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To assess the relationship between foot deformity with lower extremity function in early adulthood: Correlation study

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Abstract

Background and Objectives: Normal individuals of mean age group between 20-40 (early adulthood) years are more prone to develop stress in the lower extremity due to various origins (abnormal anatomical structures, neuro-muscular abnormality, overuse injuries) affects the biomechanics and posture of lower limb or foot. Therefore this study aims to find out the correlation between Foot Posture Index (FPI) and Lower Extremity Functional Scale (LEFS) in early adulthood.

Method: A correlational study was done after pilot study on 10 individuals and 100 individuals with mean age group of 20-40 years were included in the study. Foot Posture Index (FPI) and Lower Extremity Functional Scale (LEFS) were taken and data was analyzed by using Chi-square (x2) test, Paired and Unpaired t test.

Results: In this study total 100 individuals were included after analyzing the data we divided 58 individuals in normal group and 42 individuals in affected group. The foot posture was assessed using FPI and LEFS on both foot was given for scoring. The final data was analyzed according to the score of (FPI) Foot Posture Index, and which was correlated with (LEFS) Lower Extremity Functional Score, we found no significant positive correlation between LEFS and FPI in result.

Conclusion: This correlational study concluded that normal and affected group people have no significant positive correlation between Foot Posture Index (FPI) and Lower Extremity Functional Score (LEFS) in normal individual's population in early adulthood.

Keywords: Early adulthood, foot posture index, flat foot, lower extremity functional score

Introduction

Posture of the foot in healthy individual's highly variable in ranges high to flat arched, this variation of foot posture among healthy individuals are related with changes in biomechanics of lower limb. Due to difference in muscle activity and neuromuscular compensation in people increase risk of overload and overuse injuries [1]. A study in Germany found 13.7% prevalence of foot deformities among adolescents and another study on 426 sample first- to fourth-grade primary school children, indicated that the largest number of subjects had no noticeable foot deformity [2] but pathological foot deformities are more common in adults and elderly [3, 4]. The ankle or tibiotarsal joints are hinge type distal joints of lower limb with one degree of freedom which occurs in a sagittal plane [5]. The articular complex of the foot movements contains three planar movements in various cardinal plan and axis. Pronation (dorsiflexion, eversion and abduction) and supination (planter flexion, inversion and adduction) termed to describe complex motion that have component of each motion and axis that lies on cardinal motion of inversion/eversion and abduction/adduction and dorsiflexion/planter flexion [6, 7, 8]. Mechanically, joints distal and proximal surface contains talus and distal end of tibia and fibula forming one structure respectively. Its lower surface comprises a cylindrical cavity corresponding to cylindrical upper surface of the talus. It has three surfaces superior which (convex anteroposterior, is depressed centrally by a longitudinal groove) constrained the medial and lateral. The medial surface (body of the talus is nearly plane except anteriorly, where it is inclined medially and lies in the sagittal plane articulates with the facet on the lateral surface of the medial malleolus, which is lined by the cartilage continuous with that lining the inferior surface of the tibia), lateral surface (which runs obliquely anteriorly and laterally in concave superoinferiorly and anteroposteriorly) in contact with the articular facet of the medial surface of the lateral malleolus [5].

The medial and lateral surface of the body of the talus are hammed by two malleoli which are basically different: the lateral malleolus is bigger than the medial, it extends further distally. Ankle joint consist of ligaments that is lateral ligament (made up of three separate bands, two attached below to the talus and one to the calcaneus) and other ligaments are anterior talofibular, calcaneofibular and posterior talofibular ligament [5, 9]. Medial collateral ligament (comprises two sets of fibers superficial and deep) deep fibers consist of two talotibial bands: anterior talotibial ligaments (runs obliquely inferiorly and anteriorly to be attached to the medial aspect of the neck of the calcaneus). Posterior talotibial ligaments (runs obliquely inferiorly and posteriorly to be inserted into fossa on the medial surface of the calcaneus, its most posterior fibers are attached to the posteromedial tubercle) superficial fibers, triangular in shape, and broad, constitute the deltoid ligaments has been notched and retracted to demonstrate the deep posterior talofibular ligaments [5, 9]. The anterior and posterior ligaments of the ankle are simple localized thickening of the capsule. The anterior ligament runs obliquely from the anterior margins of lower end of the tibia to the upper surface of the anterior part of the neck of the talus. The posterior ligament consist of the fibers which springs from the tibia and fibula and converge to their insertion into posterolateral tubercle, forms the deep groove for the flexor hallucis longus. The common injuries to the ankle are fracture of the tibia and fibula bones, sprain and strain of the ligaments. Tibiofibular articulates at superior tibiofibular joint and inferior tibiofibular joint, the two bones are joined by interosseous ligament between the fibular notch of the tibia and inner surface of the fibula. Joint movements are flexion and extension which is mechanically linked with the ankle[5] and inferior tibiofibular joint essentially on the shape of the trochlear surface of the talus. Its medial surface lies in the sagittal plane and lateral surface lies in the plane which runs obliquely anteriorly and laterally. During flexion of the ankle the lateral malleolus moves away from the medial malleolus, at the same time it is slightly pulled superiorly while the fibers of the tibiofibular and interosseous ligaments, the fibula slightly rotated medially. During extension of the ankle joint the lateral malleolus is pulled inferiorly the medial malleolus is slightly rotated medially. The superior tibiofibular joint movements of the lateral malleolus during flexion of the ankle the fibular facet slides superiorly and the joint interspace opens out to form an angle facing inferiorly, the exact converse occurs during extension [5]. Talocalcaneal (subtalar joint), midtrial (transverse-tarsal), tars metatarsal, cub navicular and cuneonavicular joints are complex joints [10]. Subtalar joint is functionally defined as composite joint formed by three separate plane articulations between the talus superiorly and calcaneus inferiorly with highly variable articulating surfaces. The posterior (concave facet on the surface of the body of the talus and convex facet on the body of the calcaneus) is consistently the largest, anterior and medial talocalcaneal smaller (two convex facets on the inferior body and neck of the talus and two concave facets on the calcaneus) anterior and medial articulations in all three articulations therefore, have an intra-articular configuration that is the reverse found at the posterior facet. Posterior articulation contains anterior and medial part in its own capsule and share with talonavicular joint [11]. The joint is critical to bipedal ambulation and acts to translate the motion of the tibia to the foot or, conversely, to translate the rotation of the foot to the tibia. This translation helps to walk smoothly over uneven surfaces and pivot on one foot with apparently complex motion while remaining stable during weight bearing. The stability of the joint provides by the bony configuration, strong reinforcing ligamentous structures and the two joint capsule [12]. Thick interosseous ligament unaltered by ankle or subtalar joint position [13, 14] and appears to restrict supination more than pronation [15]. The excessive supination prevent with cervical ligament [14] while the inversion of ankle and subtalar joints limits by collateral ligaments [14, 16, 17]. Although the controversy regarding the precise axis of motion at the subtalar joint, there is remarkable agreement about the location and direction of the primary axis of the subtalar joint. The axis of the subtalar joint approximately parallel to the body of the calcaneus with the long axis of the foot projecting almost 45° from posterior to anterior and almost 25° medial [18, 19]. Outstanding to variability of the axis the subtalar joint contributes most of the inversion–eversion and adduction–abduction motion of the hind foot, while contributing minimally to plantarflexion and dorsiflexion [18, 20-22, 23, 24]. The transverse tarsal joint consists of the talonavicular and calcaneocuboid joints. The well-curved talar head articulating with the reciprocally concave posterior surface of the navicular formed the talonavicular joint. The enclosed capsule between the talus and calcaneus also supports the talonavicular articulation. Dorsal calcaneonavicular, talonavicular, plantar calcaneonavicular and spring ligament provides additional support to the joints [25]. Considerable mobility at the talonavicular joint allows due to the substantial curvature of the talus and navicular. Like most of the joints of the foot, motion at this joint is triplanar, consisting of pronation and supination. Fewer studies available data reveal that is quite mobile and contributes significantly (plantarflexion of the foot on the leg) to leg–foot motion [20, 26-27]. Approximately 12% of first 30° degrees of plantarflexion is attributable in talonavicular joint motion [20] and exhibits significant eversion/inversion, abduction/adduction during pronation and supination [21, 23, 26-27].

The calcaneocuboid joint is a saddle joint supported by a synovial joint capsule and by several supporting ligaments, the bifurcate ligament (dorsal calcaneonavicular and dorsal calcaneocuboid ligaments) supports dorsally while the planter surface supported by two strong ligaments short (plantar calcaneocuboid ligament) and long planter ligament [28-29]. Isolated motion of the calcaneocuboid joint is less well studied than the other joints of the tarsus [27]. The distal inter-tarsal joints include those between the navicular cuneiform, and among the cuneiform bones themselves. These joints supported by capsules that frequently communicate with one another and by dorsal and plantar ligaments that run between adjacent bones. The motion appears to be limited to only a few degrees but contributes to the pronation and supination of the rest of the foot [27, 30]. The tarso-metatarsal joints of the toes are gliding joints with limited mobility [28, 31]. The plantar, dorsal, and cuneo-metatarsal ligaments with these articulation reinforced by capsules (with typically form three separate joint spaces) provides stability as well as supports to the arches of the foot [32]. The mobility of the tarsometatarsal joints varies across the toes and extant in three different planes. Metatarsophalangeal joints are biaxial, supported by a joint capsule, collateral ligaments, and a fibrous plantar plate covering the plantar surface of the joints. The capsules of the toes are reinforced dorsally by the extensor tendons and by collateral ligaments that extend from the dorsal aspects of the medial and lateral surfaces of the metatarsal heads toward the plantar aspects of the medial and lateral sides of the proximal phalanges. These joints allows biaxial mobility with combine rotation and translatory motions (Flexion and extension, deviations) [31]. The interphalangeal joints of the toes are simple hinge joints are supported by a joint capsule, collateral ligaments, and a plantar plate. The plantar plate serves a purpose similar to that of the palmar plate at the metacarpophalangeal joints, protection of the underlying articular surface. Their motions are poorly studied, but the proximal interphalangeal joints reveal less than 90° of flexion, with little or no extension [28, 33]. Many complaints of pain and dysfunction in the foot, ankle, knee, or hip arise from activities such as running, jumping, or dancing. In closed chain activities the transforming movements of the foot to the leg or vice versa the role of the subtalar joint becomes critical. The foot pronates and supinates by allowing the proximal segments to move on the distal segments when the foot is fixed to the ground. The tibia and talus moving on the calcaneus articulating surface produce pronation of the subtalar joint. Pronation with fixed foot on the ground produces medial rotation of the tibia which moves the talus medially within the mortise [34-36] as the talus moves medially, pulls the cuboid and navicular into abduction and eversion with calcaneus eversion. Thus the motion of the hind foot is coupled to the motion of the leg and the forefoot. The extent to which foot motion is directly coupled with tibial motion remains unclear. In walking as the foot pronates the tibia medially rotates and as the foot supinates the tibia laterally rotates. Yet neither the magnitude nor timing of foot motion directly parallel to tibial motion [37]. Studies suggest that some of the motion of foot is absorbed within the foot rather than transmitted directly to the tibia. Running appears to increase the correlations between foot and tibial motions, suggesting more direct coupling to the motion between the foot and leg [37, 38]. Inadequate or excessive pronation and supination may complaints of foot, knee, hip and even back pain by interfering with the biomechanics between the foot and the rest of the lower extremity during weight bearing [39].

However studies investigating the relationship between excessive pronation and anterior knee pain report little association [40-42]. Like low back pain, anterior knee pain is likely to be associated with multiple, interdependent mechanical factors that together help explain the presence or absence of pain. Such factors may include the coupling of foot and leg motion, foot alignment, knee and patellofemoral joint alignment, strength and flexibility at the foot and knee, and even body weight and height [43]. Planter vault of the foot covered by layers of the muscles and planter facia provides support to the medial and lateral arches along with ligamentous support. Dynamic stability and dynamic movements of foot controlled by foot (Dorsi-planter flexors, foot evertors-invertors, long toe flexors and extensors) muscles [5]. In 1990 US national health interview survey of 119,631 people aged over 18 years included a podiatry supplement and found that 24% sample reported foot trouble, in community based sample of 3417 people of age group 18-80 years experienced pain in foot area in UK random [44-45]. Incidence of foot pain, age, and weight, females were 40% more likely to report foot pain than males. Increase age and BMI classified as obese were factors associated with increase prevalence of foot pain even significance associated with other joint pain including knee, hip and back pain. Pain in the hind foot region demonstrated highest prevalence noted in 20-30 year. Pain in the arch was most common in 20-30 years of age group [46]. Fore foot deformities intrinsic to foot, that is caused abnormal foot motion during stance phase of walking cycle. A forefoot varus or valgus deformity can occur at mid tarsal joint and a subtalar varus or valgus can occur at subtalar joint. In healthy females between age group of 18-30 years [47]. In 2015 study on various degree of foot posture on standing balance in healthy adult population says that biomechanics of foot plays significant role in standing and walking with age group of 24 to 30 years [48]. In 2010 study say that relationship between forefoot varus angle and standing rear foot angle among individuals with above average fore foot varus. As forefoot position is related to standing rear foot angle and that both may be related to pronation during gait in age group of 27 to 33 years [49]. Foot posture index (FPI) is valid and reliable outcome measure used to check foot posture and deformity which contains six components (-2 to +2) and analysis the foot and ankle joint. Approximately neutral foot posture is graded as Zero, while pronated posture is given as positive value and supinated given as negative value, and scores are combined the aggregate gives estimated of the overall foot posture. Significantly, high positive and negative aggregate values indicates pronated and supinated posture respectively, while neutral foot the final aggregate score lie around zero [50]. Lower extremity functional score (LEFS) self-reported scale with reliability and validity. Which contains twenty questions with 0 - 4 grading, with total score of 80 [51]. Therefore this study aims to find out the correlation between foot posture index (FPI) and lower extremity functional score (LEFS) in early adulthood.

Methods

A correlational study of 100 individuals (both male and female) using random sampling method was done. Individuals which were aged 20-40 years included according to inclusion and exclusion criteria of the study. The inclusion criteria for this study were both male and female age between 20-40 years, individual who don't have previous history of ankle/foot fracture or injury, who are willing to participate in the study, who did not have any lower extremity deformity, with previous ankle/foot soft tissue injury in the last 1 year and in exclusion criteria included any previous fracture in lower extremity, individuals who are not willing to participate, any neurological disorders which is hampering ambulation and gait and any other sever medical conditions.

Outcome Measures

LEFS score (Lower extremity function score) to assess function of the lower extremity (reliability r= 0.94 (95% lower limit confidence interval) = 0.89) [51] and FPI (Foot Posture Index) quantitative scale to assess foot posture in weight bearing (reliability of scale 0.95) [52] both are reliable and valid tool were used as outcome measures in this study.

The study received approval from Ethical Committee of SDM College of physiotherapy Dharwad, karnataka reference no SDMIEC: 091: 2017.

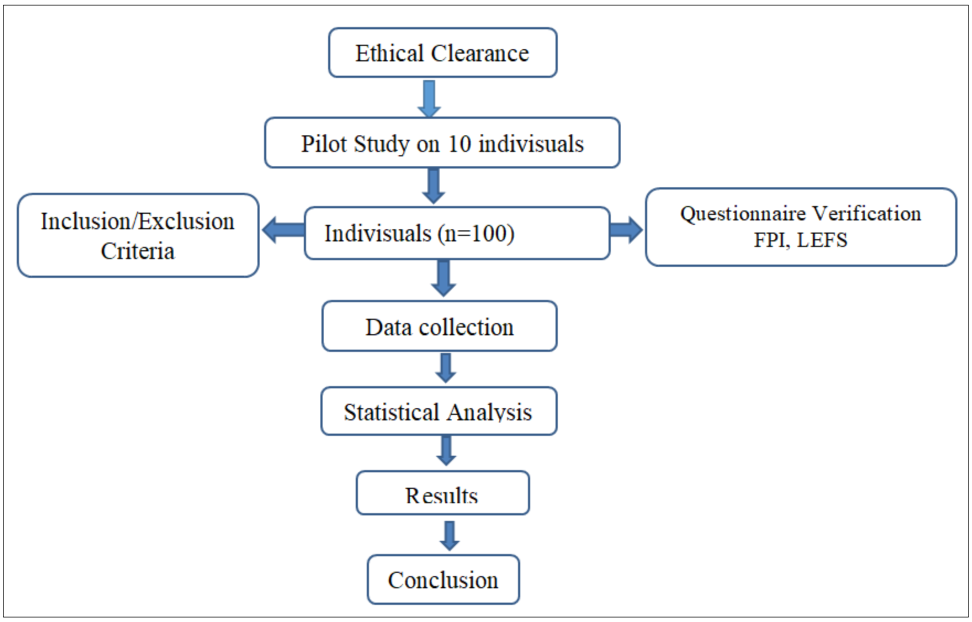

Fig 1.1: Flow chart representing the procedure of selection of individuals

Results

Spearman correlation test and independent "t" test were applied to analyze the data. All descriptive statistical analysis (frequencies and percentages) was done with utilizing the SPSS version 23.0 software, and $p< 0.05$ is considered as level of significance. The effect size is used to measure magnitude of the effectiveness of treatment (Cohen's d).

Table 1.1: Gender wise distribution

Gender	No of patients	% of patients
Male	29	29
Female	71	71
Total	100	100

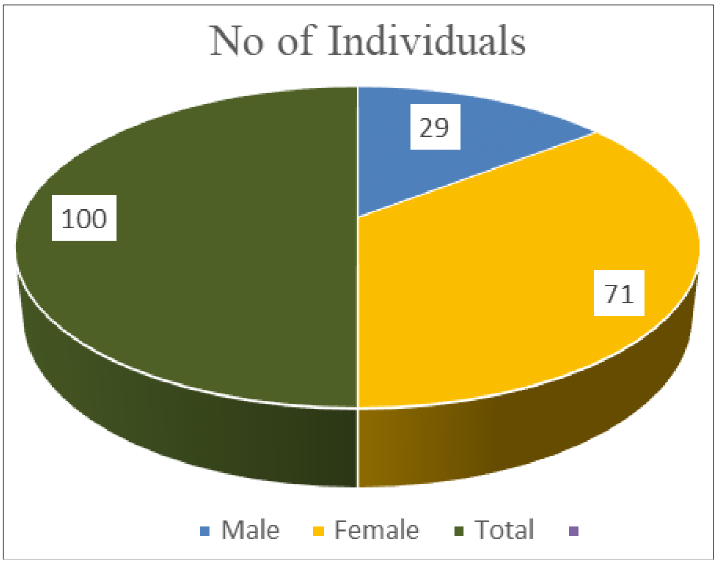

Fig 1.2: Pia chart Percentage of male and female individual's in study

Table 1.2: Comparison of males and females with mean age group and BMI

Variable	Gender	Mean	SD	SE	t-value	P-value
Age	Male	23.24	4.03	0.75	2.6333	0.0098*
	Female	21.42	2.69	0.32		
BMI	Male	23.23	3.58	0.66	2.3047	0.0233*
	Female	21.23	4.08	0.48		

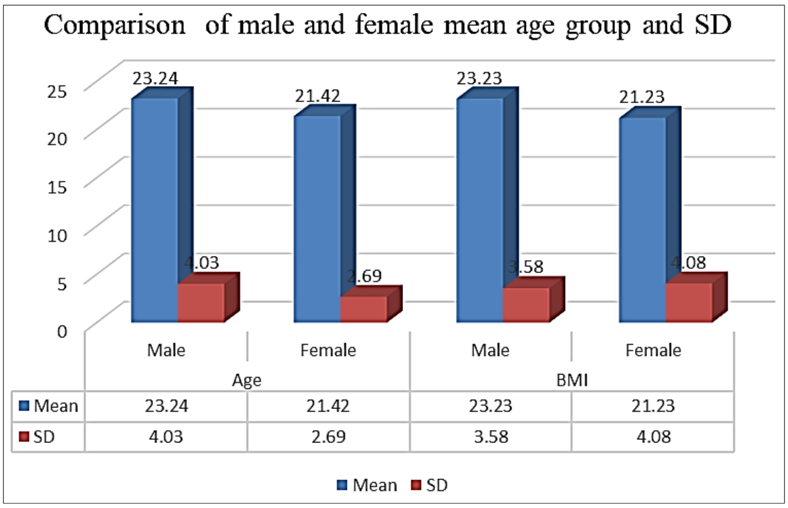

Fig 1.3: Graphical distribution of males and females with mean age group and BMI

The study was conducted on total number of 100 individual's among them there were 71 male and 29 female individuals. The mean age of individuals males were 23.24 ±4.03 and females 21.42 ±2.69, the mean BMI of male individuals were 23.23 ±3.58 and females 21.23 ±4.08 respectively.

Table 1.3: Correlation between FPI and LEFS of Affected subjects

			FPI_AFF	LEFS
Spearman's rho	FPI_AFF	Correlation Coefficient	1.000	-.163
		Sig. (2-tailed)	.	.304
		N	42	42
	LEFS	Correlation Coefficient	-.163	1.000
		Sig. (2-tailed)	.304	.
		N	42	100

Table 1.4: Correlation between FPI and LEFS of normal subjects

			FPI_NOR	LEFS
Spearman's rho	FPI_NOR	Correlation Coefficient	1.000	-.080
		Sig. (2-tailed)	.	.551
		N	58	58
	LEFS	Correlation Coefficient	-.080	1.000
		Sig. (2-tailed)	.551	.
		N	58	100

The above table shows that when mean age of the subject correlated with score there is a significant positive weak correlation. When mean hours of usage correlated with LEFS score there is no significant correlation.

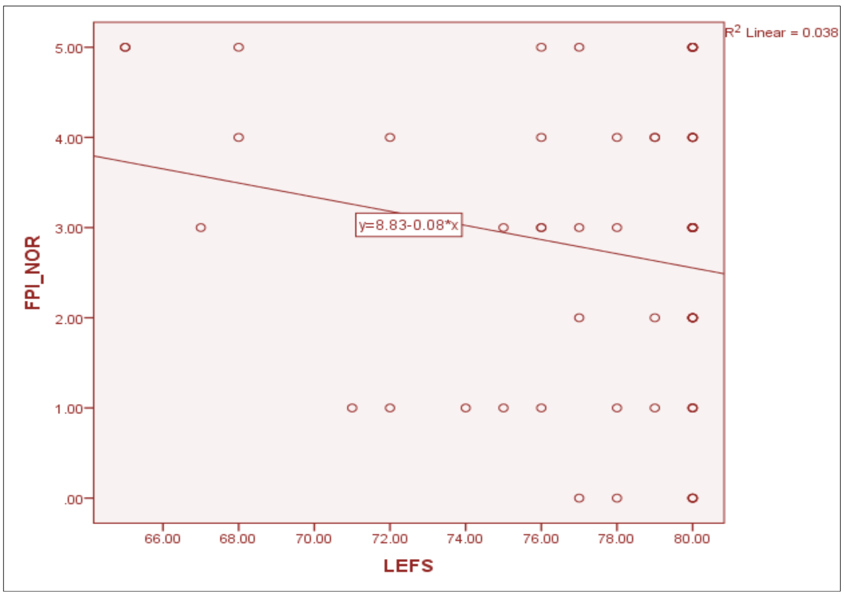

Fig 1.4: Graphical Distribution of correlation between FPI and LEFS of normal subjects

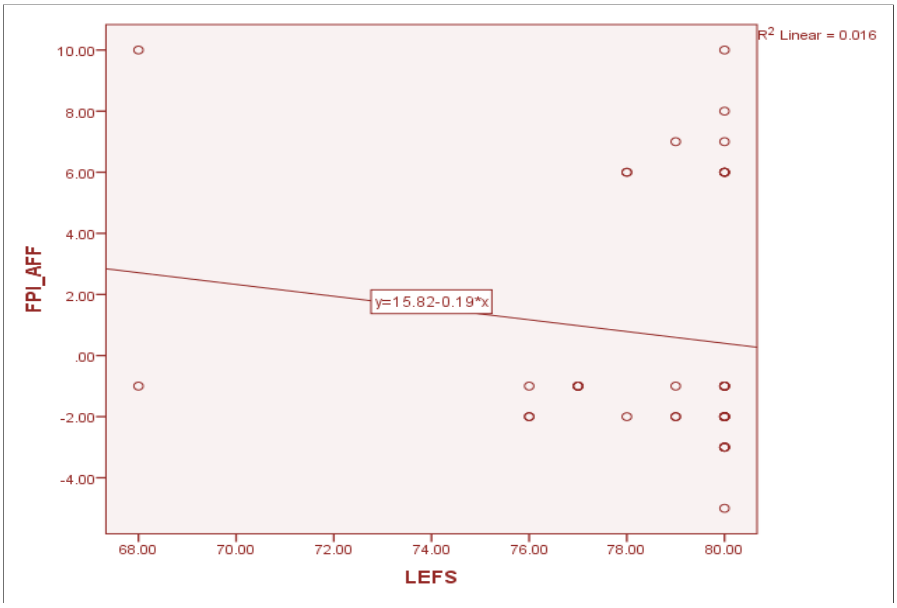

Fig 1.5: Graphical distribution of correlation between FPI and LEFS of Affected subjects

Discussion

This study was taken to find out correlation between Foot Posture Index (FPI) and Lower Extremity Functional Scale (LEFS) in normal healthy individuals between age group of 20 to 40 years. A 100 normal healthy individual's sample size was taken. These total number of 100 normal individuals among them, there were 71 (71%) male and 29 (29%) female individuals. The mean age of individual males were 23.24±4.03 and females 21.42±2.69, the mean BMI of male individuals were 23.23±3.58 and females 21.23±4.08 with Standard Error (SE) of 0.75 and 0.32 respectively. The t-value of 2.6333 and p-value of 0.0098 were in statistical analysis. Majority of individuals were females more than males. In total 100 number of individuals the age wise distribution was done in normal healthy individuals in which age group of 19 to 20 years were 42%; 21 to 22 years were 28%; 23 to 24 years were 11%; 25 to 26 years were 10% and more or equal to 27 years were 9%.There were majority in age group of 19 to 22 years among the total individuals in the study. Where it shows significant changes in comparison of males and females with mean age group and BMI. We found significant values when compared with total individuals, Age and BMI. The individuals were almost in the same group and BMI. According to the study done in October 2013 say that in 400 individuals a multiple regression model was constructed of the overall FPI against age, weight, height, body mass index, and foot size. The most frequent posture was neutral with a certain degree of pronation, with no differences in FPI values between men and women. Individuals with larger foot sizes had higher FPI values, whereas taller and heavier individual's had lower FPI values.[53] In total number of 100 individual's there were, 42 individuals had abnormality in their foot and ankle (Supinated, pronated, Highly pronated, Highly supinated). Affection of each group gives the percentage of individual's are supination 29%, pronation 10%, highly supinated 1% and highly pronated were 2% in total number of individual's, All had bilateral affection with similar values. In normal (0-5) category we found 58 individual's, who had bilateral affection with similar values. When foot posture index (FPI) of 42 individuals were correlated with total number of individuals with lower extremity functional score (LEFS), we found that, correlation coefficient of affected group was 1.000 and LEFS was -.163. When LEFS values were correlated the correlation coefficient of FPI -.163 and LEFS was 1.000.We found that individual's had more deformity in ankle and foot joint, but when we compared them with LEFS they had no difficulty in their daily activity, this may be because all the individuals were asymptomatic and normal healthy individuals. Hence we did not find any significance correlation in the results. Although age taken in the study was 20–40 years maximum individuals were age group of 20–22 years, only 9 individuals were more than 27 years. This might have affected the outcome parameter of the study In total 100 individual's 15 to 20 people were in over weight and obese category, this might be one of the reason which might have affected the outcome parameter of the study. When foot Posture Index (FPI) of 58 individuals were correlated with total number of individuals with Lower Extremity Functional scale (LEFS), we found that, Correlation coefficient of FPI of was 1.000 and LEFS was -.080. When LEFS were correlated the correlation coefficient of FPI -.080 and LEFS was 1.000. In our study when FPI was assisted on total individual's, we found 58 people in normal category with very minimal affection in foot & ankle joint, still they will be considered in the values of normal (0 - 5) in FPI reference values. But when correlated with LEFS they had no difficulty or affection in their daily activity. As individuals were asymptomatic & healthy, we did not find any significance in the results. There is no significant correlation between FPI and LEFS in early adult hood. In Denmark a 1 year epidemiological observational prospective cohort study was done in year 2014 to investigate that running distance to first running-related injury varies between foot postures in novice runners wearing neutral shoes. In study they included a total of 927 novice runner's equivalent to 1854 feet. Highly supinated (n=53), supinated (n=369), neutral (n=1292), pronated (n=122) or highly pronated (n=18) was evaluated on each foot and was categorized in Foot Posture Index. Present study of results are contradict that belief that moderate foot pronation is associated with an increased risk of injury among novice runners taking up running in a neutral running shoe [54].

Limitations
1. Sample size was less in number
2. Age group was small (20 - 40 years)
3. Study done was in normal healthy individuals
4. Other joints like hip and knee was not assessed for pain and deformity

Recommendation for Future Research
1. Further study need to be carried in larger population
2. Further study can be carried in different age group
3. Further study can be assessed other joints for pain and deformity

Conclusion
This study we concluded that there were no positive significance correlation in the foot and ankle deformities when correlated with Foot Posture Index (FPI) and Lower Extremity Functional Scale (LEFS). We have taken normal healthy individuals, these individuals are asymptomatic with age group of 20 to 40 years. When FPI was assessed on individuals we found deformity like flat foot, supinated, pronated foot, additionally when FPI was correlated with LEFS we found that individual had no difficulty or affection in their daily activity, as they were asymptomatic. Hence we did not find any significant results as individuals were asymptomatic, less in age group and less in sample size.

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