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A COMPARATIVE STUDY OF VARIATION OF FOOT ARCH INDEX WITH BODY MASS INDEX AMONG YOUNG ADULTS

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ABSTRACT

The foot forms an important support for the body, which endure high ground reaction forces generated during activities of daily living. The structure and movements of the foot are crucial for lower limb gait kinematics . The medial longitudinal arch (MLA) of the foot is the primary shock-absorbing structure particularly important for foot function . Increased body mass index (BMI) has been shown to affect the foot arch index. An arch index of less than 0.21 indicates cavus foot while greater than 0.26 is indicative of a planus foot whereas arch index between 0.21 and 0.26 corroborates normal arch height.
The aim of the present study is to correlate the arch index derived from foot print measurement in BMI based normal weight, overweight and obese young adults.
Methodology: The present study was conducted on 60 students of either sex in the age group of 18 to 25 years in the Department of Anatomy, School of medical sciences and research,Sharda University, Greater noida,UP. The standard anthropometric measures of height and weight were taken and BMI was calculated . Based on BMI, the students were divided into normal (19 to 24.9kg/m2), overweight (25 to 29.9kg/m2) and obese (>30kg/m2).Foot prints were taken on a graph paper and arch index was calculated.
Results: The mean arch index in normal, overweight and obese subjects was found to be 0.19±0.028, 0.2±30.043 and 0.26±0.045 respectively. Gender comparison did not reveal any significant difference($p>0.05$) in all the three groups.
Conclusion: The results of the study may help in establishing preventive and rehabilitative interventions to improve the quality of life of overweight and obese individuals.

INTRODUCTION

Balance is the process that maintains the centre of gravity within the body's support base and requires constant adjustments provided by muscular activity. Increase in the body weight interferes with the interaction of joints and muscles that are crucial to the functional capacity and postural balance. Obesity is excess body fat and in epidemiological studies, the body mass index (BMI) is the standard measure used to characterize normal and overweight. Gait analysis (1991) has revealed that obese adults walk with a wider support base and a lower speed, cadence and stride length than normal individuals [(1)]. Excessive increase in weight bearing forces caused by obesity may adversely affect the foot arches. The structure and the movements of the foot are crucial for lower limb gait kinematics [(2)]. The component primarily responsible for absorbing and dissipating these forces in the feet is the longitudinal arch [(3)]. Although, this arch comprises of bony articulations, ligaments and muscles, it is primarily the ligaments that support and stabilize the longitudinal arch [(4,5)]. Dowling and Steele [(6)] noted that ligaments rarely incur physiological fatigue and therefore offer a greater resistance to stress compared to muscles. However, repeated excessive loading may stretch ligaments beyond their elastic limit, damaging soft tissues and increasing the risk of foot discomfort and subsequent development of foot pathologies.
The concept of arch index was first described by Cavanagahet al [(7)] 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 greater than 0.26 is indicative of planus foot whereas arch Index between 0.21-0.26 corroborates normal arch height.

According to Williams et al (2001) arch structure might be associated with different injury patterns [8]. Such that high arched runners exhibited more bony, ankle and lateral injuries but low arched runners revealed a higher risk of soft tissue, knee and medial injuries.

Wearing (2001) while studying the comparison of foot print indices from ink and electronic foot print, disclosed that the foot print obtained on a graph sheet by conventional ink was better than electronic foot print obtained by special soft ware system [9].

The perusal of review of literature supports the view that anthropometric status of the individual does influence the lower limb joint kinematics and foot arches. However the reporting of association between BMI, range of motion and foot arch index was found to be inconsistent. Some authors observed a significant correlation while others could not find a significant association. Hence the purpose of the present study is to establish the body mass index related effects on the foot arch index for both males and females in young adults from North India.

MATERIAL AND METHODS

The present study was carried out in the Department of Anatomy, School of Medical Sciences and Research, Sharda university, Greater Noida. The sample constituted of 60 subjects (28 males and 32 females) randomly selected from various schools of Sharda University in the age group of 18-25 yrs excluding those not falling into the ambit of the inclusion criteria. Subjects with BMI of less than 19kg/m^2, with any existing neurologic and lower extremity chronic conditions, appreciable leg length discrepancy, history of acute lower extremity injury and surgery within the 6 months of data collection were excluded from the study. The study was performed after approval of the ethical committee of the School of Medical Sciences and Research, Sharda University, following the existents regulation. All the subjects for the study were provided with written informed consent and subject information sheet which discussed the procedure and objective for the study. The subjects, who agreed to participate in the study signed a letter of informed consent and underwent a general assessment before the start of the study.

METHODOLOGY

Body Mass Index (BMI) = Weight (kg)/Height(m)^2

Based on BMI, the students were divided into normal (19 to 24.9kg/m^2), overweight (25 to 29.9kg/m^2) and obese (>30kg/m^2) [10]

All the measurements were performed bilaterally on the subjects without shoes .Weight and Height of the subject was measured to calculate the BMI. Left and right foot prints of the subject were taken on a graph paper coded with name, age, sex, serial number of the subject.

Following the description of Cavanagah[7] in the foot print, the linear distance of the centre of the heel (point K) and the tip of the second (toe point J) which was the axis of the foot was measured.

A perpendicular line was then drawn tangential to the most anterior point of the main body of the foot print. Their point of intersection was marked L. The line LK was divided into three equal parts dividing the main body of the foot print into three parts. Ultimately the main body of the foot print was divided into three areas from those points with the perpendiculars from the foot axis. The anterior, middle and posterior areas were marked as A, B, C respectively. Their areas were estimated in square centimeters.

Arch index was calculated as the ratio of the area of the middle third of

the foot to the entire foot area excluding the toes.[7]

Arch Index==B/A+B+C (Fig 1)

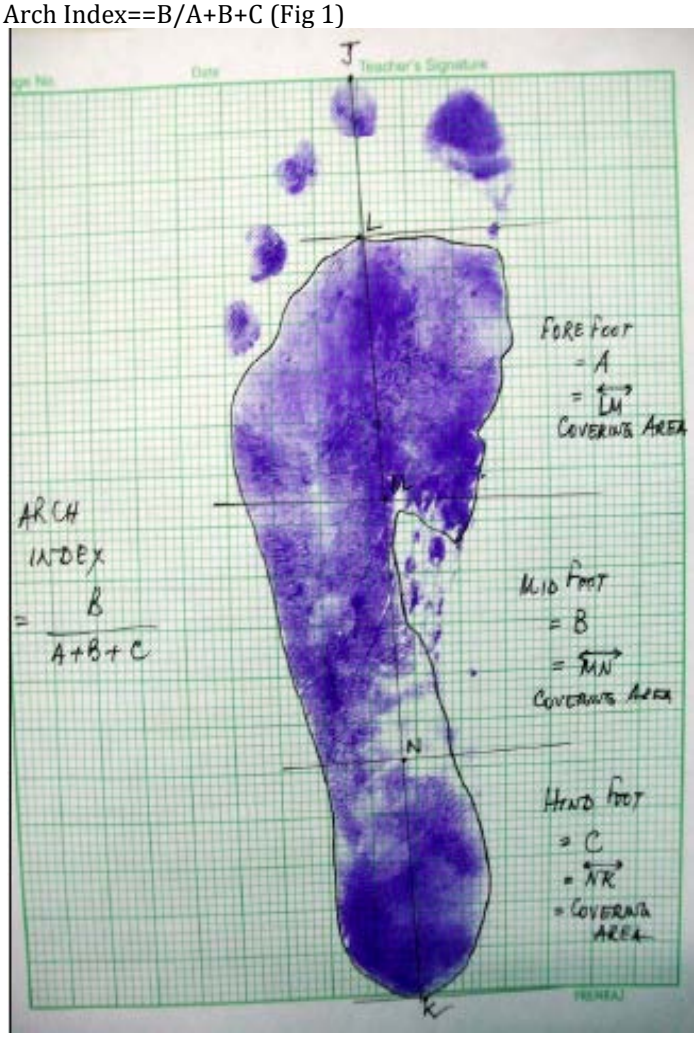

Fig 1 The photograph of left foot print of the subject illustrates the estimation of the arch index.

STATISTICAL ANALYSIS

The mean and standard deviation were determined for age, BMI and arch index in the three groups. Gender difference in above mentioned parameters and bilateral difference in arch index were tabulated. The independent *t* test was done to compare arch index in males and females. The paired *t* test was done to evaluate any bilateral differences and was calculated for significance ($p< 0.05$). The differences between subject groups were tested using one way ANOVA for multiple comparisons using a significance level of 0.05. A 5% level of probability was used to indicate statistical significance.

All statistical analysis was performed using SPSS version 22 for windows.

RESULTS

A cross sectional study wasconducted on 60 subjects which consisted of 28 males and 32 females. The subjects in

the study were in the age group of 18 to 25 years. The mean value of Body mass index (BMI) was 27.81±4.56. and mean value of LAI and RAI was 0.23±0.01 and 0.24±0.05 (Table 1)The analysis of data revealed a significant increase in arch index with BMI with 5% level of significance by using paired t test (p< 0.001). Table 2, Fig. 2 shows the comparative mean and SD values of left and right arch index in the three groups of subjects. One way Anova analysis of bilateral arch index in the three groups of normal, overweight and obese groups showed a statistically significant difference with a progressive increase in values from normal to obese. Gender wise comparison of the arch index values of male and female subjects of the three groups of normal, overweight and obese was not found to be statistically significant (p>0.05) .

Table 1: Comparison between Mean values of BMI and bilateral arch index

	BMI	LAI	RAI
Minimum	19.52	0.15	0.15
Maximum	41.00	0.30	0.34
Mean	27.81	0.23	0.24
SD	4.56	0.01	0.05
P value		0.000*	0.000 *

BMI =Body Mass Index, LAI= Left arch index, RAI=Right arch index

*indicates significant increase in arch index with BMI (p <0.001)

TABLE 2: Comparative mean and SD values of arch index in the three groups of subjects.

	BMI	LAI	RAI
Normal n=20	23.23± 1.80	0.196±0.028	0.199±0.028
Overweight n=20	26.75±1.43	0.23±0.043	0.24±0.05
Obese n=20	33.43±2.34	0.26±0.045	0.27±0.045

BMI =Body Mass Index, LAI= Left arch index, RAI=Right arch index

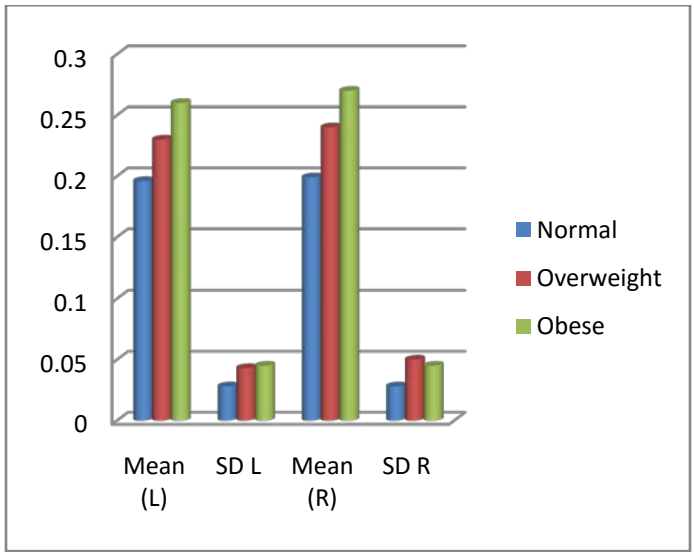

Fig 2 :Comparative mean and SD values of left and right arch index in the three groups .

There is a progressive and significant increase in values of arch index from normal to obese (p<0.05).

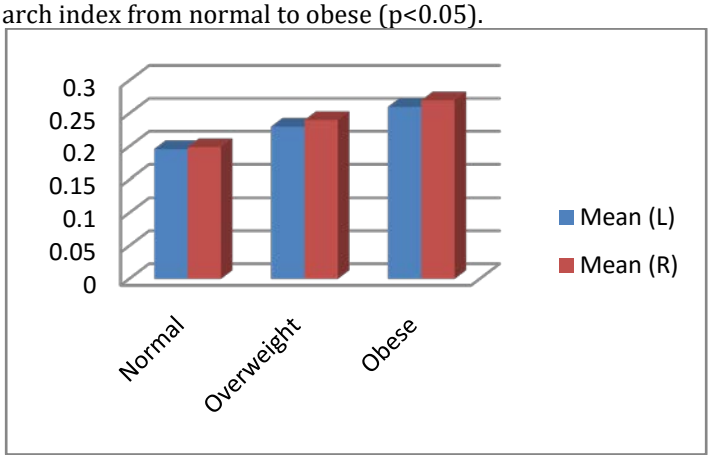

Fig 3: Comparison between mean of left and right arch index. The values of arch index were found to be statistically significant bilaterally (p<0.05) in the three groups.

DISCUSSION

The anthropometric status can influence gait biomechanics and are strong predictors of functional impairment and morbidity and exhibit differences in their magnitude of adaptation to the increased body mass.

The body mass index is a major performance determinant in a wide range of both static and dynamic field tests. In the present study, a statistically significant (p<0.05) progressive increase in the values of arch index was observed from normal to obese groups with a higher value of arch index in obese individuals signifying a flatter foot. (Table 1, 2 Fig 2, 3). The values of arch index (AI) showed a significantly positive correlation with increase in the body mass index which was in conformity with the previous study of Ganu and Panahale[11] who concluded from their study that obesity lowers the medial longitudinal arch due to the excessive increase in weight bearing forces, thus negatively affecting the foot arch index. A study done in obese children by Riddiford-Harland has also shown that the obese had significantly longer and flatter feet as compared to their normal weight counterparts [12].

An increase in the values of arch index with increasing BMI as noted in the present study was in agreement with that of Wearing who evaluated the effect of BMI on both radiographic and foot print based measures of adult arch structure and suggested that adiposity as a measure of BMI results in relative distortion of obese footprint by increasing the contact area of the midfoot without affecting the osseous alignment of the medial longitudinal arch when determined by radiographs[13]. An increase of BMI as little as 1.1kg/m^2 was seen to correspond to an increase of AI of 0.08, which was more than twice the apparent racial difference (0.03) reported for AI between African, American and European children.

In contrast, Evans did not find a positive relationship between increased body weight and flatter foot, although sample size, subject ethnicity and assessment method of foot posture may be relevant contributors to this controversy[14]. Gender wise comparison of the arch index values of male and female subjects of the three groups of normal, overweight and obese were not found to be statistically significant.(p>0.05) which was supported by Roy

et. al[15] although the foot architecture of male and female is not the same anatomically and the gait also differs between them.

The evidences elucidated from the present study indicate that the excessive increase in weight bearing forces caused by the increased body mass may negatively affect the lower limbs and feet. Additionally, future research should further subdivide the population of overweight individuals by age, gender and lifestyle factors to better inform efforts to reduce the morbidity due to the increased body mass. The results of the study could be of help in establishing preventive and rehabilitative interventions to improve the quality of life of obese individuals and counselling of overweight individuals.

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