EFFECT OF MEDIAL ARCH SUPPORT ON LOWER LIMB ALIGNMENT IN INDIVIDUALS WITH FLAT FOOT

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KEYWORDS

Medial Arch, Flat Foot, Lower Limb

ABSTRACT

Flexible flatfoot is defined as a condition in which the medial longitudinal arch of foot collapses during weight-bearing stance. The deformation into flatfoot is induced when the medial longitudinal arch has descended because the arch had been excessively relaxed to the extent that the arch cannot be maintained and causes the feet to be excessively pronated compared to normal feet so that heel eversion appears and weight load is shifted inward to compress the medial longitudinal arch. Methods fifty subjects (both male and female) who had flexible flat foot were recruited on the basis of the result of Navicular Drop Test. Lower limb alignment was measured in form of four variables (Navicular height, Q-angle, Rear foot angle and patella-apex tibial tuberosity alignment) with and without medial arch support. Mean Pre-test values for left and right knee Q- angle ;left and right foot navicular height ; left and right patella apex tibial alignment and right and left rear foot angle are 18.74±2.54 ,18.64±2.58, 28.56±4.87,28.98±4.62 ,15.22±2.80 ,15.40±2.88 and 9.14±2.20,9.40±1.65 respectively .Mean post-test values left and right knee Q-angle ;left and right foot navicular height ; left and right patella apex tibial alignment and right and left rear foot angle are18.74 ±3.33,19.02± 3.35,33.34± 4.75,33.88± 4.40, 15.20±2.77, 15.76±2.83 and8.66±2.037,8.80±1.84 respectively. The result of this study shows the significant difference in navicular height and rear foot angle.

INTRODUCTION

The plantar arches are adapted uniquely to serve two contrasting mobility and stability weight bearing functions .To accomplish the weight bearing function ,the plantar arches must be flexible enough to allow the foot to adapt changes in supporting surface ,dampen the impact of weight –bearing forces and to superimposed rotational motions. To accomplish the weightbearing stability functions, arches must allow the distribution of weight through the foot for proper weight bearing and conversion of flexible foot to rigid lever.

Flexible flatfoot is defined as a condition in which the medial longitudinal arch of foot collapse during weight-bearing stance (Lee and Vanore et al.2005).It has been reported as a common concern in the movement community and the incidence levels range from less than 1%to as much as 78% (Evans and Rome, 2011) and is one of the risk factors for lower limb overuse injuries and foot dysfunction (Kohls-Gatzoulis et al.,2004; Levinger et al.,2010).and is an

established factor in determining the function of lower limb and may have a role in a predisposition to repetitive injury.(BM et al.,1993 ;DA et al.,1998)
The clinical manifestation of flatfoot dysfunction is confirmed by the navicular drop test. This test measures the amount of the navicular tuberosity excursion height between neutral and relaxed positions (Picciano et al., 1993). Flatfoot is often accompanied by pain and frequently affects walking speed and balance , which increases the risk of fall(Menz et al.,2006;Frances et al.,). Recent studies have also indicated that the flatfoot might be attribute to functional limitations, which include abnormal performances as well as altered muscle activation (Ross, 2002; Dannenberg 2002; Benwell et al., 2015)

Pes planus is classified as being either rigid or flexible (supple). Flexible flatfoot tends to disappear when the lower limb is not weight bearing and rarely causes disability or requires treatment, although overuse may cause pain (Cappello and Song, 1998). The deformation into flatfoot is induced when the medial longitudinal arch has descended because the arch had been excessively relaxed to the extent that the arch cannot be maintained and causes the feet to be excessively pronated compared to normal feet so that heel eversion appears and weight load is shifted inward to compress the medial longitudinal arch (Flemister et al., 2007; korpelanien et al., 2001)

When the MLA has descended or has been completely lost leading to structural or functional deformation, the ability to absorb impacts will decrease or the sense of balance will be lost so that stability decreases during walking and running leading to walking difficulties and endurance decreases (Citaker et al., 2011 and Albert et al, 1994).
Pes planus result in biomechanical changes in all three planes of foot and ankle movement and are more at risk to develop lower extremity pathology. It is consisting of a constellation of physical features that includes excessive eversion of subtalar complex during weight bearing, with plantar flexion of the talus, plantar flexion of calcaneus in relation to the tibia, dorsiflexion, and abduction of the navicular, supination of the forefoot, and valgus posture of the heel (Canale, 2003 and Cappello and Song,1998). The presence of adduction of talus and eversion of calcaneum make the lower limb assume an internal rotation position with reduction in limb length and consequently, may alter the pelvis alignment (Gurney, 2002, Khamis 2007, et al; Botte, 1981; Rocksar, 1995). Bilateral calcaneal eversion produces internal rotation of the lower limb and may lead to increased pelvic ante version and consequently may cause lumber hyperlordosis (Pinto, Souza et al., 2008;Khamis et al.,2007; Levine , whittle 1996) The movement of COP during barefoot walking by individuals with low medial longitudinal arch showed that the displacement and velocity of the COP were mainly concentrated on the medial longitudinal arch(De Cock et al.,2008)
As a result, this situation may affect the normal foot weight bearing function; thus abnormal loads will be transferred to more proximal areas such as knee, hip ,and lower back(Franco,1987).Many individuals with flexible flatfoot walk with certain alterations in lower extremity kinematics .The most common alteration is excessive pronation of subtalar joint during stance phase(Lin et al.,2001;Levinger et al.,2010;Tome et al.,2006).It has been reported that individuals with flatfoot deformity may present uniformly with medial foot pain and decreased function of affected footy(Kohls-Gatzoulis et al.,2004)
Flatfoot is a frequently encountered pathology and often debilitating chronic foot and ankle condition (Stephen et al, 2006 ; Lee , Vanore et al ,2005). Flatfoot may affect one or both feet and not only increase the load acting on the foot structure but also interfere with normal foot function (Lee et al,2012 and Meisser et al,1988), and Thus, changes in foot posture may lead to the alterations of the pelvic and spine alignment (Pinto , Souza et al,2008 ,Gurney ,2002 ,

Khamis , Yizhar ,2007 and Rothbarty et al,1988) which resulted from the additional stress placed on the ligaments , joints and muscles engaged in preservation of standing posture.

METHODS

A total of 50 subjects both male and female with bilateral flexible flat feet were recruited for as per inclusion criteria. The Sources of Subjects are college of applied education and health sciences OPD.

Selection Criteria

Inclusion Criteria	Exclusion Criteria
1. Both male and females between 20-30 years 2. Bilateral flexible flatfoot 3. BMI_<25kg/m^2 4. Navicular drop present (more than 10mm).	1. Any recent limb injury or fracture. 2. Any other lower limb deformity. 3. Any implant in Lower Limb 4. No history of lower limb surgery has been done

Protocol

Subjects were taken from CAESH College

Subjects were screened for inclusion according to inclusion, exclusion criteria

Informed consent was taken from subjects

Baseline measurement were taken in stand (Rear foot angle, Q -angle patella-apex tibial tuberosity alignment and Navicular height)

Post Intervention measurements were taken in stand (Rearfoot angle, Q- angle, patella-apex tibial tuberosity alignment and Navicular height).

Data Analysis

PROCEDURE

The subjects were familiarised and were explained the study process. The inform consent was signed as per the guidelines of Indian Council of Medical Research (ICMR, 2000). The subject was categorised as having flat foot on the basis of the result of Navicular Drop Test as shown in Figure 1.

Navicular drop test: Navicular drop test (NDT) were conducted to select those that had flexible flatfoot with larger or more than 10mm difference in navicular tuberosity height. In NDT, each subject was instructed to sit on a chair with knee joint bent to 90 degree and align the second toe and the knee so that the subtalar joint was placed on neutral position and under a non-weight bearing condition, the distance from the ground to the navicular tuberosity was measured. Thereafter, the distance from ground to the navicular tuberosity was measured in a standing position with the feet place at shoulder width and weight bearing by the two feet. Using a plastic ruler and a index card , the difference in the height of the navicular tuberosity between non-weight bearing (sitting)position and weight bearing(standing)position was measured and values was used. Difference more than 10mm considered as flat foot.

Figure 1: Navicular Drop Test

The baseline measurements static lower limb measurement were taken without arch support and shoe; Q angle; Rear foot angle; patella-apex tibial tuberosity alignment and Navicular height by using following methods.

Q -angle: Q-angle was measured in degrees as the angle formed by the line drawn from the anterior superior iliac spine to centre of patella relative to the tibial tuberosity with subject in standing position. Goniometer was placed so that axis will located over the patellar midpoint, centre of stationary arm was over the line from ASIS to the patella, and moving arm was placed over the line from patella to tibial tuberosity as shown in figure 2.

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Figure 2: Q- angle

Rear foot angle measurement: were taken by the method of Gross MT (1995). Rear foot angle was assessed by measuring the angle formed between the a line representing the posterior aspect of distal third of leg and a line representing the posterior aspectof the rear foot as shown in figure 3.

Figure 3: Rear foot Angle

Navicular height: **N**avicular tuberosity was palpated and with each subject in a standing position; vertical distance between the ground and bony medial tubercular protuberance of the navicular was measured using a ruler (Stewart, Brain et al,2007). Navicular height was measured without arch support and without shoes in standing and again navicular height was measured in standing with arch support and without shoes.

Patella –apex tibial tuberosity alignment: Patella apex and tibial tuberosity were palpated.

DATA ANALYSIS

The data entry was done on Microsoft excel-2013 and statistical analysis was done by using SPSS software version 24.The demographic profile was analysed by using descriptive statistics. The comparison of with and without arch support alignment differences for rear foot angle, Q-angle, patella-apex tibial tuberosity alignment and navicular height wasdone by using paired t-test and the significant value was set as p=0.05.

RESULT

Demographic profile of the subjects

A total of 50 patients (12 males and 38 females) were included for the study. The mean values for age, weight, height and BMI are 22.30±2.93 years, 57.30±7.454 kg , 161.18±6.805 cm and 22.02± 2.14 Kg/m^{2}respectivelyas shown in table 1.1 and figure 4.

Demographic Variable	Mean	Std. Deviation
Age (years)	22.30	2.936
Height(cm)	161.18	6.805
Weight(kg)	57.30	7.454
BMI (kg/m^2)	22.02	2.14

Table 1: Demographic details of subjects

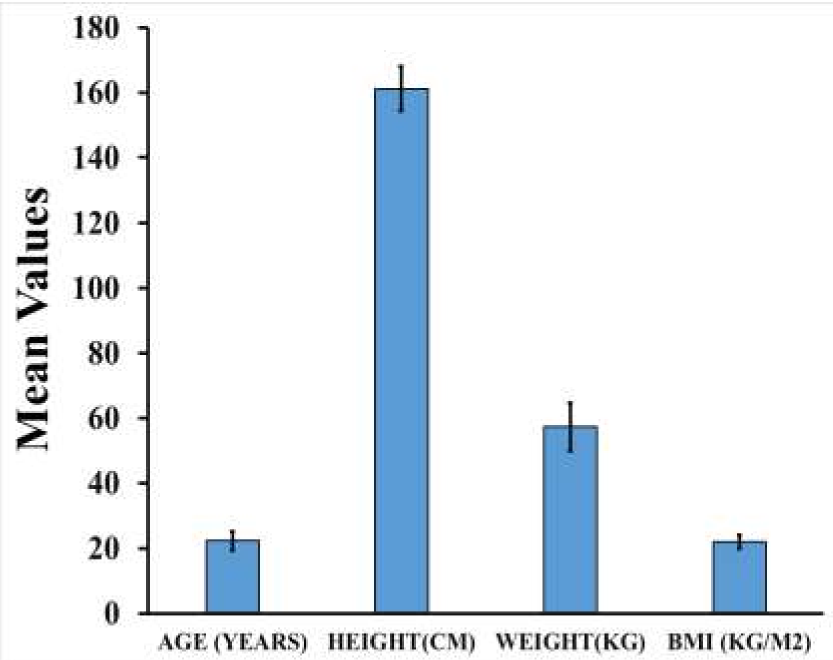

Figure 4: Demographic details of subjects

Analysis for differences in alignment with and without arch support using Paired t test

The mean values for pre Q- Angle, pre navicular height, pre rear foot angle and pre patella apex tibial tuberosity alignment are 18.74±2.46 degrees, 28.56±4.88mm,9.14±2.20 degrees, 15.22±2.81mm respectively for left side and18.64± 2.59 degrees, 28.98±4.63mm, 9.40±1.65degrees and 15.40± 2.89mm respectively for right side as mentioned in table 1.2 and figure 5. The mean values for post Q-Angle, post navicular height, post rear foot angle and post patella apex- tibial tuberosity alignment are 18.74±3.33degrees, 33.34±4.7mm, 8.66±2.03 degrees and 15.20± 2.77 mm respectively for left side as mentioned in table 1.2 and 19.02±

3.353 degrees, 33.88± 4.40mm, 8.80± 1.84 degrees and 15.76 ±2.83mm respectively for right side as mentioned in table 1.2 and Figure 5.

The result revealed statistically significant difference pre to post intervention for Left and right rear foot angle ($t=3.56$, $p<0.05$) and ($t=3.83$, $p<0.05$) respectively and statistically significant difference pre to post intervention for left and right navicular height($t= -21.02,p<0.05$) and($t=16.87,p<0.05$)respectively as mentioned in table 1.2 and Figure 5.

Mean Pre-test values for left and right knee Q- angle ;left and right foot navicular height ; left and right patella apex tibial alignment and right and left rear foot angle are 18.74±2.54 ,18.64±2.58, 28.56±4.87,28.98±4.62 ,15.22±2.80 ,15.40±2.88 and 9.14±2.20,9.40±1.65 respectively . Mean post-test values left and right knee Q- angle ;left and right foot navicular height ; left and right patella apex tibial alignment and right and left rear foot angle are18.74 ±3.33,19.02± 3.35,33.34± 4.75,33.88± 4.40, 15.20±2.77, 15.76±2.83 and8.66±2.037,8.80±1.84 respectively.

	Pre Test	Post Test	t value	P value
	Mean	Mean		
LQ ANGLE (Degree)	18.74	18.74	0.000	1.000
RQ ANGLE (Degree)	18.64	19.02	-0.820	0.416
L REAR FA (Degree)	9.14	8.66	3.562	**0.001**
R REAR FA (Degree)	9.40	8.80	3.834	**0.000**
LNH (mm)	28.56	33.34	-21.029	**0.000**
RNH (mm)	28.98	33.88	-16.878	**0.000**
LPTTA (mm)	15.22	15.20	-1.927	0.060
RPTTA(mm)	15.40	15.76	0.191	0.850

Table 2: Analysis for differences in alignment with and without arch support using Paired t test.

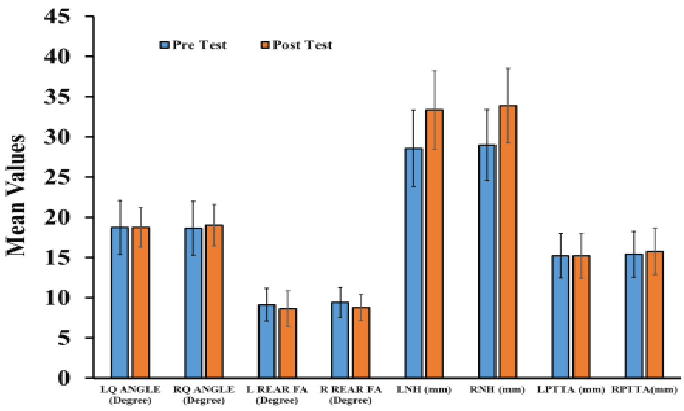

Figure 5: Pre- test and Post- test

- L Q-ANGLE= Left knee Q-Angle

- RQANGLE=Right knee Q-Angle
- L REAR FA=Left Rear foot angle
- RREAR FA=Right Rear foot angle
- LNH=Left Navicular Height
- RNH=Right Navicular Height
- LPTTA=Left patella apex-tibial tuberosity alignment
- RPTTA=Right patella apex-tibial tuberosity alignment

DISCUSSION

The purpose of this study was to know about the extent of the effect of medial arch support on navicular height, Q- angle, and rear foot angle and patella apex -tibial tuberosity alignment in individuals with flat foot. Foot posture is an established factor in determining the function of the lower limb and may therefore have a role in predisposition to repetitive injury (Nigg and Cole et al., 1993; Nawoczenski et al.,1998 and Dahle et al.,1991).Structural deformation of feet leads to lesion in ankle joint and feet and problems in lower limb joints, results in early fatigue and pain due to excessive compensating actions of the intrinsic and the extrinsic muscles and causes problem in the stability and balance of the feet during the gaits (Neumann, 2009).

In this study, a medial arch support were applied to improve flatfoot conditions through the changes in the navicular height, rear foot angle, Q-angle and patella- apex tibial tuberosity alignment and it could be seen that as there is increase /change in navicular height and rear foot angle. In flatfoot condition the navicular height decreases but with the use of arch support the navicular height increases.Functional foot orthoses support the height of foot arches, preventing the collapse of foot arches during dynamic motions (Franco, 1987 and KwangYong et al, 2015), helping to restore each joints abnormal displacement to its normal position. Park and Park found that wearing a functional foot orthoses elicited statistically significant changes in ankle joint angle of subjects through a mechanical shift of the joint below the talus in the sagittal plane. Individuals with flatfoot develop ankle and foot disorders, they can change their gait pattern ankle and foot orthoses, which can influence the other joints of the lower extremities.

<u>Limitation of the study</u>

- Age variation of the participants (ranged from 20 to 30 years old).
- Specific age was included.
- Ready made one sized arch support was used.
- Small sample size.

<u>Future scope of study</u>

- Sample size can be larger.
- Use of custom made arch support.
- Can use wider age group.
- Further study can be done in overweight population.
- Further study can be done with inclusion of equal number of male and female population.
- Other lower limb alignment measurements can be taken.

CONCLUSION

The result of this study shows the significant difference in navicular height and rear foot angle with arch support in individuals with flat feet.

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