at the same time for both foot while the ink was still wet. The feet were carefully removed from the stool and the soles were placed slowly on the paper from proximal to distal end while the individual still remained seated. The individual was then asked to stand from sitting position with his feet placed on the papers on the clipboard without moving the feet. After ensuring that the feet were placed properly the individual was asked to stand erect without any support while putting equal pressure on both foot without moving their position on the papers. The individual was then asked to sit. The feet were then lifted from the paper at the same time so that there was no overlapping of the already imprinted footprint.
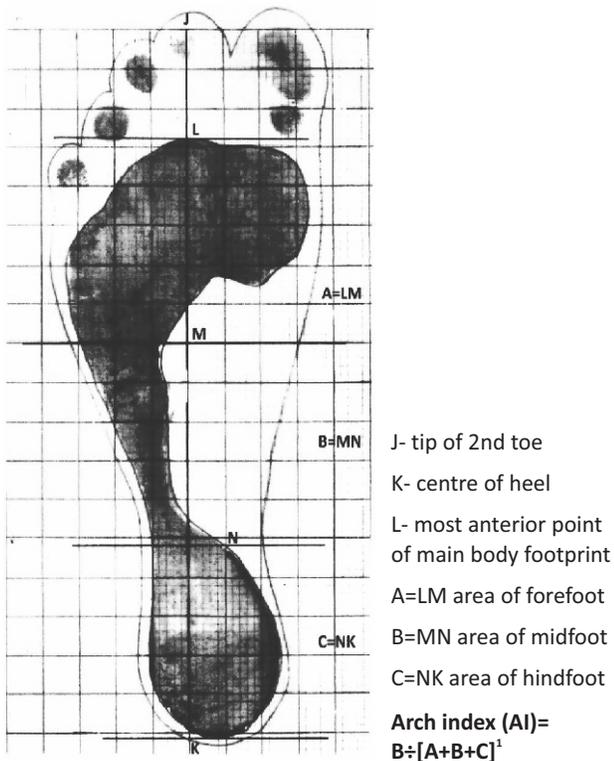
For statistical analysis, SPSS version 16 was used. The relationship between the right and left footprint measurements were determined by paired t- test. The study was approved by Ethical Committee of Dhaka Medical College.

Measurement of arch index

Arch index was calculated from the footprints superimposed by a transparent photocopied centimeter calibrated graph paper. The footprints were scanned after putting a graph paper on top which was photocopied on a transparent paper. Then the linear distance of the centre of the heel (point K) and the tip of the second toe, which is the axis of the foot (point J) was measured (Fig:1). Next a perpendicular line was drawn tangential to the most anterior point of the main body of the footprint (footprint without the toes). Their point of intersection was marked (point L). The line LK was then divided in three equal parts (LM, MN, NK). Ultimately the whole body of the footprint was divided in three areas from those points with the perpendiculars from the foot axis (Fig:1). The anterior,

middle and posterior areas were marked as A, B and C which represented the areas of forefoot, midfoot and hindfoot respectively (Fig:1). Calculations were done by counting the big boxes first (1 cm^2) then the small boxes in the centimeter calibrated graph sheet which was scanned along with the footprint. Further calculations were carried out by using the foot index formula:

Arch index (AI) = B ÷ [A + B + C]^1

J- tip of 2nd toe

K- centre of heel

L- most anterior point of main body footprint

A=LM area of forefoot

B=MN area of midfoot

C=NK area of hindfoot

Arch index (AI)= B÷[A+B+C]^1

Fig 1: Showing graph paper on footprint for calculation of arch index of foot

Table 1: Arch index of right and left footprints of adult male medical students

Index (cm^2)	Right foot (n_2=200) No. (%)	Left foot (n_2=200) No. (%)
High (<0.217)	44 (22.0)	46 (23.0)
Normal (0.217-0.261)	82 (41.0)	79 (39.5)
Low (>0.261)	74 (37.0)	75 (37.5)

Table 1 shows Arch index of the right and left foot ranged from 0.117-0.379cm^2 and 0.123-0.469 cm^2 respectively and the mean(±SD) was 0.251±0.047cm^2 and 0.250±0.047cm^2 respectively.

High arch index (< 0.217) of the right and left foot were found in 44 and 46 individuals respectively and the percentage were 22% and 23% respectively.

Normal arch index (0.217- 0.261) of the right and left foot were found in 82 and 79 individuals respectively and the percentage were 41% and 39.5% respectively.

Low arch index (> 0.261) of the right and left foot were found in 74 and 75 individuals respectively and the percentage were 37% and 37.5% respectively.

Discussion:

The present work was undertaken to study arch index from footprint of 200 (two hundred) medical college students of Dhaka city and describes a statistically based analysis that illustrates the usefulness of the footprint of an individual. The footprints of the present study were collected from the Department of Anatomy of Dhaka Medical College, Dhaka and other non-government medical colleges in Dhaka city. The main aim of the study is to calculate the arch index of foot from footprint of Bangladeshi males. The findings of this study were statistically analysed and revealed important information about variations in foot dimensions of Bangladeshi males.

The reason of dissimilarities might be due to racial variation as he used sample from tribal population who are mostly engaged in the agricultural work all the time, putting more strain on their feet while working in the fields and therefore it is most natural that the foot is more used for walking or weight bearing becomes physically better developed**.** Another reason of dissimilarity is also supported by Rao and Kotian,cited by Kewal Krishan[18] as they suggested that the difference between left and right footprints in the same individual is not a coincidence but may be explained on the basis of the **"dominant foot".** Most of the individuals have dominant foot, usually the left one, which always support the body to a greater extent while in standing or in walking**.** The shoe of this foot wears off at a faster rate than the shoe on the other foot**.** The bones in the dominant foot are regularly subjected to stronger stress forces like weight bearing pressures, than the bones of the other foot**.** This in turn enlarges the bones of the dominant foot and therefore produces a footprint of a larger dimension**.** The medial longitudinal arch also serves to distribute the weight of the body and absorb shock.[19] Damage to the normal biomechanics of the foot, caused by abnormal function of the subtalar joint and medial longitudinal arch, can result in flatfoot.[20]

Hironmoy et al. (2012) conducted study on 103 adult males and females of North Bengal.[1] The findings of their study were higher in percentage both in case of high and normal arch than the present study. Another study was conducted by Xiong S. et al.[21] on 48 (24 males and 24 females) Hong Kong Chinese adults. The findings of their study were also higher in percentage than the present study.

Hironmoy Roy[1] cited, Values of Arch Indices in respective sex-group were also calculated out to be finalized with mean of 0.22 ±0.04 and 0.23 ±0.03 among males and females. Following the classification-system as described

by McCroy et al.(1997)[15] based on the arch index, in the present population 59.8% had normal arch, whereas 35.3% and 4.9% had high and flat arches respectively.

In present study, normal foot arch was found in 41 % and 39.5% individuals on the right and left foot respectively. High arch was observed in 22% and 23% on right and left foot respectively while low arch was observed on right and left foot were found in 37% and 37.5% individuals respectively.

Conclusion:

In the present study, on calculation of the arch index, maximum distribution of foot arch was normal (41% on the right foot and 39.5% on the left foot) in type, the low foot arch type was 37% on the right foot and 37.5% on the left foot and the high foot arch showed minimum distribution (22% on the right foot and 23% on the left foot) among adult Bangladeshi male medical students.

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