

Determination of Foot Surface Area as a Ratio of Body Surface Area, in Maharashtra Population.Ravindra Vedpathak¹, Nishigandha Sadamate¹, Ranjit S. Ambad², R. B. Vaidya³¹Assistant Professor, Department of Anatomy, Dr. Rajendra Gode Medical College, Amravati.²Professor, Department of Biochemistry, Dr. Rajendra Gode Medical College, Amravati.³Professor, Department of Anatomy, BVDU Medical College, Sangli, Maharashtra.

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Corresponding Author: Dr. Ravindra Vedpathak

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Abstract**Introduction:** Estimation of Total Body Surface Area (TBSA) plays crucial role in variety of clinical conditions, such as Renal Clearance, Cardiac Index, Chemotherapy and Glucocorticoid dosage, and also in Thermal Burns related injuries.

In small and patchy burns patients hand is used to estimate percentage of burn which is traditionally 1%, Feet surface area values of this kind are usually estimated as a percentage of TBSA and it is 7% according to Lund and Browder chart. There is a discrepancy about what percentage of TBSA is continued by the Foot, therefor this study was designed to determine correctly the TBSA represented by the Foot surface area in Maharashtra population.

Aim and Objective: To correlate morphometric measurements of Foot with the Total Body Surface Area.**Materials and Methods:** 512 healthy adult age group from 30 – 40 years of both sexes (255 male and 257 female) are selected. Right and Left Foot Surface area and Body Surface area was calculated using Du Bois and Du Bois formula.**Result :** The mean Foot ratio of both sides for male and female was 3.28% and 3.18% respectively.**Conclusion:** The Hand surface area is around 3.25% of TBSA in Maharashtra population.**Keywords:** Foot Surface Area (HAS), Total Body Surface Area (TBSA).This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

Body surface area is an important indicator of metabolic mass rather than body weight because it is less affected by abnormal adipose mass. Estimation of body surface area is simpler than measurement of volume.

The relationship between body surface of animals and various parameters of their physiology has been observed over many decades. Rubner, in 1883 [1], pointed out that small animals utilized relatively more oxygen and produced relatively more heat than larger animals. He explained that smaller animals had relatively larger surface areas than larger animals and demonstrated that oxygen utilization and caloric expenditure were similar for various mammalian species and differently sized members of the same species when computed on the basis of body surface [2]. These observations have been confirmed and extended to human by many investigators, and it has long been a standard practice to express human basal metabolic rate in terms of body surface area rather than body weight [3].

Baker and Kozoll [4] determined plasma volumes and total blood volumes in 150 normal adults using iodinated human serum albumin labeled with I-131 and hematocrit determination. The ratio of blood volume to body weight was not constant, but a direct linear relationship was found to exist between body surface area and blood volume, and the authors concluded that surface area was the single most useful basis for deciding the normal total blood volume of an individual.

In clinical medicine it has been found practical to use body surface area to gauge the needs of patients for parenteral fluids and electrolytes [5]. The caloric requirements of infants and children, which generally are progressively lower in relation to body weight with increasing age, are almost identical for all ages and weights when related to body surface area.

Estimation of body surface area thus plays crucial role in variety of clinical conditions that's the like [5,6] Estimation of Renal clearance, Estimation of Cardiac index, The Quitlet index, Determination of

dosage of Chemotherapy, Determination of Glucocorticoid dosage, and in cases of Thermal Burns & related Injuries [5,6,7].

There are several methods for assessment of burn size [6], which includes the 'Lund and Browder Chart [8,9,10] and 'Rule of nine'[9,10], Sometimes these methods are used in combination. The 'Rule of nine' is convenient and rapid method to estimate the extent of burned surface area, but it is not very accurate in case of patchy burns. There is another Simple, Quick, Non-Traumatic, In-expensive method for patchy burns, in which patient's Foot is used to estimate percentage of body surface area which is traditionally 3.5% [11]. There is discrepancy about what percentage of Total body surface area is constituted by the Foot.

Also the both Feet surface area are taken together in western population to estimate the FSA (with feet), there is no study about foot ratio of right foot and left foot in both genders. And hence it is important to know the hand and foot area in the Indian (West-Maharashtra) population.

At present no studies for the body surface area are available in Maharashtra particularly in south – west Maharashtra. which shows the Foot area as a ratio of body surface area. It was therefore felt that a study be carried out in this part of Maharashtra using measurement of Hand & Body surface area, to put forth standard values.

Aims and Objectives :

To study the body surface area and Foot surface area in healthy male and female teacher population from south – western Maharashtra.

To correlate morphometric measurements of foot with the total body surface area.

Materials and Methods : 512 subjects from age group of 30 to 40 years of either sexes (255 Male and 257 Female) are selected. The selected subjects are Teachers in various Colleges and Schools which represents same special class and group.



Photo 1 - Foot Ball Girth



Photo 2 - Ankle Girth

Inclusion Criteria: Normal Foot with 10 normal finger, without any missing or deformed finger.

Body Height and Body Weight : Body Height was measured as the vertical distance between the vertex and the floor, while the head Was held in Frankfort Horizontal (F.H.) Plane. Body Weight was measured on Standard weighing machine.

Foot.: Du Bois and Du Bois formula are used to estimate foot surface area, the Foot Surface Area geometrically estimated as an area multiplied by two lengths: A foot length and a summation length consisting of foot ball girth and ankle girth. [12,13].

Each subject was made to stand on a calibrated foot board with his / her back against the wall in such a manner that the posterior most point of the heel touched gently the wall. A vertical stop was placed against the anterior most point of the foot [12,14,].

A. Foot Length :-

Is the distance between the Acropodion (most posterior projecting point on heel) to Pternion. [12,15] (most anterior projecting tip of a longest toe.)

B. Ankle Girth :-

This girth measurement is usually taken at the level of the narrowest point of the ankle. The tape may need to be moved up and down to find the point of least circumference. While recording, you need to make sure the tape is not too tight or too loose, and is lying flat on the skin, and is horizontal [16,17].

C. Foot Ball Girth :-

Foot circumference is measured with a tape so that the tape passes over the Metatarsale tibiale and the Metatarsale fibulae. The Metatarsale tibiale is the most medially prominent point on head of the first metatarsal bone, and Metatarsale fibulae is the most laterally prominent point on the head of the fifth metatarsal bone [15,1

Indices calculated from above parameters are :

1. The Body surface area calculated with “The Most-tellers formula”, which is popular with medical practitioners, for its ease of use & accurate result. Body Surface Area = [Weight (kg) X Height (cm) / 3600] ½
2. The Foot Surface area calculated by the well known generally preferred Du Bois and Du Bois estimation formula.

Foot Surface Area = 0.52 X Foot Length X (Foot Ball Girth + Ankle Girth)

Hand Ratio calculated from above Indices : The foot Percentage of BSA (Foot Ratio) was

determined by dividing Foot Surface area by Total Body Surface Area⁽⁶⁾. The mean values of TBSA, Foot Ratio, were tested using ‘t’ test. All means were expressed as Mean standard deviation. The critical level of significance of the results was considered at 0.05 levels *i.e.* P < 0.05 was considered significant.

Observations :

1. **Total Body Surface Area (TBSA) :** In this morphometric Study, the Total Body Surface Area (TBSA) for male was 1.79m², and 1.59m² for female. (Table - 1)

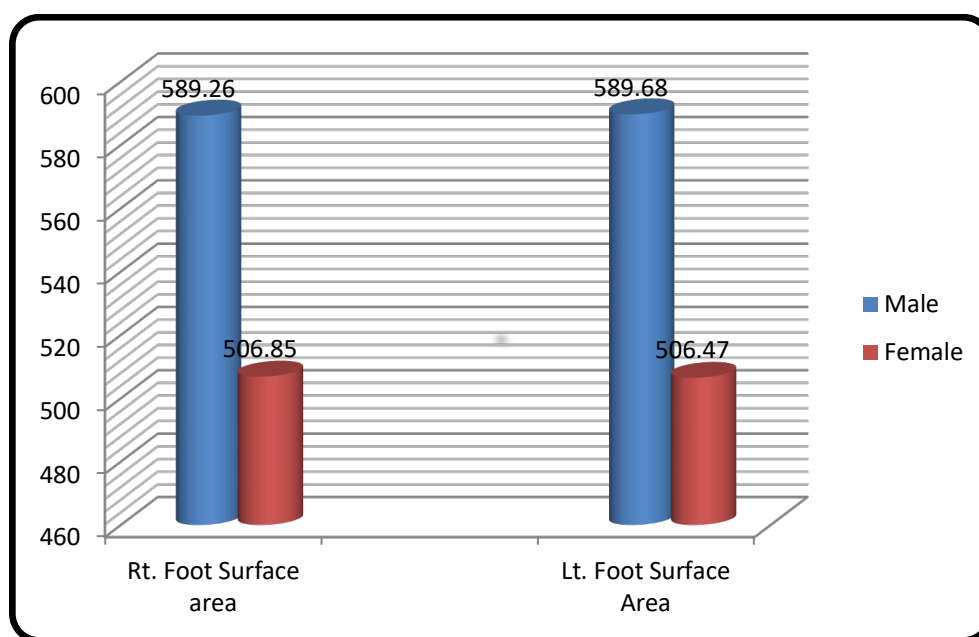
Table 1: Body Surface Area.

Body Surface Area	Male (n = 255)		Female (n = 257)		P - value	Significance
	Mean	S.D	Mean	S.D.		
Present Study	1.79 m ²	0.14	1.59 m ²	0.14	0.000	Highly Significant

2. **Foot Surface Area :** the right foot area mean in adult male was 589.26 cm², and mean for left foot area was 589.68 cm², while in adult female right foot area mean was 506.85 cm², and mean for left foot area was 5036.57 cm².

Table 2: Foot Surface Area in male and female.

	Male (n = 255)		Female (n = 257)		P value	Significance
	Mean c m ²	S.D.	Mean c m ²	S.D.		
Rt. Foot Surface Area	589.26	54.05	506.85	46.42	0.000	Highly Significant
Lt. Foot Surface Area	589.68	54.31	506.57	46.73	0.000	Highly Significant
P value	0.951		0.942			
Significance	Not Significant		Not significant			

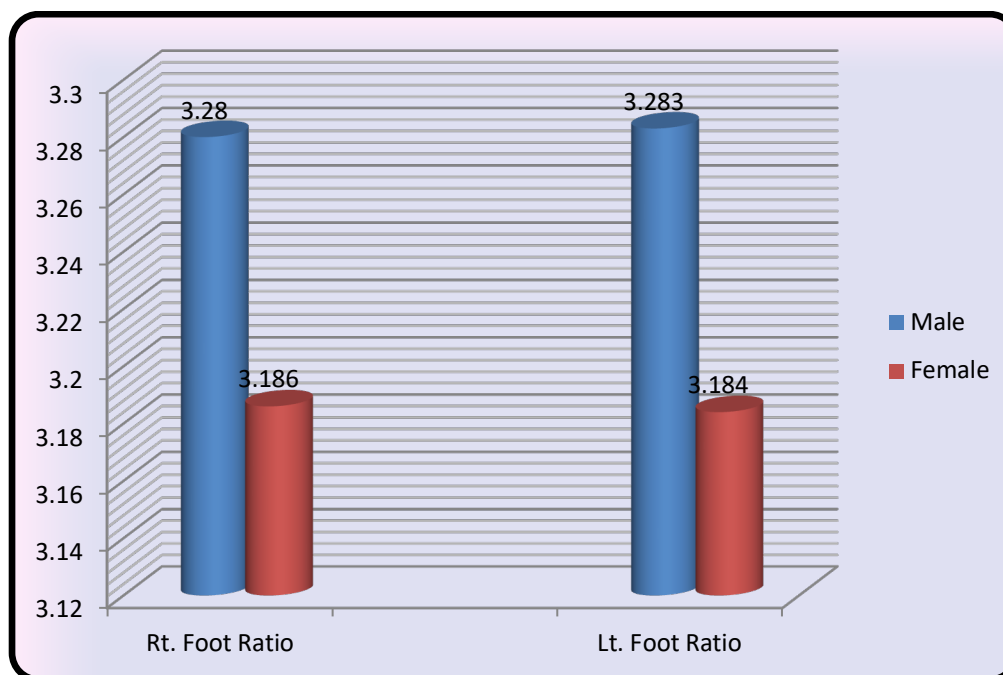


Graph 1: Foot Surface area in male and female.

1. **Foot ratio with body surface area :** the right foot ratio in adult male was 3.28 %, and left foot ratio was 3.28 %, while in adult female right foot ratio was 3.18 %, and left foot ratio was 3.18 %.

Table 3: Foot Ratio with Total Body Surface Area

	Male (n = 255)		Female (n = 257)		P value	Significance
	Mean %	S.D.	Mean %	S.D.		
Rt. Foot Ratio	3.2809	0.2075	3.1866	0.2396	0.000	Highly Significant
Lt. Foot Ratio	3.2832	0.2078	3.1847	0.2403	0.000	Highly Significant
P value	0.961		0.948			
Significance	Not Significant		Not Significant			

**Graph 2 : Foot Ratio with Body Surface Area****Discussion:**

Surface area of the human body is extensively used in clinical practice either for normalizing physiological parameters to express Basal Metabolic Rate, Oxygen Consumption, Cardiac Output, Glomerular Filtration Rate, Drug Dosage, Heat loss and Vital capacity, and to determine average skin temperature, and most importantly for the area affected by Severe Burns. Thermal burns and related injuries which are a major cause of death and disability. The single most important factor in predicting burn-related mortality, need for specialized care, likelihood of complications, treatment plans. Therefore, accurate estimation of size of burn is important.

Foot surface area is also important measurement in many applications such as medicine, Health care, Industrial hygiene and engineering design. The foot surface area estimate by looking towards tables. Such as Lund and Browder chart and its revision⁽¹⁵⁾. Foot surface area values of this kind are usually estimated as a percentage of total body surface area (TBSA) for instance, 3.

the Lund and Browder Chart and its revisions estimate FSA (with Feet) as 7 percent of TBSA.

Also the both Feet surface area are taken together in western population to estimate the FSA (with feet), there is no study about foot ratio of right foot and left foot in both genders. And hence it is important to know the foot area in the Indian population.

1. *Total Body Surface Area* : The findings as regards body surface area, differ from the study of Agarwal and Sahu, et.al., however they are similar to the studies in western countries population.
2. *Foot Surface Area* : In males, the mean right foot Surface area is 589.26 cm², and mean for left foot area was 589.68 c m², while in adult female right foot area mean was 506.85 cm², and mean for left foot area was 506.57 c m². There is statistically significant difference in the Foot area between male and Female. There is no statistically significant difference in the Foot area between right foot area and left foot area.

Table 4 : Comparison of Body Surface area with Previous Studies

Body Surface Area	Male (n = 255)		Female (n = 257)		P - value	Significance
	Mean	S.D.	Mean	S.D.		
Present Study	1.79 m ²	0.14	1.59 m ²	0.14	0.000	Highly Significant
Agarwal & Sahu et.al	1.59 m ²	--	1.43 m ²	--	--	Highly Significant
Western Population	1.90 m ²	--	1.60 m ²	--	--	Highly Significant
Dubois & Dubois	1.90 m ²	--	--	--	--	--

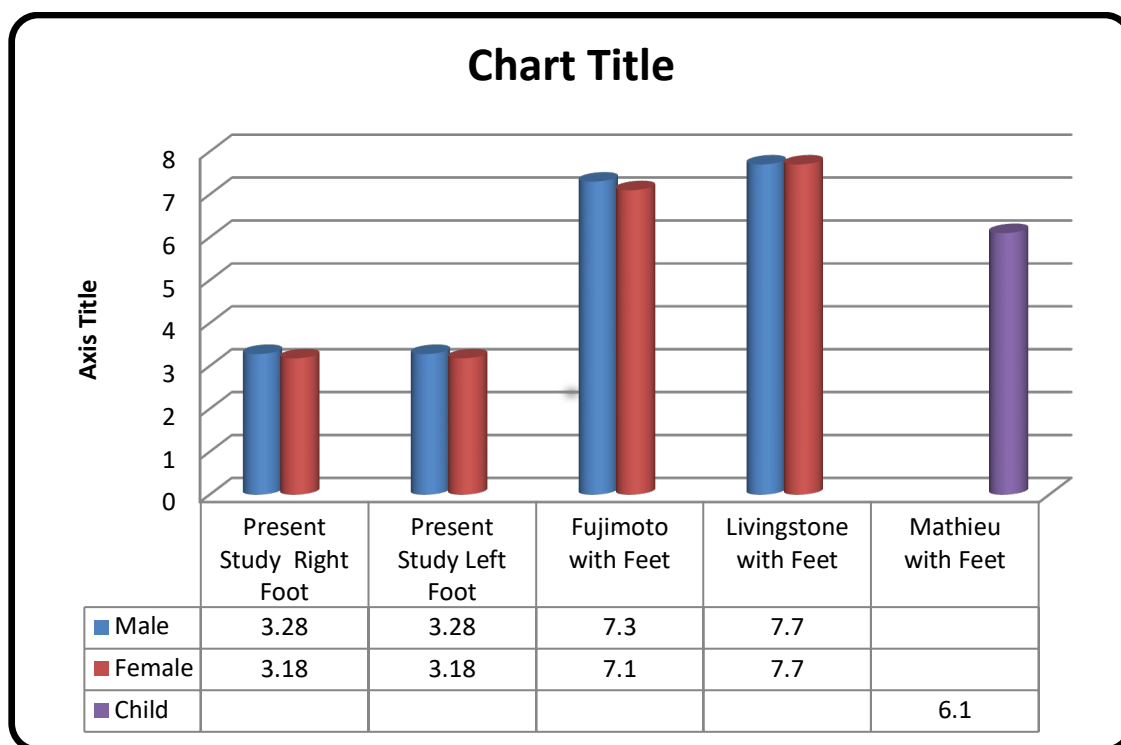
1. *Foot ratio with TBSA* : In present study, Ratio's of Right and Left Foot were studied separately in both males and females which make it a Unique study. In the Foot Ratio of male and female, there is significant difference which shows the Foot Ratio of male was larger than the female Foot Ratio.

The right foot ratio in adult male was 3.28 %, and left foot ratio was 3.28 %, while in adult

female right foot ratio was 3.18 %, and left foot ratio was 3.18 %. Livingstone and Scott Lee (2001), has studied foot ratio using B.M.I. (Body Mass Index), Out of the only two studies available Mathieu Boniol (2001) studied both the feet together and that to in children. Fujimoto and Watanabe (1969), has study foot ratio of both feet together. The present study is only one, which takes in to consideration Rt. and Lt. Foot separately.

Table 5: Comparison of Foot ratio with Previous Studies.

	Male	Female	Child
Present study	Rt. Foot :- 3.28 % Lt. Foot :- 3.28 %	Rt. Foot :- 3.18 % Lt. Foot :- 3.18 %	
Fujimoto and Watanabe	Feet = 7.3 %	Feet = 7.1 %	
Livingstone and Lee	BMI < 40 = 7.7 % in Feet. BMI > 40 = 5.2 % in Feet.		
Mathieu Boniol			Feet Ratio :- 6.1 %



Graph 3: Comparison of Foot ratio with Previous Studies.

Result:

1. The Total Body Surface Area mean for male was 1.79m², and 1.59m² for female.

2. Mean right foot area in male was 589.26 cm², and mean for left foot area was 589.68 c m², while in female right foot area mean was 506.85 cm², and mean for left foot area was 506.57 cm².

3. Mean right foot ratio in adult male was 3.28 %, and left foot ratio was 3.28 %, while in adult female right foot ratio was 3.18 %, and left foot ratio was 3.18 %

Conclusion:

The foot surface area shows around 3.25 percent of the total body surface area. Our data indicates that the feet surface area is near to 6.5 %, so use of the foot surface area as a percentage of body surface area is also good indicator.

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