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Prevalence of flat foot in Saudi Arabian primary school children in relation to age, gender, height and obesity: A cross-sectional study

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ABSTRACT

Background: flatfoot is a common problem in school age children, many factors may predispose to the development of flatfoot such as overweight, hypo kinesis, or hereditary factors. It is a common cause of pediatric orthopedic visits. *Objectives:* this study was conducted to estimate the prevalence of flatfoot in both genders in the population of 6- to 12-year-old schoolchildren, and to examine the relation of age, sex, weight, and height to flat foot. *Methods:* A total population of 563, in age ranging from 6 year to 12 years in Al-Madinah Al-Munawarah city was chosen. Foot posture was assessed by Foot Posture Index. Flat foot clinical diagnosis was determined by heel valgus position, navicular bone position, and medial arch formation on standing position. *Results:* Flat foot prevalence in male children was 74.74%, while in female children it was 86.54%. The results showed that there is no significant correlation between flat foot and weight (r=-0.051, p=0.223). Also, there was no significant correlation between BMI and flat foot (r=0.003, p=0.592). On the other hand, the results showed that there was significant correlation between age, height and flat foot (r=-0.086, p=0.041), (r—0.094, p=0.026) respectively. Equally, there is significant correlation between sex and flat foot (r=0.132, p=0.002). *Conclusion:* The flat foot prevalence in Saudi Arabia children is high compared to other countries. This means that children may require closer monitoring. The study demonstrated that medial arch development was associated with age, gender and height.

Keywords: Flat foot, prevalence, Saudi Arabia children

1. INTRODUCTION

Flat Feet (Pes Planus) can be defined as a collapse of the medial longitudinal arch of the foot, in which there is absence of the normal concavity under the medial longitudinal arch, in addition there is bulging of the foot medial side as a medial convexity, especially on weight bearing (Daniel et al., 2015). Flat feet in children are a common cause of visiting pediatric orthopedic clinics. Flat feet may be flexible or rigid. The vast majority of children with flat feet are flexible and asymptomatic (Sullivan, 1999). Flat feet may be presented clinically alone, or associated to another clinical entity including genetic conditions, collagen disorders, muscular or neurological anomalies, and ligaments laxity (Harris et al., 2004). The flexible (physiological) flat foot, is characterized by presence of the normal medial longitudinal arch in non-weight bearing and absence of the arch during weight bearing (Harris et al., 2004). A flexible flat foot is considered to be a normal variation of the foot. Most neonates have very little arch in the feet. As the child grows and walks, the soft tissues along the bottom of the feet tighten, which gradually shapes the arches of the feet (Staheli et al., 1987).

On contrary, in pathological (rigid) flat foot, the arch is fixed, not changed by weight bearing status (Harris et al., 2004), this may be attributed to many causes, and may lead to pain and functional disability. It often requires treatment (Pfeiffer et al., 2006). There are many factors that influence the prevalence of flat foot such as age, gender, and weight. A highly significant prevalence of flat foot was found in boys and overweight children (Pfeiffer et al., 2006, Garcia et al., 1999). The high incidence of flat feet children with overweight and obesity may be attributed to changes in foot structure, especially of the medial longitudinal arch, or due to presence of fatty pad under the foot medial longitudinal arch (Mickle and Steele, 2006). The prevalence for flat feet has inverse relationship with age. The prevalence of flat feet was 54% and to 24% in three-year old, and the six-year-old patients respectively (Pfeiffer et al., 2006). Full development of normal feet was observed in most children by 12 years of age (Garcia et al., 1999).

Another factor that may influence prevalence of flat feet in children is the social level; it was observed that the prevalence is diminished in children from middle and low scale families (Garcia et al., 1999). The presence of the heel in valgus position and absence of medial foot arch is the base of flat foot clinical diagnosis (Pfeiffer et al., 2006). Children with physiological flat foot at preschool age have a valgus < 20° and are able to actively correct the deformity. While those with pathological flat foot have a valgus > 20° and are unable to perform active correction (Pfeiffer et al., 2006). Six years of age is the critical age for arch developing, thereby, study of the prevalence of flat foot in children whose age less than six years, will lead to underestimation of the diagnosis (Garcia et al., 1999). Flat foot prevalence varies around the world, so the main objective of this study was to estimate the flat feet prevalence in children at primary schools in Al-Madinah Al-Munawarah city, Saudi Arabia and to evaluate the relation of age, gender, weight, and height to flat foot.

2. MATERIALS AND METHODS

A total number of 563 (392 boys and 171girls) primary schools children were enrolled in this study. Their age was between 6 and 12 years, average age was (10.12±1.588). Their average height was 131, 95±10, 34 cm, their average weight was 30, 99±11,19 kg. The research population involved four school institutions from middle and low scale classes. Children with the following inclusion criteria were enrolled in the study: age between 6 and 12 years, students from primary schools in Al-Madinah Al-Munawarah city, Saudi Arabia. An informed consent was obtained from parents or legal guardians. Children with the following exclusion criteria were excluded; those with prior foot or lower limb pathology that affect gait or support, acquired or congenital neurological disease, prior surgery of the foot, those whose parents declined participation in the study, and children who were absent on clinical evaluation day.

This study was approved by the ethics committee at college of medical rehabilitation sciences, Taibah University and the study was in accordance with the declaration of Helsinki. Demographic data including: age, gender, height, weight, body mass index, race, city, dominance were obtained and documented. Foot Posture Index (FPI-6) was used to assess foot posture (Keenan et al., 2006, Redmond et al., 2006). Flat foot clinical diagnosis was determined by heel valgus position, navicular bone position, and medial arch formation on standing position (Tachdjian's system of grading for flat foot 1990) (Tachdjian, 1990). In order to avoid the error bias of a sole observer, the clinical and the physical examination data were obtained by two independent observers.

Footprint Study

Footprints of all individuals were obtained using pedcad foot scanner (mediologic miniplate, SN502213534P, Germany). Light stripe projector is an instrument for gathering 3D, static data. It captures 3 dimensional pictures of the sole of the foot, foot impression foams, plaster models and many other parameters.

Each child was asked to stand barefoot in unipedalstance. Each child was asked to stand up and slightly flex the ipsilateral knee (about 30º) with the help of the investigator on the platform of the device. The contralateral foot was maintained out of the platform, and child's arms were relaxed. Each child was asked to look forward at a fixed point for 20 second. Three trials of the static test were registered for each child and the outcome measures of the valid test were used for further analysis. The existence of flat feet was diagnosed by measuring the plantar arch index (PAI). For measuring PAI, a tangential line was drawn connecting heel region and the edges of the medial fore foot. The mid-point of this straight line was determined. A perpendicular line was drawn from this point crossing the footprint. The same procedure was repeated at the heel region for heel tangency point. The central region's width of the footprint was considered as "A" and that of the heel region was considered as "B''. PAI was obtained by dividing the A value by B value. Plantar arch index (PAI) = A/B. If the PAI is >1.15, then it is considered as a flat foot (Hernandez et al., 2007) (figure 1 & 2).

Figure 1 Footprint

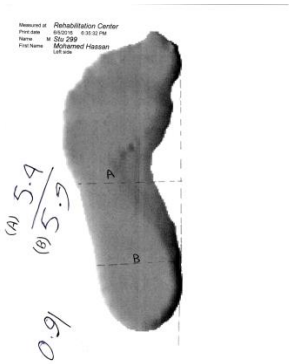

Figure 2 Measuring of the central region's width (A) and heel region (B) of the foot on a footprint. The arch index was calculated by dividing A value by B value

Differentiating between the flexible and the rigidpes planus

All participants performed a heel raise test (tiptoe standing) to differentiate between flexible and rigid pes planus after being diagnosed by the foot impression test (Canale, 2003). In the standing position, the participant was asked to do full weight bearing on the contralateral leg (the non-tested leg), then the participant was asked to plantar flex (tip toe) the ankle of the tested leg. Appearance of the arch indicates flexible flat foot, while arch disappearance indicates rigid pes planus.

Data analysis

The collected data was analyzed using the SPSS for Windows v.19 software. Histograms and the Kolmogorov-Smirnov test were used to assess Normality and symmetry. Frequencies of the variables were calculated. Mean and standard deviation (SD) for age, height and weight were calculated using descriptive statistics (table 1). The correlation between flat foot and age, height and weight, sex and BMI was performed using Pearson correlation. Level of significance was set at $p < 0.05$.

Table 1 Mean and standard deviation (SD) for age, height and weight

	Height M±SD	Weight M±SD	Foot dominance		Flat foot			Type of flat feet	
			Rt	left	Rt	Left	Bilateral	Fixed	Mobile
Male	133.466 ± 10.122	32.492 ± 11.285	361	31	236	248	54	13	471
Female	128.485 ± 10.042	27.853 ± 10.109	158	13	39	36	119	6	262

3. RESULTS

A Total number of 563 students were recruited from the primary schools of Almadinah Al-Mounawarah. More than half (392; 69.62%) of participants were male. Their age ranged from 6 to 12 years (10.12±1.588). From the 392 male subjects, 106 subjects their age were from 7–9 years old (26.97%). Regarding weight (20.75%) was underweight, (64.15%) were normal weight, (5.66%) were overweight, and (9.43%) were obese. Ninety-seven subjects (91.509%) were right foot dominance and nine were left foot dominance (8. 49%). Of the 106 subjects, 86 have flat foot. Approximately 72 had flat feet on right-side (67.9%); most of which 71 (98.611%) was flexible and one was fixed (1.389%). While 73 (68.9) had flatfoot on left side; all of them (100%) was flexible. Of the 106 subjects, 59 have bilateral flat foot.

From the 392 male subjects, 286 subjects were from 10–12 years of age (72.959%) and were either underweight (12.93%) or of normal weight (58.39%) or overweight (16.43%) or obese (12.23%). 264 subjects (92.3%) were right foot dominance and 22(7.7%) were left foot dominance. Of the 286 subjects, 207 have flat foot. Approximately 164 subjects had flat feet on right (57.3%) most of

which (159) 96.95%) was flexible and five (3.048%) was fixed; while175 (61.188%) had flat foot on left side, most of which 155 (88.57%) was flexible and 2(1.14%) was fixed. Of the 286 subjects, 135 have bilateral flat foot. The incidence of flat foot in male from6 to 12 years is 74.74%. The incidence of flat foot in female from 8 to 12 years is 86.54%

One hundred seventy one students (30.37%) of participants were female, their age ranged from 6 to 12 years (9.164±1.421). From the 171 female subjects, 90 subjects were from 7–9years of age (52.63%) and were either underweight (28.88%) or of normal weight (52.22%) or overweight (13.33%) or obese (5.55%). Seventy-nine of this age class (87.8%) were right foot dominance and eleven (12.2%) were left foot dominance. Approximately 68 (75.55%) of these ninety subjects had flat feet on right side; most of which 66(83.54%) was flexible and 2(2.53%) was fixed. while 67(74.44%) had flat foot on left side, most of which 65 (97.014%) was flexible and two (2.98%) was fixed. Of the 90 subjects, 62 have bilateral flat foot.

From the 171 female subjects, 81 subjects were from 10–12years of age (47.36%) and were either underweight (28.39%) or of normal weight (48.14%) overweight (8.64%) or obese (14.81%). 79 of this age class (97.5%) were right foot dominance and two (2.5%) were left foot dominance. Approximately 64 (81.013%) of these 79(46.19%) subjects had flat feet on right side; most of which 62 (96.875%) was flexible and two (3.125%) were fixed. While 68 (83.95%) had flat foot on left side, all of which (100%) were flexible. Of the 81subjects, 56 have bilateral flat foot. The incidence of flat foot in age range from 6 to 12 years was 74.74% in male, while in female was 86.54% (figure 3 & 4).

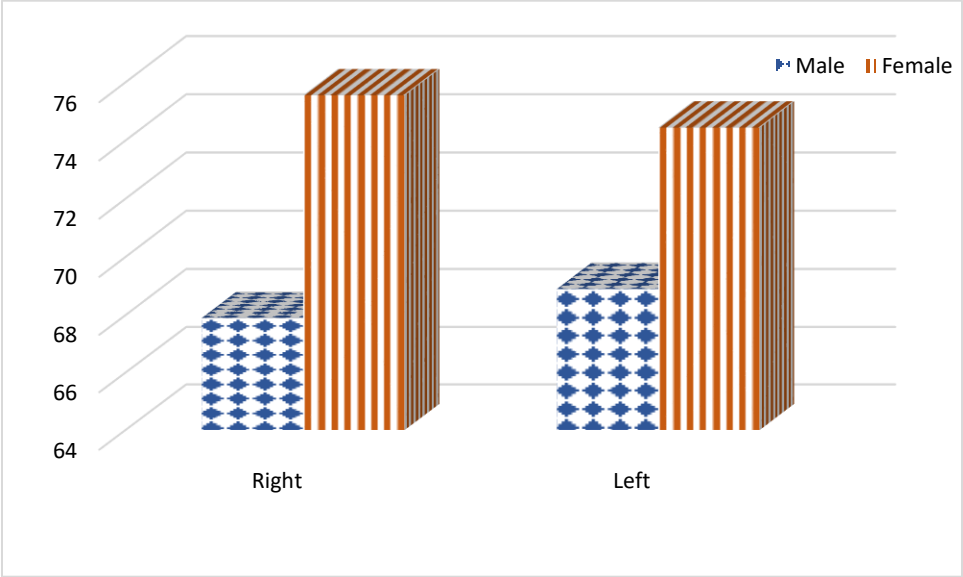

Figure 3 Prevalence of flat foot in male and female from 6-9 years

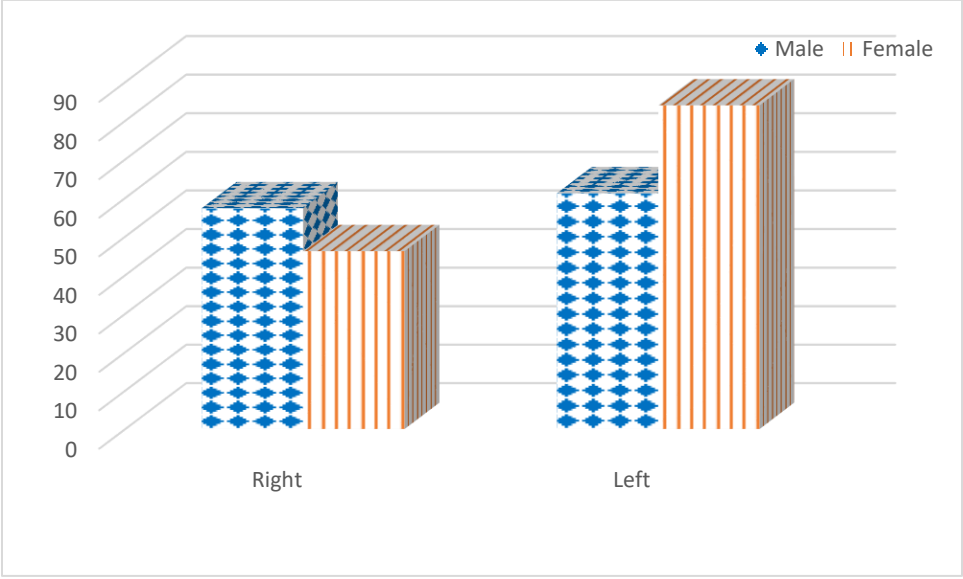

Figure 4 Prevalence of flat foot in male and female from 10-12 years

Correlation between flat foot and with anthropometric variables

The results showed that there was no significant correlation between flat foot and weight (r=-0.051, p=0.223), and flatfoot and BMI (r=0.003, p=0.592). On the other hand, the results showed that there was significant correlation between age and flat foot (r=-0.086, p=0.041), and height and flat foot (r—0.094, p=0.026). Equally, the correlation between sex and flat foot (r=0.132, p=0.002) is significant.

4. DISCUSSION

The aim of the study was to estimate theflatfoot prevalence inprimary school children in Al-Madinah Al-Munawarah city, Saudi Arabia, and to evaluate the relation of anthropometric parameters to flatfoot. The study included the children with age (6-12 years) according to Staheli et al., 1987 who reported that various types of flatfoot were invariably present in infants and were commonly present in children. Rose has also shown that the critical age for development of plantar arch is just prior to the age of 6 years and the prevalence of flat foot evaluated prior to this age may result in overestimation of the problem (Rose, 1990).

The results of the study showed that flat foot prevalence was 78.33% among students aged 6-12 years. Also it was found that bilateral pes planus was common in female subjects, while unilateral pes planus was common in male subjects, and flexible pes planus was the commonest form. Prevalence of flat foot in the current study is close to the findings of other studies such as Echarri and Forriol who reported a prevalence of flat foot of 70% in children aged 3-4 years and 40% in those aged 5-8 years (Echarri and Forriol, 2003). In another study, Gould and colleagues found that hyperpronation presented in 78% of 5-year-olds (Gould et al., 1989). This higher prevalence that reported in the studies may be due to the younger age of their participants compared with our study. Whereas Pfeiffer et al., 2006 reported a prevalence of flat foot of 44% and rigid flat foot >1% among 3-6-year-old children. This is further confirmed in a related study by El et al, in which a lower prevalence rate of 17% of moderate to severe flexible flat foot in a sample of 579 school-aged children (mean age = 9 years old) was reported (El et al.,2006). Additionally, we cannot rule out the possibility of ethnic variations in foot morphology.

These differences may be attributed to many factors such as, deficient standardized assessment, lack of experience, obesity, age range, gender, abnormal femoral and tibial torsion, genu valgum, ligament laxity, race and heredity, footwear, activity, and even living in urban andrural areas (Cetin et al., 2011). A prevalence of more than 78% in the current study means that more than 7 in every ten primary school children has flat foot, adding to the body of evidence that pediatric flat foot is not an uncommon condition. This lends credence to the need for an approach towards preventing consequent predicted complaints. Several authors suggested that flat feet in adults may be related to a higher risk of trauma or other disorders.

In a study, for instance, showed that lower foot arches seemed to raise the risk of ankle sprains (Mei-Danet al., 2005). Moreover, mid foot morphometry predicted successful treatment of patellofem oral pain with orthoses (Vicenzino et al., 2010). A lower arch height of the foot has also been associated with fascial thickening and pain in an Australian study (Wearing et al., 2007). The flatfoot prevalence in this study decreased significantly with advancing age. Independent reports have also shown a decrease in the prevalence of flat foot with advancing age (Hernandez et al., 2007, Pfeiffer et al., 2006). This may be attributed to the resolution and improvement of medial arch (Igbidi and Mpango, 1998), and rear foot angle reduction with age (Sobel ET AL., 1999).

Our findings demonstrated that female children were more likely to be affected by flat foot than their male counterparts. This is consistent with (Eluwa et al., 2009) found a higher incidence of flat foot among females compared with males. Our results come in contrast with (Chang et al., 2010), who conducted a study on (2083) Taiwanese children aged between 7 years and 12 years, and another study of 5866 Greek children aged between 6 years and 17 years(Mueller et al ., 1993). The current study showed that the weight and BMI status were not significantly associated with flat foot. A similar association has been reported by (Daneshmandi et al., 2003), however, no significant correlation was detected between BMI and flatfoot. Although, a strong significance between flat foot and high BMI in children was reported by (Chen et al., 2009).

Our results showed that the height and flat foot were significantly correlated. This comes in contrast with (Tenenbaum et al.,2013) , who performed a study of 17-year-old subjects form both sexes before their recruitment into military service to investigate the prevalence of flat foot and its relation with body mass index (BMI), body height, and sex among healthy adolescents. The Results showed that body height was correlated with a lower risk of flat foot. The findings of this study underscore the importance of school-wide screening, as well as preregistration physical examination and monitoring for flat foot, so as to engenderearly diagnosis and intervention strategies for children atrisk.

This study has several limitations. First, we did not study the prevalence of flat foot among children older than 12years of age. The results can only be generalized to those who are 7-12 years old. We did not gather information on potentially relevant factors, like parental income level, family history of flat foot, or dietary intake. Consequently, we could not compare our findings with

children of older years; neither were we able to give a precise reason for the underweight and obesity problems in this population. Further study is required to determine conclusively the age at which the flat foot in a child will not resolve with growth.

Finally, our report is cross-sectional and can only provide some insights into the association between the prevalence of pes planus and other factors (e.g., age, gender, and weight status). Causality, however, cannot be established. Therefore, the findings should be interpreted with caution. A prospective longitudinal study is needed to clearly demonstrate the influence of gender, varying BMI, and advancing age on the incidence of flat foot.

5. CONCLUSION

There is high prevalence of flat foot among Saudi Arabia children compared to figures from many countries. This means that children may require closer monitoring. The study demonstrated that medial arch development was associated with age, gender.

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REFERENCE

1. Canale ST. Pes planus. In: Campbells operative orthopaedics.10th ed. St Louis: Mosby; 2003. 4017-42
2. Cetin A., Sevil S., Karaoglu L., Yucekaya B. Prevalence of flat foot among elementary school students, in rural and urban areas and at suburbs in Anatolia. Eur J Orthop Surg Traumatol. 2011; 21:327–331.
3. Chang JH, Wang SH, Kuo CL, et al. Prevalence in Taiwanese school-aged children in relation to obesity, gender and age. Euro J Pediat 2010; 168:447-52.
4. Chen J.P., Chung M.J., Wang M.J. Flatfoot prevalence and foot dimensions of 5 to 13 year old children in Taiwan. Foot Ankle Int. 2009; 30:326–332.
5. Daneshmandi H., Rahnema N., Mehdizadeh R. Relationship between obesity and flatfoot in high school boys and children. Int J Sports Sci Eng. 2003; 3:43–49.
6. Daniel DK, Chandrasekaran C, Mano A. A study on prevalence of flat feet among school children in Kanchipuram population. Int J Anat Res, 2015; 3:1240-44.
7. Echarri JJ, Forriol F. The development in footprint morphology in 1851 Congolese children from urban and rural areas, and the relationship between this and wearing shoes. J Pediatr Orthop 2003;12:141-6
8. El O, Akcali O, Kosay C. Flexible flatfoot and related factors in primary school children: a report of a screening study. RheumatolInt 2006; 26:1050-3.
9. Eluwa MA, Omini RB, KpelaT,et al. The incidence of pes planus amongst Akwalbom State students in the University of Calabar. Internet J Forensic Sci 2009:3.
10. Garcia A, Jiménez FM, Varo MC, Gomez E. Flexible Flat Feet in Children: A Real Problem? Pediatrics. 1999; 103:84.
11. Gould N, Moreland M, Alvarez R, et al. Development of the child's arch. Foot Ankle 1989; 9:241-5.
12. Harris EJ, Vanore JV, Thomas JL, et al. Diagnosis and Treatment of Pediatric Flatfoot. Clinical Practice Guideline. J Foot Ankle Surg. 2004; 43:341-73
13. Hernandez AJ, Kimura LK, Laraya MH, Favaro E. Calculation of Staheli's plantar arch index and prevalence of flat feet: A study with 100 children aged 5-9 years. Acta Ortop Bras 2007; 15:68-71
14. Igbidi PS, Mpango L. Prevalence of pes planus among the students in Mbarara University of Science and Technology, Uganda. West Afr J Anat 1998; 6:25-7.
15. Keenan AM, Redmond AC, Horton M, et al. The Foot Posture Index: Rasch analysis of a novel, foot specific outcome measure. Rheumatology 2006, 45:28.
16. Mei-Dan O, Kahn G, Zeev A, Rubin A, et al. The medial longitudinal arch as a possible risk factor for ankle sprains: a prospective study in 83 female infantry recruits. Foot Ankle Int 2005; 26:180-3.
17. Mickle KJ, Steele JR. The feet of overweight and obese young children: Are they flat or fat? Obesity 2006; 14:1949-53.
18. Mueller MJ, Host JV, Norton BJ. Navicular drop as a composite measure of excessive pronation. J Am Podiatr Med Assoc 1993; 83:198-202.
19. Pfeiffer M, Kotz R, Ledl T, et al. Prevalence of flat foot in preschool-aged Children. Pediatrics. 2006; 118:634-9.
20. Redmond AC, Crosbie J, Ouvrier R: Development and validation of a novel rating system for scoring foot posture: the Foot Posture Index. Clin Biomech 2006, 21:89-98.
21. Rose GK. Flat foot in children. Br Med J 1990; 301:1330-1.

22. Sobel E, Levitz S, Caselli M, et al. Natural history of the rear foot angle: preliminary values in 150 children. Foot Ankle Int 1999; 20:119-25.
23. Staheli LT, Chew DE, Corbett M. The longitudinal arch. J Bone Joint SurgAm.1987. 69:426-8.
24. Sullivan JA. Pediatric Flatfoot: Evaluation and Management. J Am Acad Orthop Surg, 1999; 7:44-53.
25. Tachdjian MO. Flexible pes planovalgus (flat foot). In: Tachdjian's pediatric orthopedics. 2nd ed. Philadelphia, USA: W.B. Saunders Co., 1990:2717-58.
26. Tenenbaum, S., Hershkovich, O., Gordon, B, et al. Flexible pes planus in adolescents: body mass index, body height, and gender—an epidemiological study. Foot & ankle international, 2013: 34; 811-817.
27. Vicenzino B, Collins N, Cleland J, McPoil T. A clinical prediction rule for identifying patients with patellofemoral pain who are likely to benefit from foot orthoses: a preliminary determination. Br J Sports Med 2010; 44:862-6.
28. Wearing SC, Smeathers JE, Sullivan PM, et al. Plantar fasciitis: are pain and fascial thickness associated with arch shape and loading? PhysTher 2007;87:1002-8