

## Sex Determination of Nepalese Medical Students of NAIHS-COM by using Foot Index Method

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**Introduction:** Various biological methods are used to establish, identify and differentiate between male and female bodies in a situation. Besides recent advances, forensic experts still use pelvic bones, skull bones, sternum, and long bones, etc. as their basic tools for identification of bodies on the crime scene or in fossils.

**Methods:** In general, human population exhibits some degree of sexual dimorphism. Foot indexing procedure was used in the current study to differentiate between male and female humans.

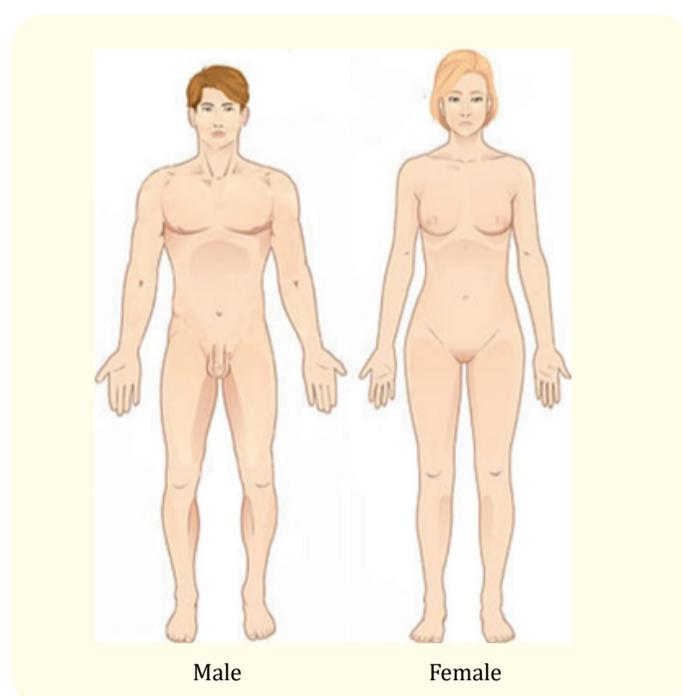
**Results:** The results on foot length in males, right foot length varied from 27.8 cm to 22.8 cm (mean 25.09 cm and S.D. 1.17). In females, right foot length varied from 24.6 cm and 19.9 cm (Mean 22.60). In males, right foot breadth varied between 12.3cm to 8.3 cm (mean 9.80). Right foot breadth in females varied between 10.3 cm to 7.0 cm (Mean 8.40 cm). In males, foot index varied from 46.24 to 34.58 (mean 39.10 and S.D. 2.06). In females, foot index varied from 44.06 to 31.12 (mean 37.52 and S.D. 2.64).

**Conclusions:** The present study established that foot studies including foot index and other measurements were interesting to distinguish between male and female subjects with greater accuracy. More work is recommended to be done in Nepal on this issue of great academic and scientific interest.

**Keywords:** Nepalese Male and Female Students; Sex Determination; Foot Index Method

**Introduction**

Sex refers to the biological characteristic that identifies human as either male or female. There are four big parameters in forensic identification to apply before entering into the details about race, age and stature (Schmitt., et al. 2006). In medico-legal practice, forensic inspectors in their initial steps prefer to examine and identify the individual by using their basic tools. Generally, sex determination is the foremost criteria to identify an individual on the crime scene [1,2]. In human studies, such identification is of prime importance because statistically the result obtained, straight away excludes half of the population [3].



The current literature review specified that sex of an individual might be derived directly by physical examination of external genitalia; however, sex assessment can be very complicated when the body is recovered in advanced stage of putrefaction, mutilated,

fragmentary and skeletonized remains. Typically human population exhibits some degree of sexual dimorphism which can well provide discriminating features regarding sex. For instance, skeleton of male are larger than female, thus the size of the skeleton can be used to estimate sex of the individual [2,4,5]. Following parameters are often used by forensic anthropologist for sex determination: (1) Dimension of pelvic bones (innominate and sacrum); (2) Dimension of skull bones (cranium and mandible); (3) Dimensions of long bones (humerus and femur); (4) Dimensions of sternum, scapula and metacarpal bones, and (5) Dimensions of hand and foot and etc.

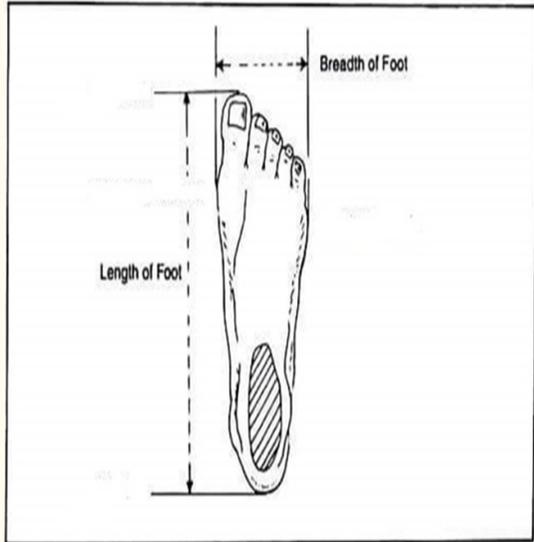
Traditionally, the pelvic bone together with skull has been used extensively for sex resolve; however, current studies have shown that anthropometric measurements of hand and foot dimensions have been very useful tools in sex determination [1,6]. Interestingly, human foot shows great variation in length, width and height in male and female due to various reasons including genetic and natural factors (Figure 1). These factors have anthropological, clinical and forensic importance [7,8].

It is worth mentioning, that in certain complex medico-legal cases parameters including studies on skull anthropometry and odontometry were considered essential to ascertain sex and stature on a criminal scene [6]. In continuation of our work on forensic sciences [9], the current study was designed and executed in the Forensic Science Department (NAIH), Nepalese Army Medical College, University of Kathmandu (Nepal). The current challenging project tasks included the identification of sex by using foot index procedure and the results are presented in the present communication. It is worth mentioning, that in certain complex medico-legal cases parameters including studies on skull anthropometry and odontometry were considered essential to ascertain sex and stature on a criminal scene [6]. In continuation of our work on forensic sciences [9], the current study was designed and executed in the Forensic Science Department (NAIH), Nepalese Army Medical

College, University of Kathmandu (Nepal). The current challenging project tasks included the identification of sex by using foot index procedure and the results are presented in the present communication.

**Aims and Objectives**

- Deriving the foot index from foot length and foot breadth.
- Determination of sex difference in foot index via the use of statistical analysis.



**Figure 1:** Measurement of foot.

**Material and Methods**

The study was conducted in the College of Medicine, Nepalese Army Institute of Health Sciences (NAIH), Kathmandu, in the year 2017 under the guidance of Department of Forensic Medicine. The study included 200 young and healthy students (100 males and 100 females) in the age group of 18 - 25 years. All the subjects were of Nepali origin. In this study, the sample comprised of the students above the age of 18 years because above this age, most people attain their maximum growth and consequently, their maximum foot length and breadth.

$$\text{Foot Index} = \frac{\text{Foot breadth}}{\text{Foot Length}} \times 100$$

The Foot Index for both the sexes was derived by dividing the foot breadth by foot length and multiplying by 100.



**Figure 2:** Making of foot outline.

**Foot Length:** The foot length is a straight distance between the most posterior projecting point of heel and the most anterior projecting point (the end of great toe or second toe) when placed on flat surface (Figure 2 and Figure 3). This measurement excluded any nail extending over the end of the toe [10].

**Foot Breadth:** It is the straight distance from the most medial point on the head of first metatarsal to the most laterally placed point on the head of the fifth metatarsal [8,10,11].

The individuals with foot deformities or those who underwent a foot surgery were excluded from the study. Consent was previously taken from each one separately after explaining the purpose of this study. All the measurements were taken on right side in each subject. The measurements were taken in centimeters.



**Figure 3:** Making of foot outline.

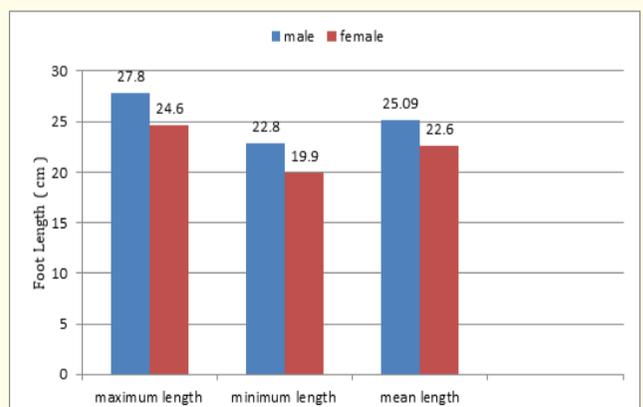
Each person was made to stand on a plain sheet paper with right foot placed on the paper as shown in figure 2, figure 3. The ankle was kept perpendicular to the foot. Foot outline was drawn, and later foot length and foot breadth were measured using calibrated scale.

**Results**

The results on foot length in males, right foot length varied from 27.8 cm to 22.8 cm (mean 25.09 cm and S.D. 1.17). In females, right foot length varied from 24.6 cm and 19.9 cm (Mean 22.60) as shown in table 1 and graph 1.

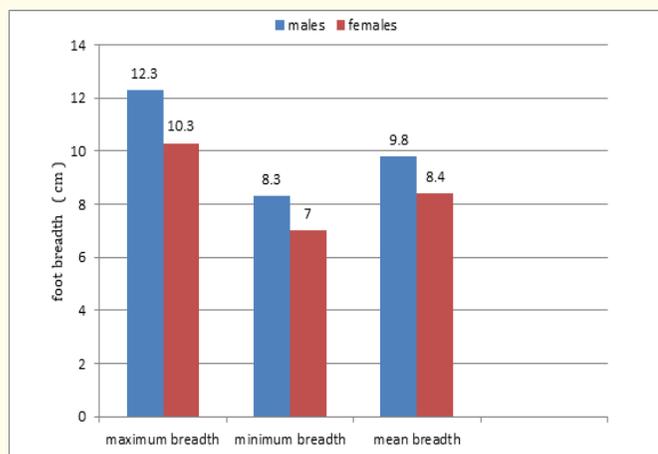
Gender	Maximum	Minimum	Mean	S.D.
Males	27.8	22.8	25.09	1.17
Females	24.6	19.9	22.60	1.15

**Table 1:** Measurements of foot length in males and females.



**Graph 1:** Measurement of foot length in males and females.

**Foot Breadth:** In males, right foot breadth varied between 12.3 cm to 8.3 cm (mean 9.80). In females, right foot breadth varied between 10.3 cm to 7.0 cm (Mean 8.40 cm) as shown in table 2 and graph 2.

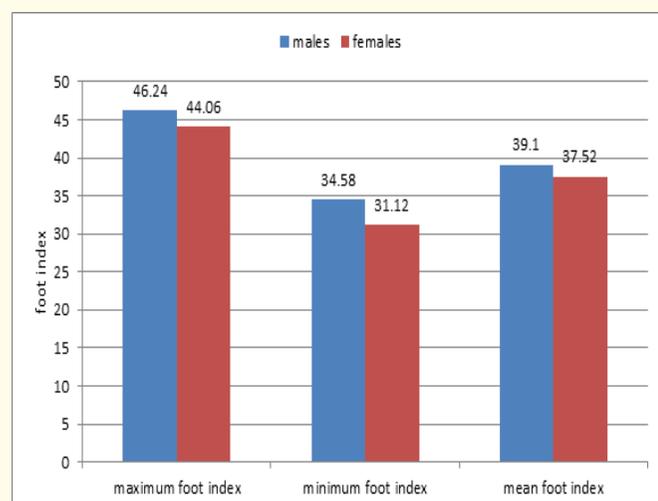


**Graph 2:** Measurement of foot breadth in males and females.

Subjects	Maximum	Minimum	Mean	S.D.
Males	12.3	8.3	9.80	0.61
Females	10.3	7.0	8.40	0.65

**Table 2:** Measurements of foot breadth in males and females.

**Foot index:** In males, foot index varied from 46.24 to 34.58 (mean 39.10 and S.D. 2.06). In females, foot index varied from 44.06 to 31.12 (mean 37.52 and S.D. 2.64). The data is presented in table 3 and graph 3.



**Graph 3:** Measurement of Foot index in males and females.

## Discussion

All the parameters studied (foot length, foot breadth and foot index) in Nepalese were higher in males as compared to female participants. In the present study, the mean foot index was established to be 39.10 and 37.25 for males and females respectively.

Our study is in agreement with the study conducted in Slovakia and foot index was higher in males as compared to females [12]. It worth note-worthy that mean foot index in females was found greater than 37 in an earlier study conducted on 250 Indian students. Those results added support to use foot index value 37 as a deviation point for the determination of sex with fair accuracy in that population [10]. On the other side, in a study on North Indian population, the foot index was found to be slightly higher in females as compared to their male counterparts. It was claimed that foot index of more than 38.9 would mean female origin. The study revealed that foot length and foot breadth were helpful in detecting the differences between male and female, however, only foot index could not be justified as a conclusive tool in sex determination studies [13].

In study involving 130 Ga'anda Adamawa, Nigerian subjects (65 males and 65 females), with age between 18-45 years) reported mean foot index as:  $37.21 + 3.18$  and  $37.60 + 2.64$  for males and females respectively. This study demonstrated that foot index was a little bit higher among the females but mean difference was statistically not significant [7]. This investigation with some limitation is supporting our present work.

On the other side, a total of 600 subjects: 300 Haryanvi Jats (150 males, 150 females), and 300 subjects from North Indian mixed population (150 males, 150 females) of age between 18 - 50 years were examined [14]. Average foot length in Haryanvi Jats was found to be 2 cm larger than female whereas foot breadth was 1 cm greater than female group. In North Indian mixed population foot length was found to be 3 cm greater than female foot length. The male foot breadth was 1 cm greater as compared to female individuals. The statistical analysis verified that in both populations there was a highly significant difference in foot length as well as foot breadth in males and females. In both the populations, female foot index was above 36 and less than 36 in males. The foot index value of 36 was successfully used as deviation point for sex determination purpose [14]. The study strongly supported the successful use of foot index in sex determination studies.

Nonetheless, our current study results regarding mean foot index in male Nepalese showed some inconsistency with some several reports [7,10,13]. Such a controversy might be associated to the environmental, genetic and physical factors. Nepalese population is known to do relatively much physical labor and walking long distances carrying goods due to shortage of expensive modern transportation machinery besides lack of roads. Such practices and weight bearing habits are known to affect their feet, other bones, and muscles, thus justifying the results of our present study [15].

## Conclusion

Our study concluded that foot index measurement is higher in males as compared to females but there are no sufficient data to support accuracy of foot index measurement in determination of sex. These findings can be used as corroboratory findings along with other parameter in the field of forensic investigations in fu-

ture. Our findings may also be useful for shoe industries. The results of our current study warrant further investigations on the foot research and use of foot index to determine sex.

### Acknowledgement

The author AHS is professor at a distance learning university: Islamabad, Pakistan.

### Conflict of Interest

The study was conducted purely for academic purpose and there is no conflict of interest with any organization or institution.

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Volume 2 Issue 2 May 2018

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