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CORRELATION OF FOOT ARCH INDEX WITH DYNAMIC BALANCE IN UNDERWEIGHT PARAMEDICAL STUDENTS- AN OBSERVATIONAL PILOT STUDY

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ABSTRACT

Introduction: The ankle and foot complex plays a very important role being the most distal segment of lower extremity and represents small base of support on which the whole balance of the body is maintained, especially in single leg stance. Even the minor neuromuscular or biomechanical changes may be influence postural control strategies to maintain the balance.

Methodology: In this study 40 subjects were included according to the inclusion criteria. Baseline data was documented in form of age, BMI, limb length. Foot arch index was assessed using foot print method on white sheet paper and arch index was calculated. Y Balance test was examined for both the leg simultaneously in all 3 directions and composite score was calculated.

Result: There is weak negative correlation between foot arch index and dynamic balance with (pearsons coefficient r=-0.22, -0.12-0.22, -0.19) the relation is not significant as $p>0.05$. There are no significant differences noted between male and female in foot arch index, but significant differences present between Y Balance test score ($p<0.05$)

Conclusion: There is weak negative correlation noted between foot arch index and dynamic balance in both male and female. This says that there might be no dynamic balance issues present with altered arch indexes as the proprioceptors might not be that much affected. But there are significant differences present between male and female Y balance test score suggest significant gender differences present in dynamic balance.

Keywords: underweight BMI, Foot arch index, Dynamic balance, Y balance test.

Introduction

The arches of the feet are important in protecting the internal structures of the feet and body from impacting forces, while it mainly helps in transferring the internal forces to the ground, also involve in lifting weight, and mainly shock absorption. (1) The arches are classified into two categories: longitudinal arches and the transverse arches. These arches maintain proportional distribution of the body weight. (2)

In literature, the arches are classified based on footprints into three groups as ‘flat foot’, ‘high arched’ and ‘normal foot’. (3) Pes planus (flat foot) is described in the studies as an anomaly which is characterized by decreasing or disappearing completely the height of the medial longitudinal (MLA)

of the foot. Pes Cavus (high arch) is a pathologic arch which presents as the elevation of the height of the MLA of the foot. [4] It has been evident that the biomechanics of the foot are influenced by the structure of the foot, especially by the medial longitudinal arch. [5]

The alterations in the arches are very well known by the literatures of almost all the categories. Along with that in the medical field the prevalence of flat foot was bilaterally 11.6% and unilaterally 3% in students. The students though being in the medical field were not aware about their own affected arches causes' pain which affected their quality of life. [6] There are several techniques to determine the alterations in the arches. However, the techniques based on radiological examinations, clinical examinations and footprints are the most used ones. Many authors stated that footprint is one the techniques which is more effective methods for determining the altered arches mainly pes planus and pes cavus, as its more practical and cheaper than others. [7][8][9]

Balance is of two types: static and dynamic. Static balance is defined as the ability of the individual to maintain the balance in a stationary position. While the dynamic balance is defined as the ability of the individual to maintain the balance in a moving state.[10] Foot along with arches acts as a key stone in maintaining stable platform for static as well as dynamic functional activities.[11] The assessment technique for a person's dynamic postural control is not as simple as testing their static postural control since dynamic postural control tasks require some level of predicted movements without jeopardizing the established base of support.[12]

Y Balance test is one of the methods to assess the dynamic balance. The Y-balance test (YBT) is a more time-efficient test that examines dynamic limits of stability and asymmetrical balance in only three directions (anterior, posterolateral, posteromedial) based on earlier research revealing redundancy in the 8 directions of the SEBT.[13][14][15]As a result, this test necessitates a combination of foot, ankle, knee, and hip movements, as well as increased strength and joint range of motion in the stance leg, as well as proprioception and neuromuscular control in the opposing leg to maintain balance while reaching with the opposite leg.[16]For the three reach directions, interrater test–retest reliability was good, with ICC (2,1) values ranging from 0.80 to 0.85, an associated SEM ranging from 3.1 to 4.2 cm, and MDC values ranging from 8.7 to 11.5 cm.[17] Plisky et al found that people with anterior left/right asymmetries of more than 4 cm on the YBT were 2.5 times more likely to have a lower extremity injury.[18]

Need of the study

The literature describing the relationship between arch height and balance in underweight category is very less to our knowledge. Yet, these studies contradicted each other's result of association between BMI variation to foot arch height and dynamic balance. So, the need of the present pilot study is to determine the correlation of foot arch index with dynamic balance in underweight paramedical students and the results may be useful for prevention of occupational hazards.

METHODOLOGY

A. SOURCE OF DATA:

Students of Parul University of Physiotherapy, Ayurved, Homeopath, Nursing.

B. METHOD OF COLLECTION OF DATA:

Study design: Observational Study (Cross Sectional Study)
Sampling Method: Selective sampling who fits in Inclusion criteria.
Study Duration: 6 Months
Data Collection Duration- 2 Months
Sample Size : N= 40

C. INCLUSION CRITERIA

Students of Parul Institute of Physiotherapy, Homeopathy, Ayurveda, Nursing.
Age 18-25 Years.
BMI <18

D. EXCLUSION CRITERIA

Any past history of treatment or injury to lower limb.
Neurological or Vascular Deficit affecting Balance.
Pain / Swelling near Ankle and Foot.
Visual or Vestibular Impairment.

E. SUBJECTS:

The study was done among physiotherapy students aged 18 to 25 years. After the participants gave their agreement for the study, they were evaluated for inclusion and exclusion criteria, and those who met

the inclusion criteria were included in the study. The order of the participants in this investigation was completely random.

F. MATERIALS

Weighing Machine
Height Measuring Tape.
Black ink and sponge.
White Sheet Paper.
Measuring tape.
Y- Balance Test Kit.

G. PROCEDURE:

Forty subjects were included in the study according to the inclusion criteria. After taking consent from the participants, the subjects were assessed for the baseline characteristics in form of age, height, weight. BMI was calculated. Subject's lower limb reach was also normalized to leg length, which was measured from the anterior superior iliac spine to the most distal portion of the medial malleolus.[19]

Foot Arch Index.

Foot Arch Index was calculated with the foot print method on white paper by applying ink on the sole of the foot and asking them to stand on the white sheet paper giving equal weight on both the feet. Foot axis was drawn on the foot print from center of heel to tip of the second toe. Perpendiculars were drawn to the anterior and posterior aspects of footprint excluding toes. Then foot axis was divided into three equal part. Fore foot(A), Mid foot(B) and Hind foot(C)

$$\text{Foot Arch Index} = \frac{B}{[A+B+C]}$$

fig: high arch, normal arch and flat foot, footprints

If AI is between 0.21-0.26, the foot will be classed as normal, pronated (flat foot) if FAI is greater than 0.26, and supinated if AI is less than 0.216. [20][21]

Y Balance Test

Subjects were instructed and 3 trials were given. Participants completed 3 consecutive trials for each reach direction and to reduce fatigue subjects altered limbs between each direction. Participants were instructed to stand on the center plate and reach towards three directions (anterior, posteromedial, and poster lateral) by the great toe of testing leg as much they can. The score of the Y balance test was calculated by the following formula. [22]

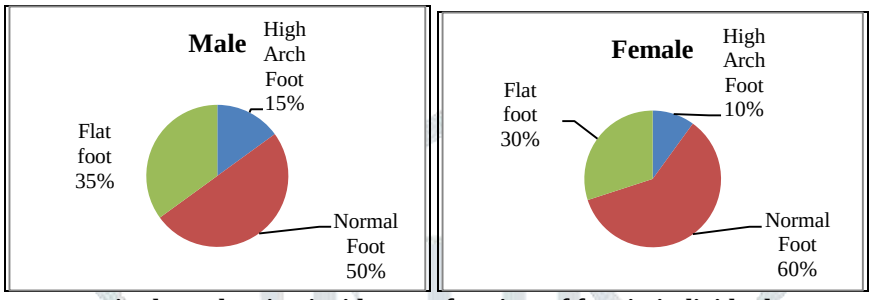
$$\text{Score of Y Balance Test} = \frac{\text{Anterior + Postero medial + Postero lateral distance}}{\text{3* Limb Length}} * 100$$

Result

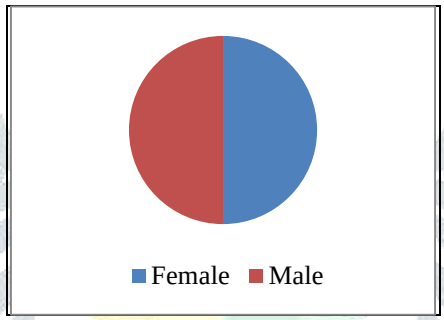
A total 40 paramedical underweight student took part in this study out of which 20 were male and 20 were female.

table no.1 mean and standard deviation of all data

Mean and Standard Deviation		
Variable	**Male**	**Female**
Age	21.7	21.3
BMI	16.65	16.28
Limb Length	81.4	80.6
Foot Arch Index Rt	0.24 +_0.94	0.26 +_0.56
Foot Arch Index Lt	0.25+_0.81	0.27 +_0.56
Y Balance Test Score Rt	95.56+_9.93	86.59 +_8.69
Y Balance Test Score Lt	101.2+_10.73	87.75 +_11.69



pie chart showing incidences of variety of foot in individual



pie chart showing gender distribution

table no. 2 mean values of y balance test

Gender	Side	Anterior	Posterolateral	Posteromedial
Male	**Right**	**74.94**	**79.65**	**77.4**
	Left	**80.55**	**82**	**83.15**
Female	**Right**	**67.6**	**70.15**	**71.45**
	Left	**68.1**	**71.85**	**71.7**

table no. 3 correlation of foot arch index with y balance test score in male and female

Category		RFAI-RYBT	LFAI-LYBT
Male	Pearson's correlation	-.241	-.125
	Sig. (2 tailed)	.307	.599
Female	Pearson's correlation	-.229	-.196
	Sig. (2 tailed)	.331	.407

The above table shows the correlation of Foot Arch Index with Y Balance test score of male and female. There is negative correlation between FAI and YBT, indicated that if the foot arch increases Y Balance test score increases. The correlation is 30-60% significant as the p value is >0.05.

table no. 4 comparison between male and female foot arch index and y balance test score.

Independent Sample t test - FAI and YBT of Male and Female						
Comparison between	Levene's Test for Equality of Variances		t-test for Equality of Means			
	F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Right- FAI	1.78	0.18	-.64	.520	-.016	.024
			-.64	.521	-.016	.024
Left-FAI	1.40	0.24	-.74	.461	-.016	.022
			-.74	.461	-.016	.022
Right-YBT	1.81	0.18	3.12	.003	8.96	2.87
			3.12	.004	8.96	2.87
Left-YBT	0.01	0.91	3.79	.001	13.51	3.56
			3.79	.001	13.51	3.56

The above table is of comparison between male and female Foot Arch Index and Y Balance test score, the foot arch index differences between male and female of both right and left is 50% and 60% as the p value is 0.5and 0.4 respectively. The Y Balance test score differences between male and female of right leg is significantly different with p value 0.03 ($p<0.05$), same with the left Y Balance test score there is significant difference with p value 0.01 ($p<0.05$) between male and female score. Here, the null hypothesis is rejected.

Discussion

The purpose of the current cross sectional pilot study was to explore the relationship between Foot Arch Index and Dynamic balance in underweight male and female paramedical students. In our study underweight students were taken, though being underweight their arches were fallen which says that even if the weight is less the arches can be fallen. These results are contradictory with Shobha M Bhave et al, who concluded that if the BMI increases dynamic balance decreases and if the BMI decreases, dynamic balance increases. [(23)]

There were 15% and 10% High arch students, 35% and 30% Flat feet students and 50% and 60% Normal arch students in Male and Female respectively. On comparing means between right and left foot arch index and Y balance test score, the value is not significantly different which says that there is symmetry present between the two limbs. This result is supported by Kunika K Jaiswal et al, by which it was concluded that the plantar arch index is easy to obtain from footprints and that there are no differences in Right and Left Side. [(24)] Along with that Ali H Alnahdi et al, stated that no differences they noted in Y balance composite scores between the limbs in males and females. [(25)]The interlimb differences more than 1.2 cm in female could be consider beyond the normal range. However, the differences between the limbs >4cm YBT anterior direction was associated with an increased risk of lower-extremity injury. [(18)(25)] These results are also seen in males of our group, and in females were -0.22 and -0.196 which says that there is negative correlation between foot arch index and dynamic balance. If the height of arch increases which is seen in underweight which makes it necessary in the clinical setup to evaluate the differences between the limbs to avoid risks of falls.

The Pearson correlation in males were -0.24 and -0.12 student as well, the dynamic balance will decrease. The results are correlating with Poonam Kulkarni et al, who concluded in her study that increase in the arch height leads to pronation of the foot and affects the dynamic balance. [(26)] But the significance is 40-60% which makes the correlation not significant. The fact of not having found significant correlations in the present study suggests that somatosensory feedback of the skin and joint mechanoreceptors may have not changed sufficiently in the individuals with cavus or flat feet, thus keeping the postural balance in both the assessed conditions, which is also seen in our study. [(27)] This

result says that even if the arches are affected the dynamic balance might not be affected in individuals.

On comparing the data between male and female, the foot arch index shows no significant differences between them with p >0.05. But with Y balance test score, there is significant differences between male and female. The mean value of male Y balance test score was 95.56 and 101.2 while in females it was 86.59 and 87.75 for right and left leg respectively, these results says that the scores are higher in males compare to females. There are significant differences noted between the scores with p <0.05. This results are supported by Ali H Alnahdi et al, and concluded that males showed higher Y Balance test composite scores compared with females. [24] Along with that the differences between the all 3 directions are also evident. These results are also supported by another literature which indicated that males showed greater normalized reach distances in the posteromedial and posterolateral directions and higher composite reach scores than the females did. [28]

The reasons for affected arch height with underweight BMI can be the reason of prolong standing hours in the clinics. According to the CCOHS report, standing for long periods of time efficiently limits the blood supply to the muscles, causing weariness and soreness in the legs, back, and neck muscles, as well as blood pooling in the legs and feet, which leads to varicose veins. (Canadian Centre for Occupational Health and Safety (CCOHS) Basic information on standing at work. 2014). In our study the students reported 4-5 hours of standing out of 8 hours of college, which says that 40-50% of the whole day the students are standing in the clinics and in the lab. Standard workday based on needs, guidelines should be making. Groups like AORN and Dutch researchers, have suggested time limits for prolong standing; along with that ergonomic interventions are also necessary being in the paramedical field as well. The dynamic balance was tested using Y Balance test in which the males shows more values in all the directions compare to females, which concludes that males are having good balance compare to females. This results are supported by Elizabeth Carter et al, who concluded that Among collegiate soccer and lacrosse players, male athletes appear to exhibit superior dynamic balance in the posteromedial direction when compared to females.[29] But we found out in all the directions.

Conclusion

This study concluded that there is negative correlation between foot arch index and dynamic balance in male and female underweight paramedical student. There is a difference present between right and left foot arch index and Y Balance test which is more in male. There are no significant differences noted between male and female FAI. However, there are significant differences noted between male and female Y balance test in all 3 directions along with composite score. This result says that gender differences in dynamic balance are significantly present in this population.

Limitation of the study

The sample size was less compare to the other studies which can be the reason for the variations in the results. The problems which were faced by the students while performing test was not noted.

Future recommendation

In future all the BMI should take into considerations to correlate with arches and dynamic balance with more sample size to conclude effectively.

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