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Correlation of Foot Structure Alteration with Grades of Obesity

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ABSTRACT

Objectives: To assess foot structure alteration and correlate with grades of obesity
Materials and Methods : 100 confirmed cases of overweight and obese samples within 19-35 years of age were taken and foot structure of the fore-foot, mid-foot and hind-foot and navicular drop were noted.
Results: 100 of the samples showed altered foot structure, while, navicular bone was dropped markedly.
Conclusion: The foot angle do alter in AP dimension with alteration of rarefoot to leg angle first followed by medial longitudinal arch and then navicular drop with forefoot angle. There are many factors for altered foot structure out of which overweight and obesity is one of them. Also, overweight and obesity is one of the serious factor as it can further lead to arthritis. Along with that, it can cause weakening of the lower limb extensor muscles. Timely interpretation and interventions along with weight loss will b the key entities to deal with it.
Keywords : Overweight or obesity grade 1,2,3

I. INTRODUCTION

Obesity is defined as a surplus of adipose tissue resulting from excessive energy intake relative to energy expenditure. There are many etiological factors causing obesity such as

Genetic influence
Racial factors
Physical incapacity
Improper diet
Life style
Ageing

The physiology behind obesity is that, in infants of 1 year old it is due to increased size of fat cell,where it is not mandatory it continues in adulthood. From the age of 4 to 11 years the reason for obesity is increase in size of fat cell which becomes a lifelong risk. Adult obesity is due to increase fat cell size but when the fat cells reach a finite capacity, there will be increase in cell number.

It recognized as major health problem in major parts of the world and the incidence of condition is at alarming rate [1]. Adult obesity has been associated with higher prevalence of musculoskeletal disorders, primarily affecting lower limb. Few studies have quantified the prevalence of musculoskeletal problems in overweight and obese subjects [2]. Relative to extensive literature now available on many aspects of the obese condition there is a dearth of information pertaining to structural and functional limitations by overweight and obese1. However, the implications of persistent obesity on musculoskeletal and locomotors systems, particularly weight bearing are poorly understood. Owing to the enormity of the problem of obesity, and the relative paucity available there is an urgent need to focus on the physical consequences of repetitive loading of major structures, particularly in lower extremity [1]

The foot is able to sustain large weight bearing stresses while accommodating to variety of surfaces and activities. As the terminal part of lower kinetic chain, the lower leg, ankle and foot have the ability to distribute and dissipate the forces acting on the body through the contact with the ground. In the foot, the movement occurring at each individual joint is minimal. Therefore, fore ease of understanding, the joints of the foot is divided into three sections: hindfoot, midfoot and forefoot. Again these foot structure is divided according to it's applied anatomy.
Hindfoot : tibiofibular joint, talocrural joint, subtalar joint. Midfoot : talocalcaneonavicular drop, cuneonavicular, cubiodeonavicular, cuneocuboid, calcaneocuboid. Forefoot : tarsometatarsal, intermetatarsel, metatarsophalangeal, interphalengeal.
Pronation and supination are the motion that occurs around the axis that line the angle for cardinal [3]. The weight bearing position of foot shows these two motion in the foot. Where in supination, there is inversion and outward rotation of the heel, adduction of the forefoot with inward rotation at tarsometatarsal joints to maintain contact with the ground and outward rotation at mid tarsal and plantar flexion at subtalar joint. Pronation of the foot involves eversion and inward rotation of the heel, abduction of forefoot and outward rotation at the tarsometatarsal and dorsiflexion at the subtalar joint.
As feet are the foundation for stance and dynamic tasks, it is postulated that the increased loading associated with obesity would place the feet at risk of pathology. The feet, as the base of support of the body, are continuously exposed to high ground reaction forces generated during daily activities[1]. Obese subjects have been found to display an increased plantar contact area and excessive increase in weight bearing forces compared to non-obese subjects[1,3]. In addition the foot shape of obese subjects feet were found to be different from subjects of normal mass. This is due to the increased stress placed on the foot by the need to bear excessive mass. However, there is relatively less research available examining between altered foot mechanics and obesity in developmental context.
The primary aim of the study is to review the current literature pertaining the effect of overweight and obesity on structures and function[1]. Structural deviations in the ankle and foot complex predispose the individual to change in weight bearing, muscle balance, resulting in compensatory strategies[7]. It seems obvious that increased body weight would result in increased plantar pressure. The body weight is also significantly associated with elevating loading of the foot. A previous study showed a strong relationship between foot arch type and injury risk. This relationship may influence the kinematic and may also contribute to musculoskeletal injuries4. Other than lower extremity it also increases the center of gravity this influences the postural stability and biomechanical inefficiencies like upper body forward lean[5]. The main musculoskeletal problem caused is heel pain which contributes both the factors that is maligned foot type and increased body mass index with reduced calf strength and increased plantar fascia thickness and age is also the criteria[6].

Despite the potential negative consequences of obesity on lower limb structure, only limited research has considered the effect of obesity on foot structure in obese [1]. An analysis of plantar peak pressure was done in an article, however, showed significantly increase values at heel for the obese group. It is unknown whether the greater prevalence of flat footedness in obese children is the result of presence of fat pad that remains or develops in their instep[1]. This study focuses on the bony structure of the foot therefore it will the actual foot structure relation with obesity.

II. MATERIALS AND METHODS

100 confirmed cases whose BMI is more than 25kg/m ^{2} in the age group of 19-31 were taken. A correlational study design was conducted. Exclusion criteria were individuals who have BMI normal or underweight, patient with any medical conditions like congenital deformities, any recent fractures. Materials such as goniometer, card paper to measure the navicular drop, digital weighing machine and stadio meter.

Permission was obtained from the institutional ethical committee. Informed consent was taken from the individuals willing to participate as per the inclusion and exclusion criteria and the purpose of the study was explained to them and the samples were screened.

PROCEDURE

Individuals were screened according to the age criteria and BMI was calculated. Individuals with BMI >25Kg/m^2 were included in the study.

At the time of participation subjects stood in weight bearing position were their BMI was calculated with a standard scales to classify them in categories of overweight and obese subject. The height of subject is taken in metres where as weight is taken in kilograms and calculated.

The waist hip ratio is to be calculated to find the comparison between the circumference of waist and hip by placing the inch tape above the navel or below diploid process for waist circumference and for hip circumference place the inch tape around the buttocks above the gluteal fold.

Next, the foot structure is classified again in weight bearing position. The medial longitudinal arch angle and rarefoot-to-leg angle is calculated to measure the hindfoot angle.

- The medial longitudinal arch is an obtuse angle between the line connecting the medial malleolus and navicular tuberosity and line connecting navicular tuberosity and medial most aspect of first metatarsel head. The rarefoot-to-leg angle is the acute angle formed by the longitudinal bisecting line of calcaneus and longitudinal bisecting line of distal one third of the leg. A foot is classified is rarefoot angle is lesser or greater than 9° and medial longitudinal arch angle was greater than or less than 134°.
- To measure the midfoot angle navicular drop test is done. Using small rigid ruler, the examiner first measures the height of the navicular from the floor in neutral position using the prominent part of navicular tuberosity and then measures the height of navicular in relaxed position. The difference is called navicular drop and indicated the amount of pronation or flattening of the medial longitudinal arch. Any measurement greater than 10mm is considered abnormal.
- To measure the forefoot, subject lying in prone position with one leg externally rotated and bent at knees. Place the computers stationary arm bisecting the calcaneus and movable arm bisecting the metatarsal head. Forefoot varus is in positive degrees and valgus is in negative degrees by determining the angle between the perpendicular to bisection of calcaneus and imaginary line bisecting the metatarsal head.

OUTCOME MEASURES

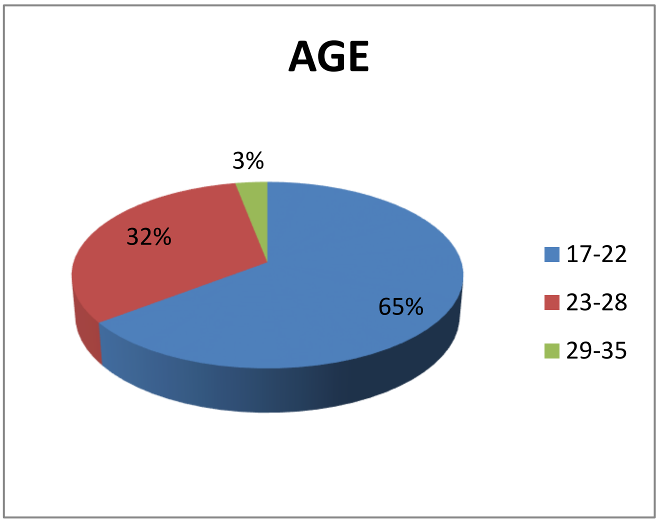
- Navicular drop test
- Medial longitudinal arch angle
- rarefoot-to-leg angle to measure the foot type
- Forefoot static alignment

DATA ANALYSIS

TABLE 1 : Age criteria

AGE	NO. OF SAMPLES
17-22	64
23-28	32
29-35	4

GRAPH NO.1:



GENDER	NO. OF SAMPLES
MALES	17
FEMALES	83

GRAPH NO.2:

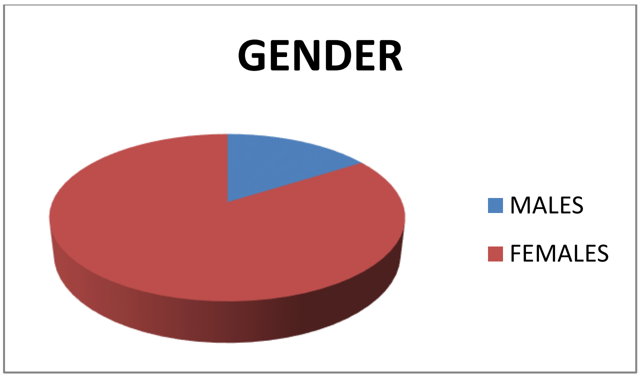
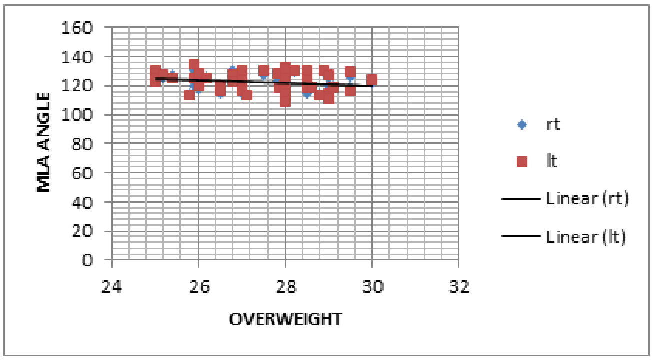


TABLE NO.3: Correlation of medial longitudinal arch angle with overweight of BMI

	Left	Right
S.D	47.8759	
r	-0.227	-0.237

GRAPH NO.3:

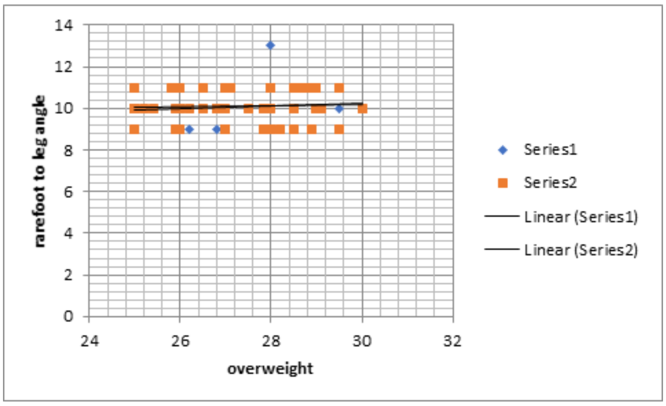


INTERPRETATION: The above graph shows weak negative correlation with medial longitudinal arch with overweight.

TABLE NO.4 : Correlation of overweight with rarefoot to leg angle.

	Left	Right
S.D	8.653978	
r	0.032	0.105

GRAPH NO.4

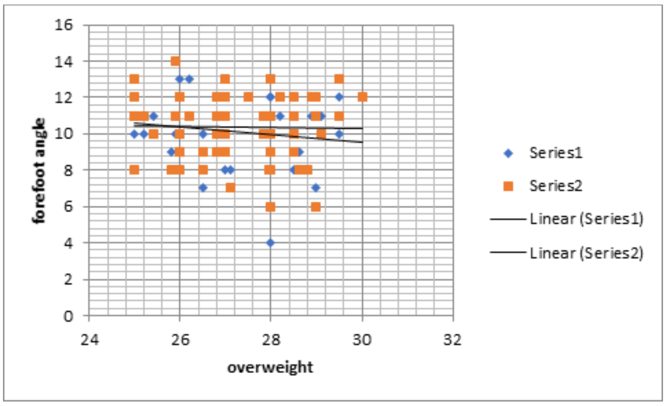


INTERPRETAION: the above graph shows weak positive correlation of rarefoot to leg angle with overweight.

TABLE NO. 5: Correlation of overweight to forefoot angle.

	left	Right
S.D	8.655497	
r	-0.160	-0.025

GRAPH NO.5

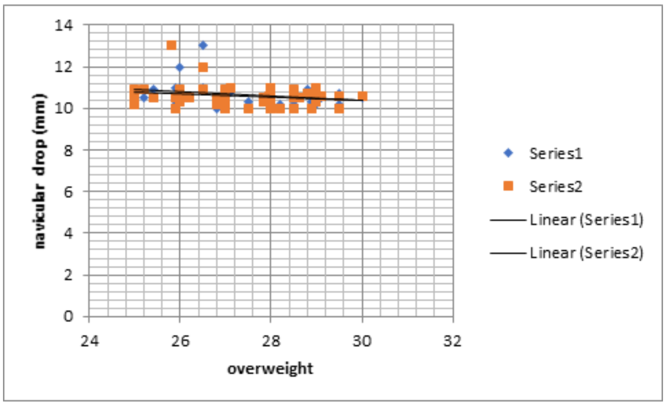


INTERPREATION : The above graph shows weak negative correlation of forefoot angle with overweight.

TABLE NO. 6 : Correlation of overeweight with navicular drop test.

	Left	Right
S.D	8.386493	
r	-0.242	-0.207

GRAPH NO.6:

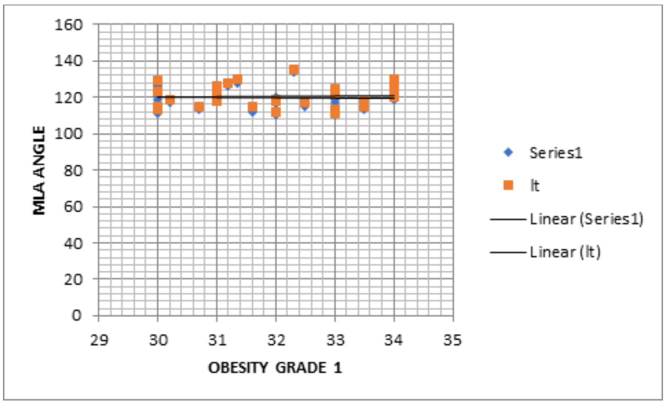


INTERPRETATION : the above graph shows weak negative correlation with overweight

TABLE NO.7: Correlation of medial longitudinal arch with obesity 1

	left	Right
S.D	44.43051	
r	-0.025	0.012

GRAPH N0.7

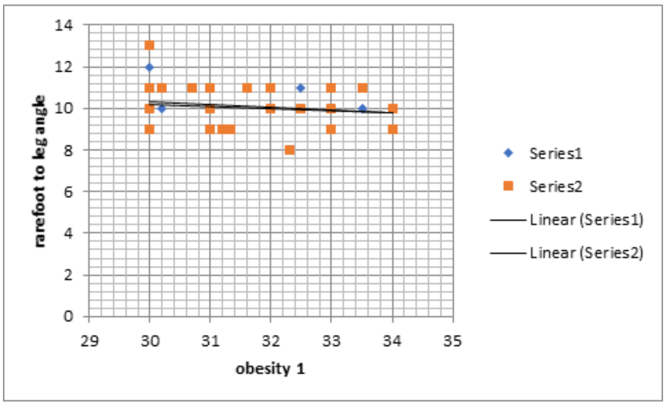


INTERPRETATION : the above graph interprets medial longitudinal arch angle has negative correlation with obesity 1.

TABLE NO.8 : Correlation with obesity grade1 with rarefoot to leg angle.

	Left	Right
S.D	11.03917	
r	0.157	0.158

GRAPH NO.8

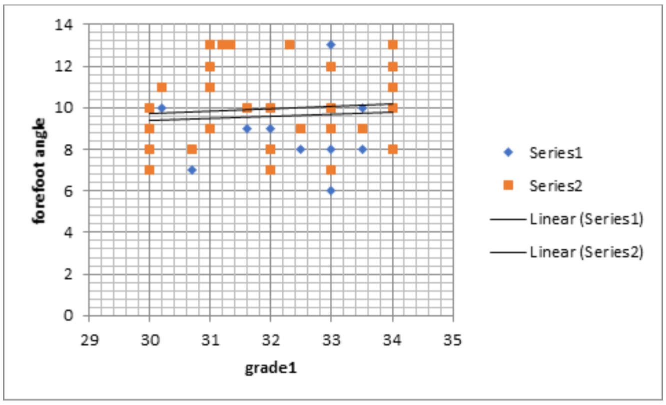


INTERPRETATION : the above graph interprets that the rarefoot angle has positive correlation with obesity 1.

TABLE NO. 9 : Correlation of grade1 to forefoot angle.

	left	Right
S.D	11.22687	
r	0.062	0.080

GRAPH NO. 9

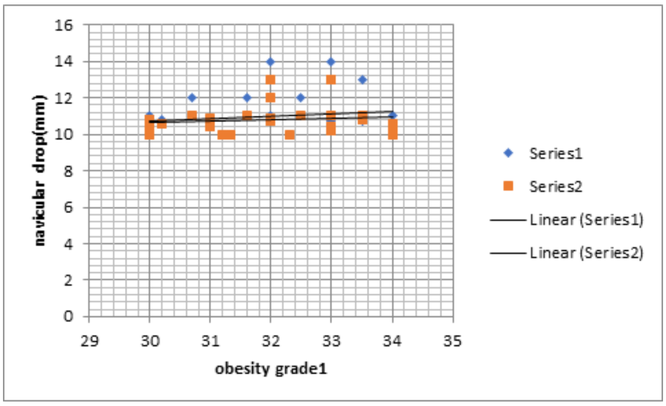


INTERPRETATION : the above graph shows weak positive correlation of forefoot angle with grade 1 obesity.

TABLE NO. 10: Correlation with grade1 obesity with navicular drop test.

	left	Right
S.D	10.59625	
r	0.175	0.127

GRAPH NO.10:

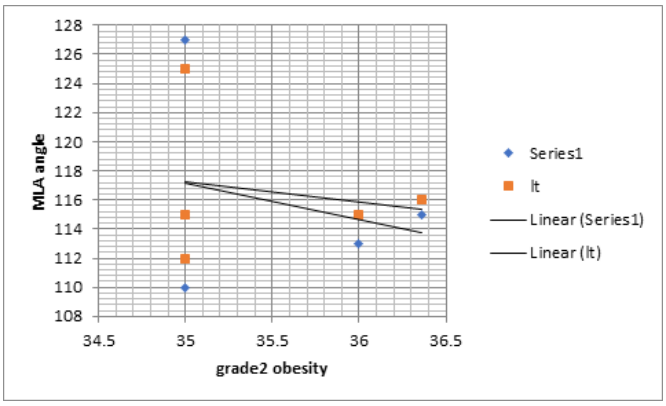


INTERPRETATION: The above graphs shows positive correlation of navicular drop with grades of obesity.

TABLE NO. 11: correlation of medial longitudinal arch with obesity grade 2

	left	Right
S.D	40.58041	
r	0.255	0.861

GRAPH NO.11

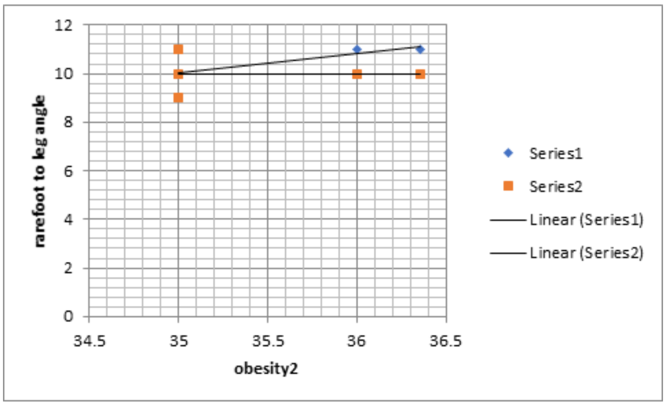


INTERPRETATION : The above graph shows that moderately positive correlation of medial longitudinal arch with grade 2 obesity.

TABLE NO.12: Correlation of obesity grade2 with rarefoot to leg angle.

	Left	Right
S.D	12.65393	
r	0.601	0.000

GRAPH NO. 12

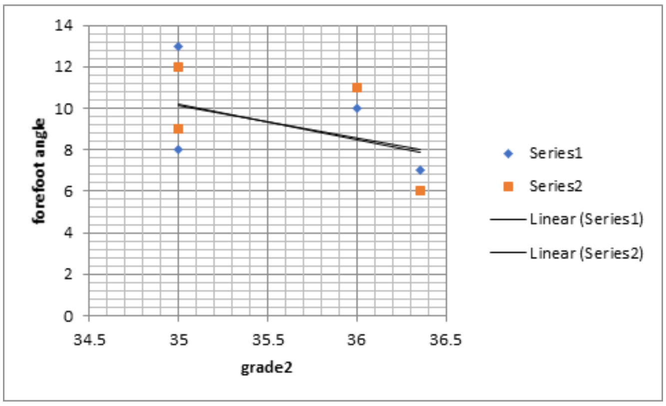


INTERPREATION : the graph shows moderately positive correlation of rarefoot to leg angle with grade 2 obesity.

TABLE NO 13 : Correlation of grade 2 of obesity to forefoot angle.

	left	Right
S.D	13.12368	
r	-0.439	-0.498

GRAPH NO.13:



INTERPRETATION : the above graph shows negative correlation of forefoot angle with grades2 obesity.

TABLE NO.14: Correlation of grade2 obesity with navicular drop test.

	left	Right
S.D	12.18841	
r	-0.263	-0.263

GRAPH NO. 14:

INTERPRETATION: The above graph shows negative correlation of navicular drop with grade 2 obesity.

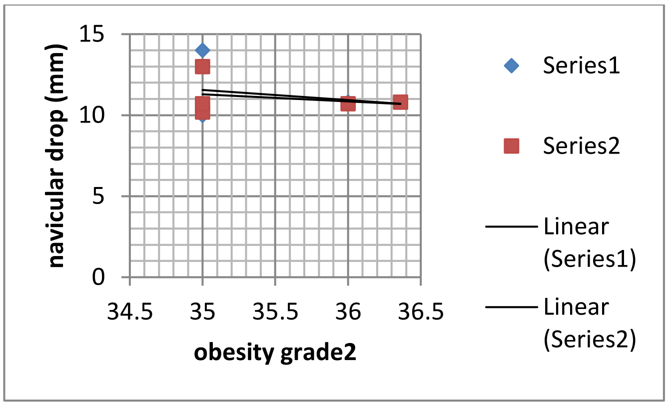
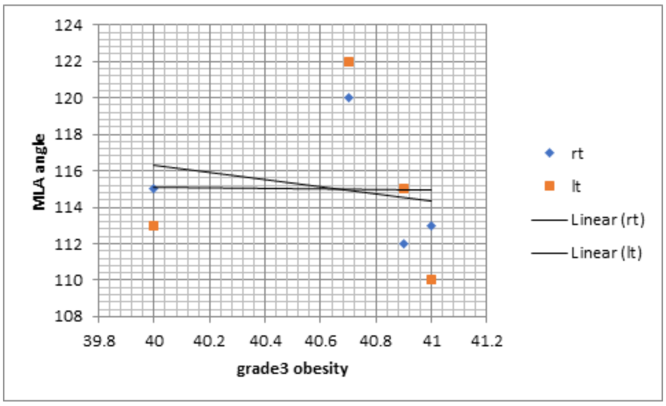


TABLE NO. 15 : Correlation of medial longitudinal arch with obesity grade3.

	Left	Right
S.D	37.271	
r	0.249	0.015

GRAPH NO.15:

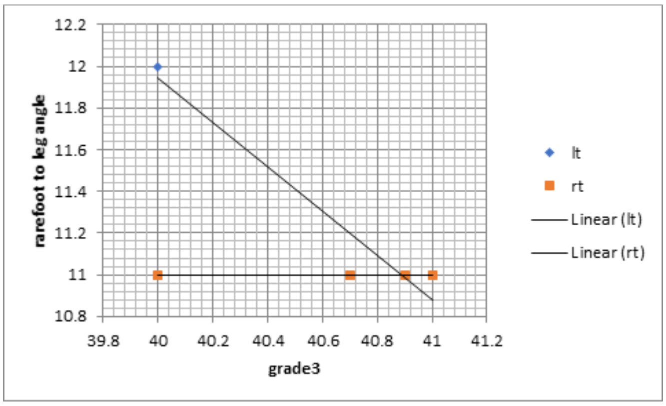


INTERPRETATION : the above graph shows positive correlation of medial longitudinal arch with grade3 obesity.

TABLE NO. 16: Correlation of grade3 with rarefoot to leg angle.

	left	Right
S.D	14.5819	
r	0.769	-0.384

GRAPH NO.16

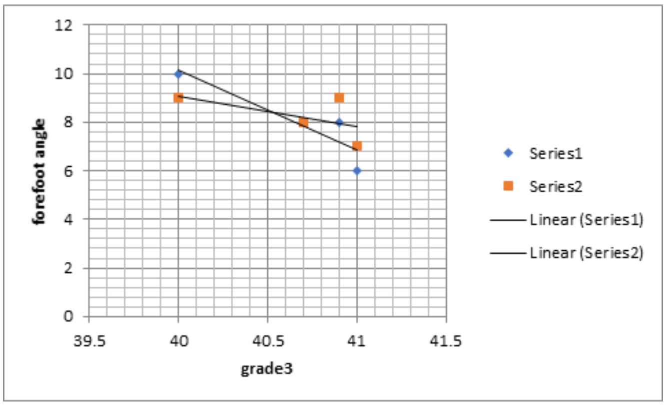


INTERPRETATION: The above shows moderately positive correlation in left foot and negative correlation of rarefoot to leg angle with grade3 obesity.

TABLE NO.17 : Correlation of grade3 of obesity with forefoot angle.

	Left	Right
S.D	16.28573	
r	-0.06	-0.450

GRAPH NO.17:

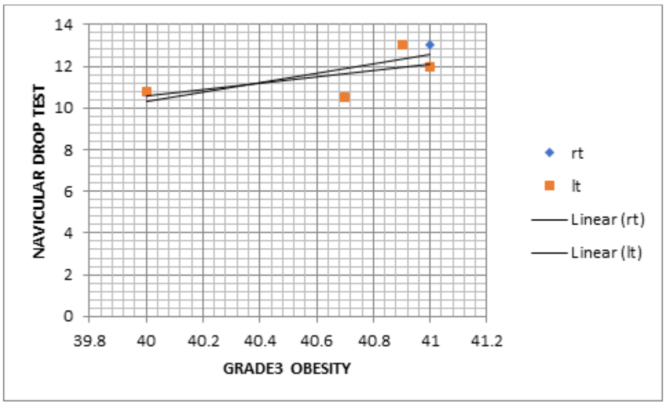


INTERPRETATION: the above graph shows negative correlation of forefoot angle with grade3 obesity.

TABLE NO. 18: Correlation of obesity grade3 with navicular drop test.

	left	Right
S.D	14.50512	
r	0.730	0.614

GRAPH NO.18:



INTERPRETATION: The above graph shows moderately positive correlation of navicular drop with grade3 obesity.

III. RESULTS

Graph 3 represents as the range of overweight criteria increases the angle of medial longitudinal arch decreases than 134° but there is negative correlation.(r = -0.224,-0.237). Graph 4 represents that as the overweight criteria increases in range the rarefoot to leg angle increases more that 9°but the correlation value is not significant(r= -0.032,0.105) Graph 5 represents that there is decrease in forefoot angle but still most of the samples fall under normal degree with negative correlation.(r = -0.160,-0.025)

Graph 6 represents increase in magnitude more than 10 mm with negative correlation.(r= -0.242,-0.207). Graph 7 represents that the angle does not change in left foot much as compared to right foot is shows decrease in angle but not significantly with increase with obesity with positive correlation but not significant.(r = -0.025, 0.012). Graph 8 represents the rarefoot angle is decreasing but not significantly with the grade but not significant.(r= 0.157,0.158). Graph 9 represents decrease in angle but in normal ranges with positive correlation but not significant.(r = 0.062,0.080). Graph 10 represent increase in magnitude of navicular drop with grades of obesity but no correlation.(r = 0.175,0.127)

Graph 11 represents that the degree of foot angle decreases with increase in BMI with moderate correlation.(r= 0.255,0.861). Graph 12 represents that as the grade increases the rarefoot to leg angle also increases with moderate correlation.(r = 0.601, 0.000). Graph 13 represents forefoot angle decreases with grades of obesity with negative correlation.(r = -0.439,-0.498). Graph 14 represents shows decrease in magnitude but not that significant to the grade of obesity with negative correlation.(r = -0.263,-0.263). Graph 15 represent that as the obesity grade increases the angle decreases with positive correlation but not significant.(r = 0.249,0.015)

Graph 16 represents the angle remains constant for right foot but in left foot it increases with moderate correlation.(r = 0.769,-0.384). Graph 17 represents that decrease in angle less than 8° in obesity grade 3 with negative correlation.(r = -0.06,-0.450). Graph 18 represents increase in navicular drop in grade 3 obesity with moderate correlation.(r = 0.730,0.614)

IV. DISCUSSION

This study examined the effect of foot structure alteration with different grades of obesity, where subjects was assessed for medial longitudinal angle, forefoot angle, navicular drop test and rarefoot-leg angle. Subjects enrolled in this study had distinguishable foot structure alteration in left and right feet based on the inclusion criteria for the study. Subjects indicated no age related difference and gender related differences.

This study showed correlation of overweight population with different outcome measures, like, medial longitudinal arch angle, rarefoot to leg angle, forefoot angle, navicular drop test which showed that there is decrease in the angle of medial longitudinal arch and rarefoot leg angle and also navicular drop. Because in most of the subject, the subtalar joint is normally in slight valgus with forefoot in slight varus and calcaneum in slight valgus. Previous study done by SAMI S. ALABDULWAHAB concluded that increase body mass may impact the maintenance of the longitudinal arch, i.e, in heavier individuals, the arch drops. Therefore this correlation with overweight individuals shows decrease in angles but slight drop in arch that is why the correlation value is negative but clinically the values is decreased than the normal foot angle values.

The study also shows correlation with different grades of obesity. When angles of foot was compared with grade 1 obesity shows decrease in the angle but when compared to overweight the values are not that decreased. But the correlation value shows moderate correlation with obesity1 grade. The foot angles falls under pronation values of the foot. This study shows that the medial longitudinal arch and rarefoot to leg angle shows positive correlation by the examination but the forefoot angle and the navicular drop does not show any significant correlation in grade 1 . According to ALABDULWAHAB SS there is negative relationship between increasing BMI and FPI is that excess bodyweight leads to greater mechanical loading of the foot particularly on midfoot and forefoot. But this study shows that the hindfoot shows particular foot structure alteration as compared to midfoot and hindfoot. . As the normal weight distribution on foot is 60% on hindfoot, 4% on midfoot and 8% on forefoot.

Furthermore, study was done on grade 2 and grade 3 of obesity with the foot structure angles which gave result of significant values which indicated that increasing BMI influences the structure of the foot. Here, the navicular drop shows positive correlation with the grade 2 and 3 of obesity. The foot structure is altered with positive significance in both midfoot and forefoot which suggests that obesity increases the stresses applied to foot directly and indirectly to the foot structure. This is because, as there is increase in abdominal fat there is poor core stability due to which there is change in the spine curves where is thoracic kyphosis seen with increase lumbar lordosis due to which the pelvis goes into anterior tilt that causes femur into internal rotation that causes patella to shift laterally and tilts medial leading to lateral tracking which causes the tibia rotate internally that causes the subtalar joint go into inversion. This causes the navicular drop because of weak invertors and plantarflexors. In forefoot, the angle is decreased because of weak intrinsic muscles and extensor hallucus longus Here, the study from journal of exercise rehabilition is proved right .

In this study the subjects have more pronated group and there were no individuals with supinated foot. MARJOLIEN KRUL studied that foot structure in 2-17 year old overweight and obese children have decreased navicular height, lower medial arch and higher plantar pressure.

Finding that the group is falling under pronated foot LIANG-CHING TSAI studied that pronated foot have greater normalized center of pressure and maximum displacement in AP direction. The normal weight distribution on foot is 60% on hindfoot, 4% on midfoot and 8% on forefoot there is displacement in AP dimension as compared to mediolateral dimension because the distribution is according to the structure.

V. CONCLUSION

Present study concludes that, there is foot structure alteration as the obesity grades increases. The angle do alter in AP dimension with alteration of rarefoot to leg angle first followed by medial longitudinal arch and then navicular drop with forefoot angle. Where grade 3 shows more positive correlation study.

VI. LIMITATIONS

- Small sample size
- No. of gender samples were not equal in number
- The samples of obese grade 3 were lesser in number
- Sampling was done in limited area

VII. FUTURE SCOPE

As further more studies can be done to check if weight reduction can cause any alteration in foot structure. To minimize any malalignent or malfunctioning of lower limb treatment should be given earliest.

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