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Association of flat foot with obesity in middle-aged individuals

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ABSTRACT

Flat foot can be classified as a foot with collapsed or minimally developed longitudinal arches. Another term used for flat foot is pes planus in which the medial longitudinal arch of the foot has collapsed**.** The frequency of flat foot is not explained properly as there is a lack of comprehensive definition, better method to classify and proper radiographic criteria for defining a flat foot. Due to obesity, there is an increase in forces at weight-bearing areas of the lower limb and feet. Long term continuous loading effect, specifically related to the feet region due to obesity, has not been extensively evaluated. To find the association of flat foot with obesity in middle-aged Individuals. A total of 120 subjects in the age range of 30 to 50 years were recruited with 60 subjects in each two groups formed on the basis of BMI indexes as Group A (Normal with BMI score 17.5 – 22.99) and Group B (Obese with BMI score >28). Navicular Drop Test and Waist/Hip ratio were measured using Brody's method and inch tape method, respectively and the correlation between Navicular drop and W/H ratio was evaluated thereafter in both the groups. The result of the study demonstrated that there is a statistically significant positive correlation between navicular drop test and W/H ratio in both the groups, with a stronger association in the obese group *(r=0.7 at p=0.05).* This study concluded that there is a strong correlation between flat foot and body weight in middle-aged individuals. Hence individuals should be physically active to maintain their body weight in order to avoid any biomechanical alteration in feet structures.

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INTRODUCTION

Flat foot can be classified as a foot with collapsed or minimally developed longitudinal arches. Another term used for flat foot is pes planus in which the medial longitudinal arch of the foot has collapsed (Shree *et al.*, 2018). Obesity is the abnormally excess accumulation of body fat that increases the overall adipose tissue mass in the human body. Excessive accumulation of body fat leading to obesity is a major health problem. Long term continuous loading effect, specifically related to the feet region due to obesity, has not been extensively evaluated (Periya and Alagesan, 2017). Additional loading force due to increase body weight are putted on our locomotor system that lead to restrictions at functional and structural levels, thereby increasing the abnormal stress level in structures of connective tissue and increasing the overall risk of musculoskeletal injuries (Heggannavar *et al.*, 2016). Of these musculoskeletal disorders, foot problems in obese adults are most frequent. This may be due to the increased stress placed on the feet through the need to bear excessive mass. Foot problems are frequent because the interface between body and ground is the feet and they are subjected to high stresses and load (Wearing *et al.*, 2006; Daneshmandi *et al.*, 2009). Obese persons may compensate for excessive loading by abnormal lower extremity alignment. Modifications in the arches of the feet can lead to different biomechanical alteration in the feet posture. Causes for acquired type of flatfoot can be related to any lower limb injury, prolonged continuous abnormal stress level at foot structures, obesity, illness, and defective biomechanical alignment. It is characterized by the valgus alignment of the calcaneum leading to a tibial internal rotation with the collapse of the medial longitudinal arch and forefoot moving into abduction as depicted in Figure 1 below,

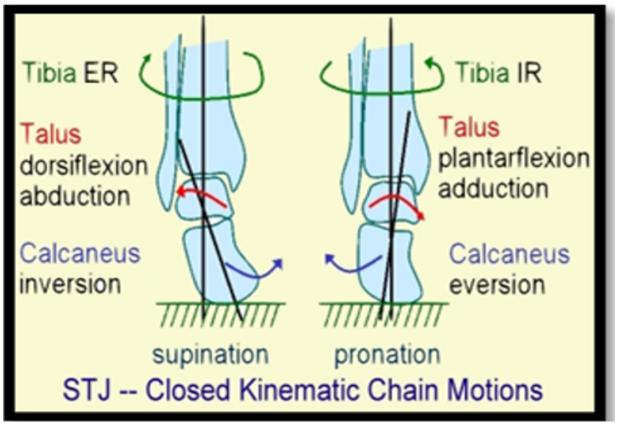


Figure 1: Lower Limb Kinematic Chain Movement

Acquired adult flatfoot can be caused by dysfunction of the posterior tibial tendon. Sedentary lifestyles, food habits with a high content of fat and calories intake lead to an increase in Body Mass Index (BMI). The stress level of the individual also leads to an increase in body weight. With ageing, there is a reduction in muscle mass and metabolism that may lead to a gain in body weight. A higher body mass index with weak musculature may lead to a collapse of the foot arches due to extra forces on the arches and consequently weakness of the respective muscles. This predominantly changes the surface of the contact of the foot arches in relation to the ground. (Cibulka, 1999) According to (Chougala *et al.*, 2015), high BMI can be linked with increase fat around the belly, lading to weak abdominal muscles and, in turn, causing increase lordosis in the lower back posture. This leads to changes in transmission of a line of gravity and overall affects the force transfer along the foot region. As a result, the areas of the feet, which means to bear the body weight, get altered. WHR may be used as a tool for measuring the degree of obesity and one of the significant markers for other introspective health conditions (Lam *et al.*, 2014). The WHO states that "abdominal obesity is defined as a waist-hip ratio above 0.90 for males and above 0.85 for females". Navicular drop is defined by Mueller MJ "as the distance the navicular tuberosity moves in standing, as the subtalar joint is allowed to move from its neutral position to a relaxed position. The measure of a navicular drop has been used as an indicator of pronation at the foot. The navicular drop has been suggested to be the most appropriate parameter for assessment of foot pronation" (Mueller *et al.*, 1993). There is a scarcity of researches related to the evaluation of the effect of abnormal excessive continuous loading due to the increase in body weight on the structural region of the foot. As the feet are important to weight-bearing elements of the body, increase body weight can lead to changes in the arches of the feet structure and this study is evaluating the association between them.

MATERIALS AND METHODS

A study was conducted as a correlation study design on 120 subjects which were divided in 2 groups with 60 subjects in each group formed on the basis of Asian classification of BMI as measurement index (**BMI = Weight in Kg/Height in m**^{2}), **Group A as Normal group** (BMI score 17.5 to 22.99) and **Group B as Obese group (BMI score > 28).** Both males and females between 30-50 years were included in the study. Outcome measures used were the **Navicular drop test and Waist-Hip ratio**.

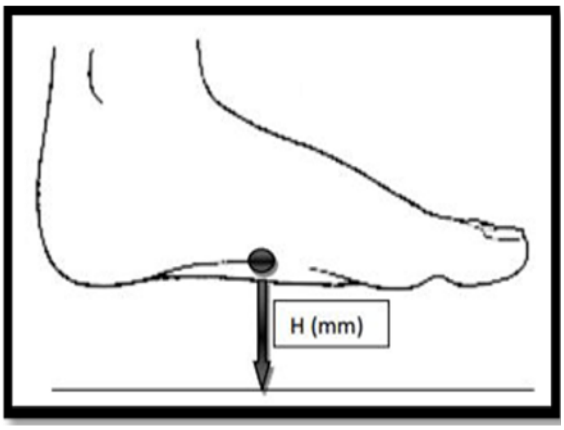


Figure 2: Navicular Height

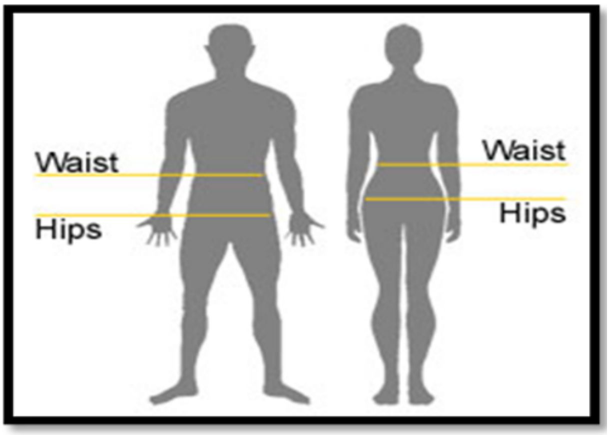


Figure 3: Waist-Hip ratio Measurement

Procedure

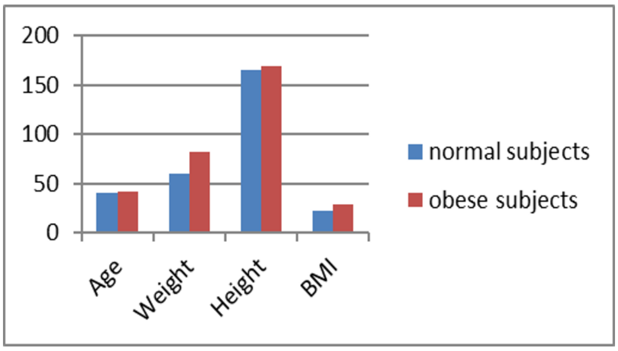
Potential subjects were apprised of the procedure and its benefits. Prior to testing, the subjects were familiarized with the testing procedure. Navicular drop test and W/H ratio were done through Brody's method and Inch tape method, respectively, for all the subjects in two groups. Descriptive data were also taken for all the subjects. According to Brody method of navicular drop measurement, "the subject was placed in a sitting position with their feet flat on a firm surface and with the knees flexed to 90 degree and ankle joints in a neutral position. The most prominent point of the navicular tubercle while maintaining a subtalar neutral position was identified and marked with a pen. A subtalar neutral position was established when talar depressions are equal on the medial and lateral side of the ankle. The index card was placed on the inner aspect of the hindfoot, with the card placed from the floor in the vertical position passing the navicular bone. The level of the most prominent point of the navicular tubercle was marked on the card. The individual was then asked to stand without changing the position of the feet and to distribute equal weight on both feet. In the standing position, the most prominent point of the navicular tubercle relative to the floor was again identified and marked on the card. Finally, the difference between the original height of the navicular tubercle in the sitting position and weight-bearing positions was then assessed with a tape measure rendering the ND amount in millimetres, as shown in Figure 2. The ND was calculated for both feet." According to Brody classification, "Navicular drop less than 10 mm are considered normal and more that 10 mm are considered as abnormal." (Park and Park, 2018; Deng *et al.*, 2010)

For waist-hip ratio (WHR), according to WHO, "the waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a stretch-resistant Inch Tape. Hip circumference was measured around the widest portion of the buttocks, with the tape parallel to the floor" as shown in Figure 3. (Lam *et al.*, 2014; Rothman, 2008)

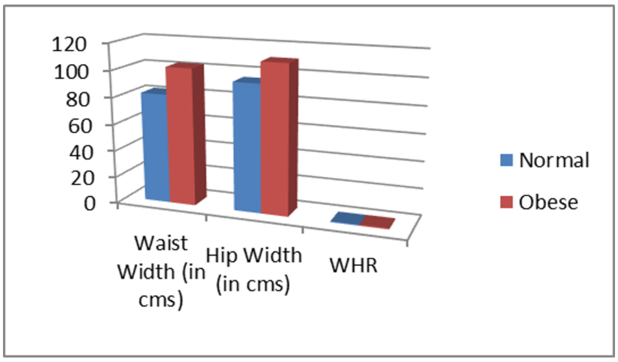
RESULTS AND DISCUSSION

In this study, the statistical analysis was done using SPSS (version 17). Mean and standard deviation were obtained for all dependent variables. Data was analysed by taking out mean, a standard deviation of the Navicular Drop test and W/H ratio. Correlation of navicular drop and W/H ratio of right and left was evaluated and then represented by scatter graphs for each group.

Tables 1 and 2 showing descriptive data of the Normal group and Obese group respectively. The mean value of NDT in both the foot was found to be greater in an obese group in comparison to the normal group.



Graph 1: Demographic details of normal weight subjects and obese subjects



Graph 2: Waist width, Hip width & Waist-Hip ratio of normal and obese subjects

Graph 1 showing the mean values of age, weight, height and BMI in both groups. Graph 2 showing the mean values of waist width, hip-width and waist-hip ratio (WHR) in both the groups and Graph 3 showing the mean values comparison of waist-hip ratio, navicular drop test, in both the foot, among normal and

Table 1: Mean and SD of variables in Normal Group

Normal Group	Mean	SD
Age	40.7	11.09
Weight (kg)	59.75	8.31
Height (cm)	164.8	9.91
BMI (kg/m2)	21.95	1.94
Right NDT (mm)	7.35	0.93
Left NDT (mm)	7.3	0.8
Waist Width (cm)	82.1	5.35
Hip Width (cm)	95	5.62
WHR	0.86	0.02

Table 2: Mean and SD of variables in Obese Group

Obese Group	Mean	SD
Age	41.4	10
Weight (kg)	82.2	9.46
Height (cm)	168.6	7.91
BMI (kg/m2)	28.92	2.94
Right NDT (mm)	11.3	1.62
Left NDT (mm)	11.7	1.86
Waist Width (cm)	102.5	5.53
Hip Width (cm)	110.55	4.5
WHR	0.92	0.03

Table 3: Showing the positive correlation between NDT and WHR significant at p<0.01

	Normal Group	
WHR Ratio	Right NDT	Left NDT
	r = 0.782**	r = 0.639**

**Correlation is significant at the 0.01 level (2-tailed).

Table 4: Showing the positive correlation between NDT and WHR significant at p<0.01

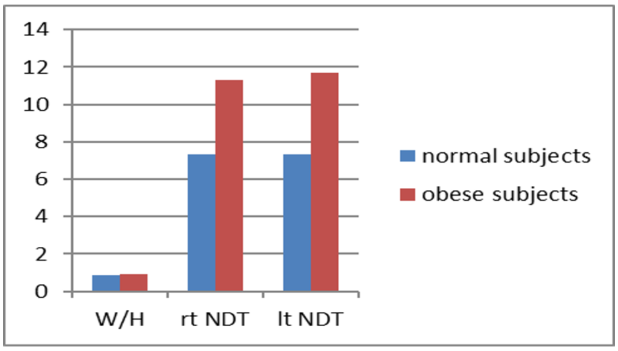
	Obese Group	
W/H Ratio	Right NDT	Left NDT
	r = 0.790	r = 0.843

**Correlation is significant at the 0.01 level (2-tailed).

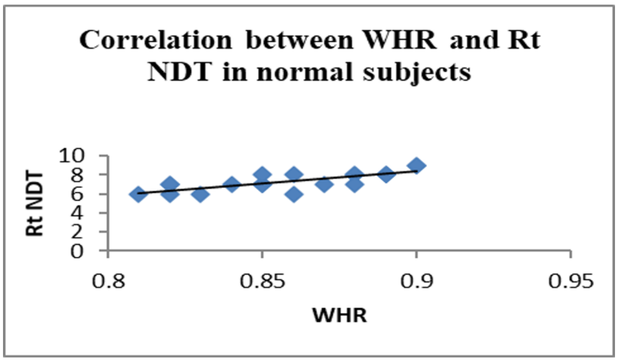
obese individuals. Mean values of WHR were 0.86 $\pm$ 0.02 and 0.92 $\pm$ 0.03 in the normal group and the obese group, respectively. Mean values of NDT right and left were 7.35 $\pm$ 0.93 & 7.3 $\pm$ 0.3 and 11.3 $\pm$ 1.62 & 11.7 $\pm$ 1.86 in normal and obese group respectively.

Tables 3 and 4 showed a positive significant correlation between NDT and WHR in both the groups with an r-value of 0.78 at $p<0.01$ (NDT Rt & WHR) and 0.63 at $p<0.01$(NDT Left & WHR) in the normal group. There was a slight stronger correlation in Obese individuals with an r-value of 0.79 at $p<0.01$(NDT Rt & WHR) and 0.84 at $p<0.01$ (NDT Left & WHR).

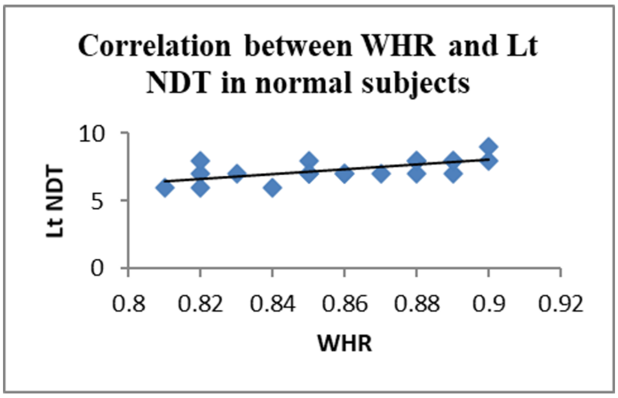
The correlation Graphs 4 and 5 of the result showed a positive significant correlation between the flat foot and WHR in middle-aged individuals with body weight categorised as normal, at $p<0.01$. In addition, Graphs 6 and 7 showed a more stronger positive significant correlation between the flat foot and WHR in middle-aged individuals with body weight categorised as obese, at $p<0.01$. So, the result exhibited that with an increase in body weight, there was more navicular drop among obese individuals.



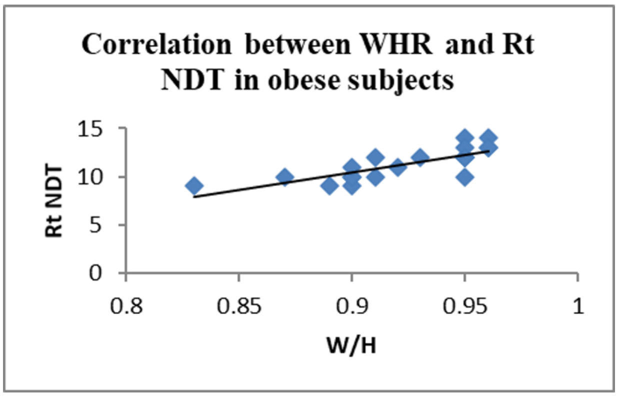
Graph 3: Navicular drop test of normal and obese subjects



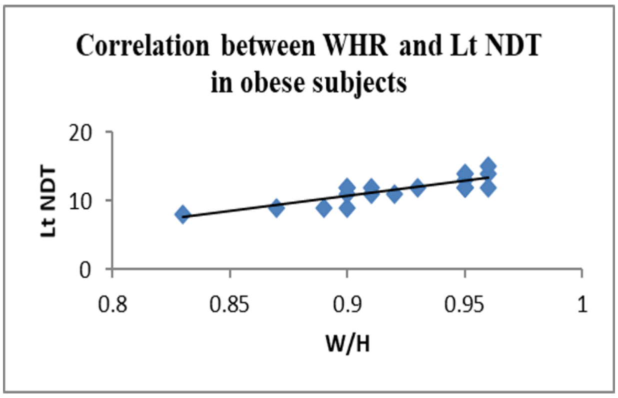
Graph 4: Correlation between WHR and Rt NDT in normal subjects.



Graph 5: Correlation between WHR and Lt NDT in normal subjects.



Graph 6: Correlation between WHR and Rt NDT in obese subjects



Graph 7: Correlation between W/H and Lt NDT in Obese subjects

The study was performed to find the association between flat foot and obesity in middle-aged individuals. This study found that there is an association of flat foot with obesity in middle-aged individuals. It shows that in overweight individuals, the navicular drop is affected by their weight. Result of the study is in line with the findings of a study done by Ganu SS, Panhale V 2013 (Ganu and Panhale, 2013) that showed an excessive increase in weight due to obesity leads to an increase in forces around weight-bearing areas of the foot that may produce a negative effect on the mechanics of the lower limbs and feet. Some studies had shown that an increase in body weight alter the overall biomechanical functioning of the foot structures as seen in the flat foot in all ages, including children and adults both (Hajirezaei *et al.*, 2017). Universal reasons for gain in weight are lack of physical exercise and imbalance in overall consuming and expending food energies. This lead to more accumulation of stored fat in adipose tissue that can result in causing different pathology. In adulthood, causes for weight gain can be numerous that may include bad eating pattern, idle way of life and miscellaneous external factors (Pourghasem *et al.*, 2016; Rothman, 2008). With respect to frame of time, excessive pressure over feet structures may be categorised as short term or long term effects. A short term effect is due to an increase in body weight for a short span of time for example while holding a bag or putting on a belt which has a weight that leads to increase body mass for a period of time in the way of life. Contrary, on the other hand, when an increase in body weight is continuous, permanent in nature for a long period of time example, obesity (Shree *et al.*, 2018; Daneshmandi *et al.*, 2009). Overall, the MLA structure in the foot region gets flattened and leads to disturbance in the normal way of bearing weight and ultimately result in abnormal functional alteration in the foot region. Symptoms include shortening of the elevator muscles (peroneal muscles), tenderness of plantar fascia, laxity of supporting structures on the medial side of the foot and tibialis posterior (Headlee *et al.*, 2008; Nigg, 2001). Conclusively, obesity can lead to lowering of the medial longitudinal arch of the foot and this condition leads to flattening of the arch and rolling in of the ankle.

CONCLUSION

Present study lead to a conclusion that there exists an association among flat foot and obesity in middle-aged individuals. Hence, middle-aged individuals should be physically active to maintain their body weight and decrease the risk of developing anomaly at the foot region and kinematic chain disturbance associated with alteration at foot structures.

Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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