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Anatomical Basis of Flat Foot

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Abstract
Pes planus also referred to as flat foot, planovalgus foot or fallen arches refers to the loss of medial longitudinal arch of foot. As a result the foot either comes closer to the ground or makes contact with the ground. The condition can be either congenital or acquired. Congenital flatfoot occurs due to ligamentous laxity and lack of neuromuscular control[5]. Acquired flatfoot occurs most frequently secondary to dysfunction of posterior tibial tendon[6].
The medial longitudinal arch formed by calcaneus, talus, navicular, cuneiform and medial three metatarsals is higher, tougher and elastic compared to the lateral counterpart thus allowing it to vary dynamically in shape and configuration during gait. It gives more resilience to the medial part of the foot and also facilitates propulsive action. It acts as a support for the entire body and helps to transmit the body weight to the ground. It also stores energy during the gait cycle. Dysfunction of medial longitudinal arch can result in alteration of lower limb biomechanics as well as lumbar spine resulting in enhanced risk of pain and injury[1].

Introduction

Flat foot also termed as Pes planus occurs due to the loss of medial longitudinal arch of the foot.The foot comes either contacts or nearby contacts the ground[2]. The foot consists of series of three intersecting arches namely a lateral longitudinal arch, a medial longitudinal arch and a transverse arch. As these arches are related to each other functionally, dysfunction of one arch affects the other arch and vice versa[9]. Medial longitudinal archis made up of tarsal bones including calcaneus, talus, navicular, cuneiform and medial three metatarsals. The various ligaments including talocalcaneal interosseous ligament, tibionavicular portion of deltoid ligament, spring ligament and medial talocalcaneal ligament helps in stabilizing the arch of foot[3].

Infants have abundant plantar fat and flat feet without any arch[14-16]. The arches develop around 3-6 years of age with appearance of medial longitudnal arch first followed by other arches up to the age of 12 to 14 years of age[14-17]. There are many factors responsible for development of arches including appropriate ossification at sustentaculum tali and navicular bone, soft –tissue stabilizers, proper plantar fascial tone and non-contracted Achilles tendon[17]. The developmental flat foot usually remains asymptomatic in adults except in 7-15% of the cases which become symptomatic and require medical attention[18, 19].
The condition can be congenital or acquired[2]. Congenital flat foot being , though fairly common in infants[4] persists into the adulthood without any symptoms. The arches may be absent during childhood due to the ligamentous laxity and

neuromuscular control[5].The flat food can also be associated with Down's syndrome, Marfan's and Ehler'sDanos syndrome as there may be congenital ligamentous laxity associated with these conditions[11-13]. Acquired flat foot occurs most frequently secondary to dysfunction of posterior tibial tendon[7]. The latter is common in females above forty years of age having diabetes and obesity[8]. The condition can also occur in persons who participate in high impact sports including running, basketball, soccer[9]. The condition may also result due to trauma midfoot and hindfoot[20,21] It has been observed that Pes planus of some degree has been observed in 20-37%of the population[22-24]. Also as it is having a genetic predisposition, it runs in families[25]. Rigid pes planus is rare. It develops from the tarsal coalition, accessory navicular bone, congenital vertical talus or other forms of congenital hind foot pathology[1]

Diagnosis of the condition is made by taking lateral weight- bearing radiographs. A Meary's angle (talus – first metatarsal angle) greater than four degrees convex downwards is suggestive of pes planus . It constitutes the angle obtained from lines drawn from center longitudinal axes of the talus and metatarsal. Further if a calcaneal inclination angle less than eighteen degrees is also indicative of pes planus. This angle is obtained from the calcaneal inclination axis and horizontal surface on which the foot is placed[1] . Magnetic resonance imaging can be performed if there is posterior tibial tendon dysfunction or injury to spring ligament and supporting soft tissue structures is suspected. Sensory nerve injury can be evaluated by means of EMG and nerve conduction studies[1].

Material and Methods

It was a cross-sectional study including 500(250 males and 250 females) healthy subjects aged between 5 to 45 years from January 2021 to December 2021. The study participants were healthy having and were free from any apparent symptomatic deformity in the foot. Participants with major medical diseases such as diabetes mellitus, cerebral palsy heart, liver and kidney diseases that could affect physical fitness were not included in the study. Participants with musculo-skeletal disorders (such as clubfoot, limb deficiency and leg length discrepancy) and recent lower limb injuries were excluded from the study.

Unauthenticated

Download Date | 12/29/17 10:58 ries or disorders in the foot bones which affecting footprint measurements were excluded from the study. The materials used for this study were custom made index card and Vernier caliper. The participants were briefed about the nature of the study and intervention and only those participants willing to take part were recruited for the study and informed consent was obtained. The requirements taken from each subject included name, age, gender, and date of birth. All subjects underwent footprint screening. Printing India ink was applied on the soles of both the feet of each student and dynamic footprints were obtained on A4 size papers. Quantitative and Qualitative Analysis was done (Fig 1). Steps performed to take the footprints Quantitative analysis included calculating Staheli's Plantar Arch Index. It is defined as the ratio of the width of the central region of the foot (A) to the width of the heel region of the foot (B). It is used to determine the presence of pes planus. The arch indices can range from 0.0-1.0 and are indicative of cavus and planus foot respectively though, the normal range of Plantar Arch Index is between 0.5-0.8

Results

This study revealed that 123 out of 284 subjects had Pesplanus,67 out of 142 males and 56 out of 142 females had the deformity. It was observed that 168 out of 546 feet (272 subjects) were flat i.e. had Pesplanus. Statistical analysis showed no significant difference between the incidence of pesplanus in males and females as well as between the right and the left foot. Furthermore, out of the 67 male subjects having pesplanus, 29 had unilateral flat foot and 36 had bilateral flat

foot. Among the 51 female subjects with pesplanus, 22 had unilateral flat foot and 29 had bilateral flat foot. Statistical analysis showed significant difference between the incidence of unilateral & bilateral flat foot by the method of Binomial test for proportion.

Fig 01

Discussion

Flat foot also termed as pes planus is a common foot deformity characterized by loss of medial longitudinal arch of the foot. The arch being tough and elastic serves to dissipate the forces of weight bearing and stores mechanical energy. The condition can be congenital or acquired. Developmental flat foot in adult age is considered to be physiological until the person shows some symptoms[18,19]. Only 7-15% of the adult population with developmental flatfoot present with symptoms which really need medical attention[18]. The shape and the size of osseus structures help in stabilizing the arch. The soft tissue structures like posterior tibialis muscle, flexor digitorum longus, flexor hallucis longus, peroneus longus, gastrocnemius and soleus support the arch as they have fascial connections with the calcaneus and plantar fascia[26]. The most conspicuous stabilizers include spring ligament, talocalcaneal ligament, deltoid ligaments, plantar fascia and tarsometatrsal joint complex[10]. Tibialis posterior, the deepest and most central calf muscle lies posteromedial to the ankle joint and medial to the subtalar axis, The posterior tibial tendon helps inplantar flexion as well as inversion of the foot[18,19,26]. It works along with flexor digitorum longus, flexor hallucis longus tendons, gastrocnemius and soleus[27]. It has been well and known well accepted fact that rigid flat are secondary to bony defects such as tarsal collision where as flexible flat feet are usually secondary to soft tiisue and muscle implablance. During simple standing, the posterior tibial tendon helps to maintain proper tension of secondary stabilizers because of its distal attachments to these structures[14,15]. However during walking the proper functioning of PTT is of immense significance to establish the medial arch and proper alignment for effective activity.

Flat foot need treatment if they cause discomfort indicating an underlying disorder. The variety treatment for flexible flat feet includes arch supports for the shoes, stretching or a structurally supportive shoe. Ankle supports and shoe inserts can help recovery as they take stress off the tendon. In most of pateints, these methods brings symptomatic relief. In case of rigid flat feet, surgery is indicated in most of the cases though results are not so encouraging.

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