



Journal Homepage: - www.journalijar.com
**INTERNATIONAL JOURNAL OF
 ADVANCED RESEARCH (IJAR)**

Article DOI: 10.21474/IJAR01/9315
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/9315>



RESEARCH ARTICLE

SYMMETRICAL ANALYSIS: AN X-RAY STUDY OF TALUS WITH ITS PHYSIOLOGICAL CORRELATION.

Kavya¹, Sowmya Panju² and Ashwin Kumar³.

1. Assistant professor, Department of Anatomy, Bowring and Lady Curzon medical college and research institute, Bangalore.
2. Assistant professor, Department of Physiology, Bowring and Lady Curzon medical college and research institute, Bangalore.
3. Professor & HOD, Department of Radiology, Kasturba Medical college, Mangalore.

Manuscript Info

Manuscript History

Received: 15 April 2019
 Final Accepted: 17 May 2019
 Published: June 2019

Key words:-

Talus, foot, X-ray.

Abstract

Out of all the bones in the foot involved in movement, talus has constantly formed the sole link between the leg and the rest of the foot. Differences have been noted between or within body structures within an individual (intra-individual variation) with regard to the size and shape. Talus helps in receiving the body weight and transmitting it to the plantar below. The dome of the talus articulates with the tibia and fibula, and has a key role in ankle motion and also supports the axial load during weight bearing.

Aim: To study the talar symmetry and to identify the incidence, possible etiological factors and its clinical significance.

Materials and methods: This study included 96 healthy normal subjects whose age and sex are known who were scheduled for anteroposterior and lateral plain ankle radiographs because of clinical hind foot symptoms. Measurements such as length, breadth, height and volume were noted down for a period of 2 years to the Department of Radiology, K.M.C. Mangalore.

Result: In this study the measurement of right tali were higher than left except for breadth of the body of the tali.

Conclusion: The human foot is called upon to support the weight of the body when standing and to provide a smooth functioning interface between the body and the ground during gait. Its function depends on relatively complex mechanical interactions of numerous small bones; pain free motion of small joints, an intact soft tissue envelope, including the plantar pad; and an appropriate secondary feedback³².

Copy Right, IJAR, 2019,. All rights reserved.

Introduction:-

Talus is a main tarsal bone that connects bones of the leg with the bones of the foot. It has neither muscular attachments nor the tendinous attachments¹. The talus (astragalus) sits at the top of the tarsal skeleton³. Head is ovoid and convex; its long axis is also inclined inferiomedially to articulate with the proximal navicular surface. No muscle is attached to the talus, however many ligaments confer the stability to the joints². Blood supply to the talus

Corresponding Author:-Sowmya Panju

Address:- Assistant professor, Department of Physiology, Bowring and Lady Curzon medical college and research institute, Bangalore.

is rather tenuous because of the lack of muscle attachments. The extra osseous blood supply is via the posterior tibial, dorsalis pedis and fibular arteries ².

Talus helps in receiving the body weight and transmitting it to the plantar below. The dome of the talus articulates with the tibia and fibula, and has a key role in ankle motion and also supports the axial load during weight bearing. The subtalar joint is a simple single axis joint which behaves like a oblique hinge. The average inclination of the subtalar joint axis is 42 degree from the horizontal in a sagittal plane and 16 degree from the longitudinal axis of the foot in the transverse plane thus; the axis is aligned in an oblique direction. The oblique orientation of the axis allows it to traverse all three cardinal planes and movement about the axis is termed "triplane motion." It is important to note that these motions occur about the subtalar joint axis only and do not include talocalcaneal or midtarsal joint motions. When the foot is weight bearing in stance phase, pronation and supination of the subtalar joint continue to occur. In an open kinetic chain, minimal movement occurs between the talus and the calcaneus as motion occurs distal to the subtalar joint axis. In a closed kinetic chain, movement occurs both proximal and distal to the axis of the subtalar joint, i.e., leg rotation and foot movement, respectively. The direct effect of subtalar joint is to create an immediate shortening of the lower extremity at heel strike, thus providing a small degree of shock absorption ³.

Aim:

To study the talar symmetry and to identify the incidence, possible etiological factors and its clinical significance.

Materials and methods:-

This study included 96 healthy normal subjects whose age and sex are known who were referred as patients to the radiology department, for an ankle x-ray (anterior posterior and laterl) with hind foot disorder. Ankle joint radiograph having talar and subtalar pathology were excluded and normal ankle radiograph were included from the study

The data was collected for a period of 2 years in the Department of Radiology, K.M.C. Mangalore.

Study sample size calculation: With 95% Confidence level and 80% Power, a sample size of 96 was calculated by using the formula,

$$\text{Sample size (n)} = 2 \times \frac{(Z\alpha + Z\beta)^2 \times \sigma^2}{\delta^2}$$

The data collected was tabulated in Microsoft excel worksheet and computer- based analysis was done using the statistical package for social sciences software IBM SPSS 20.0 (Chicago, IL, USA) for windows.

The general descriptive statistics was done for all the parameters providing means and standard deviations (S.D) separately.

Student's t test was used to check whether significant differences exist ($p \leq 0.05$) between right and left mean measurements.

Measurements of dimensions on radiograph:

On anterior posterior radiograph

1. Breadth of the body of talus- the distance between the medial and the lateral surface. On lateral radiograph
2. Length of talus- the distance between the foremost part of the rounded articular surface of the head to the apex of the lateral tubercle.
3. Height of talus- the distance between the superior and inferior surface.
4. Volume is calculated by multiplying the value of length, breath and height.

Results & observation:-

Table 1:-Difference between Parameters of Talus based on side (Radiograph)

PARAMETERS	MEAN	S.D	P VALUE (STUDENT'S T TEST)
------------	------	-----	----------------------------

	Right (n= 46)	Left (n= 50)	Right (n= 46)	Left (n= 50)	
LENGTH OF TALUS (cms)	5.7359	5.6306	0.6075	0.5331	0.368
BREADTH OF BODY OF TALUS (cms)	3.0833	3.0990	0.4081	0.4238	0.854
HEIGHT OF TALUS (cms)	3.2280	3.2248	0.6179	0.6078	0.979
VOLUME OF TALUS (cu. Cm)	57.8570	57.2086	16.9943	17.8569	0.856

Average length of right talus is 5.7359 ± 0.6075 cms. The average length of left is 5.6306 ± 0.5331 cms. Average breadth of the body of right talus is 3.0833 ± 0.4081 cms. The average breadth of body of left talus is 3.0990 ± 0.4238 cms. Average height of right talus is 3.2280 ± 0.6179 cms. The average height of left talus is 3.2248 ± 0.6078 cms. Average volume of right talus is 57.8570 ± 16.9947 cu cm. The average volume of left talus is 57.2086 ± 17.8569 cu cm. The P values for length, breath, height and volume were 0.368, 0.850, 0.979 and 0.856 respectively, which are statistically insignificant this showed that both the talus were symmetrical.

Discussion:-

The human foot is called upon to support the weight of the body when standing and to provide a smooth functioning interface between the body and the ground during gait. Its function depends on relatively complex mechanical interactions of numerous small bones; pain free motion of small joints, an intact soft tissue envelop, including the plantar pad; and an appropriate secondary feedback⁴. It is important to analyze the anatomical features of talus that predispose it to complex injury. Restoration of the normal anatomy is very important to prevent development of secondary pathology and morbidity.

In the present study average **length** of the right talus on radiograph are **5.7359 cms** and the left talus is **5.6306 cms** respectively. It has been observed that right talus were longer than the left. According to Ari I, Kafa IM⁵, the mean values were 5.72 for right side and 5.64 for left side, which were slight higher as compared to the present study. In a study conducted by Mahato NK, Murthy SN⁶ the length varied from 5.57 cms on right side and 5.58 cms on left side, another study by Otag I, Cimen M⁷ the length of right tali measured 5.594 cms and left tali measured 5.654 cms and a similar study by Gautham K et al⁸ the length varied from 5.23 on right and 5.29 in left side.

The average **breath** of right talus on radiographs is **3.0833 cms** and the left talus is **3.0990 cms** respectively. It has been observed that left talus was broader than the right. In a similar study conducted by Ari I, Kafa IM⁵, the mean values were 4.91 for right side and 4.69 for left side, which were higher to the present study. According to a study conducted by Mahato NK, Murthy SN⁶ the breath varied from 2.99 cms on right side and 3.03 cms on left side and a study conducted by Gautham K et al⁸ the breath varied from 3.79 cms on right and 3.68 on the left side. In a radiological study by Kuo CC et al⁹ the talar breath varied from 2.63cms to 2.96 cms with an average of 2.99 cms, which is slightly lower than the values of the present study.

The average **height** of right talus was **3.2280 cms** and left talus is **3.2248 cms** respectively. It has been observed that right talus was taller than the left by 0.0032 cms. In another study by Otag I, Cimen M⁷ observed that the height of right tali measured 3.149 cms and left tali measured 3.215 cms.

In the present study the average **volume** of right talus on radiographs is **57.8570 cu cms** and left talus is **57.2086 cu cms** respectively.

Studies of lateral asymmetry of the legs have confirmed that the left leg is heavier than the right but the results of differences in length are not uniform (Latimer & Lowrance 1965; Singh 1970). The dominance of the lower extremity is less marked than that of the upper. The dominant leg is expressed by the stronger tibia usually on the opposite side of the dominant arm¹¹. In the present study right tali exhibited greater dimensions than left except breadth of talus. In a study by Harris SM, Case DT¹⁰ they observed that talus on the right side was generally exhibited greater dimensions than those from the left side. The asymmetry was less pronounced in case of tarsals and metatarsals. Structural asymmetry in fetal metatarsal bones on the right and left side was reported by Gawlikowska *et al.* (2007). In the younger group, the character of the asymmetry fluctuated. A clear one-sided domination in all metatarsal bones appeared only in the oldest group (over 26 gestational weeks). These results demonstrate that such asymmetry forms and matures during ontogenesis, similarly to other systems and organs (Gawlikowska *et al.* 2007). Asymmetry can be of genetic or nongenetic origin. Among the former type are the fundamental forms for which the signals present in the inherited genetic constitution produce definite right-left differences. The nongenetic forms of asymmetry can be determined by the influence exerted by the external environment, or they may be due to random developmental differences in the internal environment of the two halves of the body. The origin of lateralization involves both ontogenetic and phylogenetic factors (Babcock, 1993). The following factors are considered to be responsible for presence or absence of asymmetries in different structures of the body.

Genes:

A variety of genetic studies, including twin, family, adoption, and cross-fostering studies, demonstrated that handedness in humans has a significant genetic component (Arnold, 1844; Gennadis, 1858; Schultz, 1926, 1937; Chamberlain, 1928; Pande & Singh 1971; Singh 1971; Annett, 1974; Carter *et al.*, 1976; Hicks & Hinsborne 1976; Longstreth, 1980; McManus, 1991; Vettivel *et al.*, 1995; Scheuer & Black, 2007).

Hormones:

Majority of studies suggest that gonadal steroid hormones affect functional development during early ontogenesis (Murphy *et al.*, 1994). Hormones appear to play a large role in mediating bodily asymmetry and phenotypic sex is related in systematic ways to cerebral asymmetry (de Courten-Myers, 1999; Frederikse *et al.*, 1999; Kulynych *et al.*, 1994; Moffat *et al.*, 1998).

Environmental Factors:

Ability to change is one of the important property of a living organism which is well visible in the course of individual life. Degree of asymmetry is a constant property in the process of ontogenesis where change in functional, dynamic and morphological asymmetry appearing with age (Wolanski, 1972). During childhood, the shape of the body continuously changes because of the different rates of growth of different parts. The gross changes in bodily proportions during growth in the human have been analyzed (Medawar, 1944). The degree of asymmetry reflects the degree of force exerted onto the right or left limb whereas the particular bone site showing the asymmetry indicates the kind of force exerted (Cuk *et al.*, 2001). Vigorous training might change bone dimensions if this was undertaken before closure of the epiphyses has been completed (Tittle & Wutscherk, 1992; Haapasalo *et al.*, 2000). Asymmetry is also influenced by mechanical loading or disuse of a limb (Singh, 1971; Steele and Mays, 1995). Use of dominant limb in athlete's results in greater asymmetry (Ruff & Jones, 1981), while the activities involving non-dominant limb may change the asymmetry (Stirland, 1993). Activities involving both limbs equally may result in lack of asymmetry (Rule, 1982; Stirland, 1993). Protein deficiency diminishes the asymmetry as reported by Steyn & Iscan (1999) and Mall *et al.* (2001). Though, right dominance is considered as congenital phenomenon (Pande & Singh, 1971; Taylor JR & Halliday, 1977), the dominance pattern could also be influenced by postnatal adaptation and physical work (Prives, 1960; Krishan, 2008) and can be enhanced or reduced according to individual's habits and activities, age, nutrition, overuse or disuse of the limb (Papaloucas *et al.* 2008). Industrial groups exhibit relatively less asymmetry than pre-industrial humans and less dimorphism in asymmetry. A mixture of influences from both

genetic and behavioral factors is implicated as the source of these patterns (Auerbach & Ruff, 2006). Adaptive development requires the organism to resist genetic and environmental stresses that disrupt the genetic plan for growth, a buffering capacity termed developmental stability (Thoma *et al.*, 2002). One way to carefully assess how various stressors affect morphology is to investigate concomitant physiological changes in the body. For example, human experience elevated steroid hormone concentrations, namely glucocorticoids in response to stress. Glucocorticoids in turn determine how the body effectively copes with the stressors. These influences may not only affect immediate survival, but future growth, health, and reproduction (Handa *et al.*, 1994; Ferin, 1999; Viau, 2002; Viau *et al.*, 2005; Kudielka & Kirschbaum, 2005), all implicated as correlates of FA (Knierim *et al.*, 2007). In addition, sex steroid hormones, namely androgens and estrogens are in part responsible for growth and reproduction (Kudielka & Kirschbaum, 2005), and for the observed sex differences in response to stress (Kudielka & Kirschbaum, 2005; Maclusky & Naftolin 1981; Mc Ewen, 1981; Migeon & Wisniewski, 1998). Several studies also linked androgens and estrogens to fluctuating asymmetry (Cunningham, 2000; Manning *et al.*, 1997)¹¹.

Clinical Implications:

The examination of the upper and lower limb asymmetries can be useful to medical scientists, archeologists, and anthropologists (Iscan & Shihai 1995; King *et al.*, 1998), to the police and forensic experts and for medicolegal studies (Steyn & Iscan 1999; Mall *et al.* 2001).

Conclusion:-

Body asymmetries indicate the developmental instability of an individual (Watson & Thornhill 1994) and may indicate association with various disorders in the body. Knowledge and understanding of these asymmetries is important to achieve a good diagnosis and focus on an appropriate treatment and management plan. Evidence from behavioural, electrophysiological, and functional neuroimaging studies should be used to understand how these developmental disorders differ so that accurate differential diagnoses and appropriate targeted techniques can be effectively applied for remediation. Likewise, there are various etiological factors: genetic, environmental and functional to be well understood for a proper diagnosis and thus appropriate to focus on a plan treatment. Morphological parameters were different for right and left tali, where right tali exhibited greater dimensions compared to the left indicating the right tali is under more stress compared to left. Although this study shows the difference in measurements for right and left tali but it is statistically insignificant.

References:-

1. Bilodi AK. Study of Calcaneal articular facets in human tali. Kathmandu Univ Med J 2006; 4:75-7.
2. Standring S. Gray's anatomy- The anatomical basis of clinical practice, 40th edn., Spain: Elsevier Limited 2008:1429-62.
3. McPoil TG, Nye HG. Biomechanics of the Foot in Walking: A Function Approach. J Orthop Sports Phys Ther 1985; 7:69-72
4. Sangeorzan BJ, Hansen ST Jr. Early and late post traumatic foot reconstruction. Clin Orthop Relat Res 1989; 243:86-91.
5. Ari I, Kafa IM. Bone length estimation and population specific features of calcaneus and talus bones of the late Byzantine Era. Coll Antropol 2009; 33(2): 613-8.
6. Mahato NK, Murthy SN. Articular and angular dimensions of the talus: interrelation and biomechanical significance. Foot 2012; 22(2):85-9.
7. Otag I, Cimen M. Morphometric measures of Talus bone in skeleton remains belonging to Anatolian Geography. Indian journal of applied research 2013; 3(8):530-31.
8. Gautham K, Clarista MQ, Sheela N and Vidyashambhava P. Morphometric analysis of the human tali. CIBTech Journal of Surgery 2013; 2(2):64-8.
9. Kuo CC, Lee GY, Chang CM, Hsu HC, Leardini A, Wu Lu T. Ankle morphometry in the Chinese population. Journal of Foot and Ankle Research: 2008; 1:011.
10. Harris SM, Case DT. Sexual Dimorphism in the tarsal bones: Implications for Sex Determination. J Forensic Sci 2012; 57(2): 295-305.
11. Zeenat FZ. Body asymmetries: incidence. Etiology and clinical implications. Australian Journal of Basic and Applied Science, 2011; 5(9): 2157-91.