ORIGINAL ARTICLE

Nr 2024;14 (2):300-306

Comparison of Radiological Parameters to Predict the Adult Acquired Flatfoot Deformity (AAFD) in Indian population: A Retrospective Study

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DOI:
10.32098/mltj.02.2024.09

LEVEL OF EVIDENCE: 3

SUMMARY

Background. The purpose of the study was to describe the most sensitive and specific radiological parameter to diagnose symptomatic adult acquired flatfeet deformity (AAFD) with weight bearing radiographs in Indian population.

Methods. A retrospective study was conducted in which 50 consecutive patients with 100 flat feet were included at department of orthopedics from August 2021 to October 2022. Amongst them, 32 were bilateral (64 feet) and 18 were unilateral (18 flat feet and 18 normal feet) flat feet.

Results. Out of these 50 subjects, 32 (64%) had bilateral flat feet, 18 (36%) were unilateral (11 left foot and 7 right foot). Out of 50 patients (100 feet), 24 had symptoms on left foot, whereas 26 had symptoms on right foot (total number of symptomatic patients were 50). Amongst our study population (50 subjects), 23 (46%) patients did not have any co-morbidities. 18 (36%) patients had type 2 diabetes, 5 (10%) patients had hypertension, 3 (6%) patients were associated with hypothyroidism and one individual (2%) showed psychiatric disorder. The talar 1st metatarsal angle in lateral view, talar uncoverage angle and the talar 1st metatarsal angle in anteroposterior (AP) view, were found to be statistically significant.

Conclusions. Three radiologic parameters-talar 1st metatarsal angle in lateral view and talar uncoverage angle and talar-1st metatarsal angle in anteroposterior view can be the most relevant radiological parameters in the assessment of AAFD in Indian population. We also conclude that the talar uncoverage angle has a higher sensitivity of 82% to predict symptomatic flat foot in adults.

KEY WORDS

Flatfeet; Indian population; evaluation; radiological parameter; radiographs.

BACKGROUND

Painful, AAFD is a common condition, which is also known as pes plano-valgus, pes planus, or lateral peri-talar subluxation. The deformity involves "shortening" of the lateral column, plantar inclination of the talar head, and lateral peri-talar subluxation of the navicular bone (1). Dysfunction of the posterior tibial tendon is a most common pathology to cause AAFD, associated with collapse of the medial longitudinal arch, subtalar joint eversion, forefoot abduction at the talonavicular joint, and hindfoot valgus (1, 2). AAFD can be diagnosed by multiple modalities and one of the most common method is clinical evaluation supported by plain

weight bearing radiographs, which is reliable and affordable (3). Younger *et al.* (4), in his study, the 'radiographic assessment of adult flatfoot' states that a few selective radiographic parameters can be used as a diagnostic tool for flat foot deformity in adults. Among the several radiographic parameters, few parameters like calcaneal pitch angle, arch angle, talar first metatarsal angle, lateral talar 1st metatarsal angle, talar inclination angle and the navicular index are of significance as described by Khan *et al.* (2). MRI can be considered as the gold standard for detecting posterior tibial tendon dysfunction and can be used to get a three-dimensional image of the foot and thereby accurately diagnose AAFD. But the advantages of using simple lateral radiograph of foot to diagnose flatfoot cannot be discredited as it is fast, low cost and simple to perform (5). The present study is relevant, as there is no study till date to our knowledge, which describes most sensitive and specific radiological parameter to diagnose symptomatic AAFD in Indian population. The present study aims to identify and define the most relevant radiological parameter for assessment of AAFD.

MATERIALS AND METHODS

Patients, presented with AAFD to outpatient department of orthopedics of our institution were chosen for the study. The inclusion criteria were adult patients with AAFD between the age of 18 to 70 years. This research included fifty patients, among them, 33 (66%) were female and 17 (44%) were male. Database, including demography, clinical symptoms were identified. Patients presented with pain, commonly had posterior tibial tendon dysfunction which was diagnosed clinically and confirmed by ultrasonogram. The patients with previous surgeries of foot and ankle, with pre-existing congenital/developmental/metabolic deformities of foot and ankle, and patients with rheumatoid arthritis or osteoarthritis and Charcot arthropathy involving the lower limb joints were excluded. Weight bearing plain radiographic views, antero-posterior (AP) and lateral were taken, with patient standing on straight knee, with the hands resting on railings and the opposite foot non-weight bearing for both the views (4).

After obtaining the radiographs in digital format with picture archiving and communication system version 4 (PACS), the patients identity information was cropped, the contrast and brightness were optimized, and the measurements were performed as per the description by Younger *et al.* (4) and Chadha *et al.* (6). The standard normal radiological values were considered from the study done by Flores *et al.* (7). After blinding and assigning the random numbers, intra and interobserver error was determined using 10 radiographs viewed on two occasions by two observers (fellowship trained foot and ankle surgeon and musculoskeletal radiologist).

The 82 flatfeet from our subjects were compared with the 18 normal feet. These 18 normal feet were from the unilateral flatfoot patients of our study group. This means that, these 18 patients were having flat foot only one side and on the other side, there was no flat feet (**table I**).

Table I. Patient details.

Gender	Frequency	Percent
Female	33	66.0
Male	17	44.0
Deformity		
Bilateral flatfoot	32	64.0
Left flatfoot only	11	22.0
Right flatfoot only	7	14.0

Data analysis

Data obtained was stored and analyzed using the statistical package for Social Sciences Software (SPSS) version v 21.0 IBM corporation (SPSS Inc., Chicago, Illinois). Descriptive statistics were used to describe epidemiological variables such as age, gender, comorbidities (like hypertension, diabetes), side of symptomatic foot. Independent t-test was used to compare independent variables including, the radiological parameters for the assessment of flatfoot. A P-value of < 0.05 was considered significant. For the correlation of the radiological parameters between symptomatic and asymptomatic flatfeet, Spearman's correlation coefficient was used. P-value of < 0.05 and area under the ROC curve of more than 0.6 was considered statistically significant.

This present study has the approval of our Institutional Ethics Committee, and it is in accordance with the international ethical standards, as per the opinion of Padulo *et al.* (8). Before starting the present study, the approval was obtained from Kasturba Medical College and Kasturba Hospital Institutional Ethics Committee (Registration number ECR/146/Inst/KA2013/RR-19; DHR Registration No.EC/NEW/INST/2019/374; reference number IEC:399/2021; date of approval: April 14, 2021). Since, the present study is a retrospective analysis of the data, signed informed consent to participate and consent to publish from the patients are not applicable.

RESULTS

The total number of symptomatic patients in this study were 50. Among them, 32 (64%) had bilateral pes planus, 11 (22%) had left side flatfoot and 7 (14%) had right side flat foot (**table I**). Overall 100 feet, 24 had left side symptoms, and 26 had right side symptoms. Out of 50 subjects, 23 (46%) of the subjects did not have any co-morbidities. Type 2 diabetes 18 (36%) was the most common co-mor-

bidity followed by hypertension 5 (10%), hypothyroidism 3 (6%) and psychiatric disorder 1 (2%) (**table II**).

Table II. Distribution of subjects based on the symptomatic side and co-morbidities.

Symptomatic side	Frequency
Left	24
Right	26
Total number of symptomatic feet	50
Co-morbidities	
Type 2 DM	18
Hypertensive	5
Hypothyroid	3
Psychiatric disorder	1

Comparing different angles and heights, between flatfoot and normal foot in our study population

After the assessment of all the radiological parameters, it was observed, that the lateral talar 1st metatarsal angle (**figure 1**), the talar 1st metatarsal angle (**figure 2**) and talar uncoverage angle (**figure 3**) AP view were found to be statistically significant ($p < 0.05$) (**table III**).

Sensitivity, and specificity amongst the statistically significant three radiological parameters

With respect to lateral talar-1st metatarsal angle, at a cut-off value of 13.2250°, the sensitivity and specificity was 58% and 70%, respectively. With respect to talar-uncoverage angle, at a cut-off value of 10.055°, the sensitivity and specificity was 82% and 60%, respectively. With respect to talar 1st metatarsal angle in AP view, at a cut-off value of 8.64°, the sensitivity and specificity was 76% and 62% respectively (**table IV**).

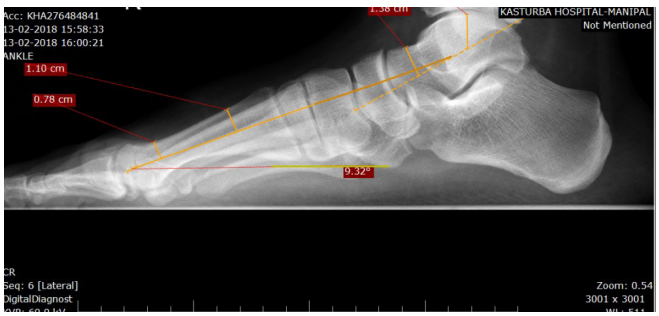

Figure 1. Lateral view, weight bearing radiograph, showing lateral talar 1st metatarsal angle (Meary angle). It is the angle created by drawing lines along the axis of the talus bone and the first metatarsal. These axes are normally parallel, but in this subject with AAFD radiograph it is showing an angle of 9.32°.

Figure 2. Anteroposterior (AP) view, weight bearing radiograph, showing AP talar 1st metatarsal angle. It is the angle created by drawing lines along the axis of the talus bone and the first metatarsal. Normally talar axis is angled slightly lateral to the axis of the 1st metatarsal shaft (13), but here talar axis is making an angle of 22.06°to that of 1st metatarsal axis.

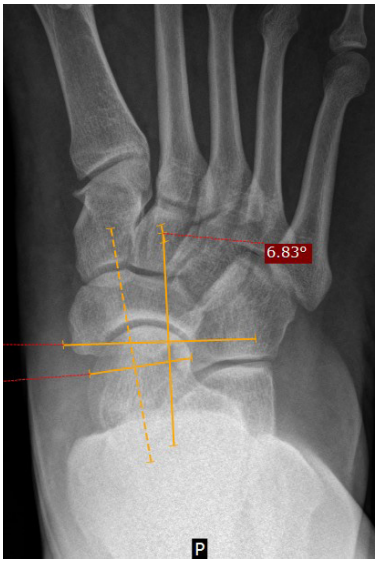

Figure 3. Anteroposterior (AP) view, weight bearing radiograph, showing talar-uncoverage angle. It is the angle created by articular surface of talar head and articular surface of proximal navicular bone. Normally they are parallel. In the present radiograph it is making an angle of 6.83°.

The comparison of relevant radiological parameters of foot alignment for the assessment of AAFD in our study with the standard is represented in **table V**.

Table III. Comparing different angles and heights between flatfoot and normal foot in our study population.

Group		n	Mean	Standard deviation	Median	P-value
Calcaneal pitch angle	Flatfoot	82	14.05°	4.80	14.30°	0.556
	Normal	18	13.43°	6.00	13.02°	
Lateral talar-1st metatarsal angle	Flatfoot	82	15.16°	6.56	13.67°	0.001
	Normal	18	10.68°	5.16	10.61°	
Medial column height	Flatfoot	82	1.52	0.29	1.50	0.159
	Normal	18	1.59	0.25	1.58	
5th metatarsal medial cuneiform height	Flatfoot	82	0.44	0.21	0.42	0.450
	Normal	18	0.41	0.16	0.38	
Lateral column height	Flatfoot	82	1.31	0.40	1.41	0.874
	Normal	18	1.34	0.33	1.40	
Talar un-coverage angle	Flatfoot	82	15.77°	7.58	14.67°	0.000
	Normal	18	10.23°	7.47	6.76°	
Calcaneo fifth metatarsal angle	Flatfoot	82	160.94°	6.46	161.57°	0.959
	Normal	82	161.03°	6.53	163.02°	
AP talar 1st metatarsal angle	Flatfoot	82	12.61°	5.26	11.73°	0.000
	Normal	18	9.00°	4.25	7.83°	

Table IV. Cut-off value, sensitivity, and specificity of lateral talar-1st metatarsal angle, talar un-coverage angle and AP talar 1st metatarsal angle.

Predictor	Value	Sensitivity	Specificity	Area	P-value	Asymptotic 95%CI	
						Lower bound	Upper bound
Lateral talar-1st metatarsal angle	13.2250°	58%	70%	0.697	0.001	0.596	0.799
Talar un-coverage angle (AP view)	10.0550°	82%	60%	0.729	0.000	0.628	0.830
Talar 1st metatarsal angle (AP view)	8.6400°	76%	62%	0.704	0.000	0.600	0.807

Table V. Comparison of relevant radiological parameters of foot alignment for the assessment of AAFD in our study with the standard.

Radiological view	Radiological metric	Construction	Normal (7)	Abnormal	Our study (mean)	P-value
Lateral	Talar-first metatarsal angle	Angle between the long axis of the talus and the long axis of the first metatarsal	0° (parallel)	Mild: > 4 Moderate: > 15 Severe: > 30 Pes planus: < 18	15.16°	0.001
Antero-posterior	Talar un-coverage angle	Angle between the articular surface of the talar head and the articular sur- face of the proximal navicular bone	0° (parallel)	Pes planus: > 7	15.77°	0.000
Antero-posterior	AP talar 1st metatarsal angle	Line drawn along the long axis of the talus, extended into the forefoot, its orientation compared with that of the first metatarsal shaft	0° (parallel)	Mild: > 4 Moderate: > 15 Severe: > 30	12.61°	0.000

DISCUSSION

The present study aimed to identify the most common radiological parameter to define AAFD and also the most sensitive and specific radiological parameter to diagnose symptomatic flatfoot with plain radiographs. Though multiple radiological parameters can be measured, there is no specific radiographical parameter to define and diagnose AAFD amongst Indian population. In a study done by Vulcano *et al.* (9), on approach to treatment of AAFD, states that the peak age of presentation was 55 years and women were more commonly affected than men. In our study it was observed that the mean age of presentation is 49 years, which is lesser than the mean age reported by Vulcano *et al.* (9). However, in our study too, females were more commonly affected than males (66 and 44 percent respectively). In a study done by Goss *et al.* (10), on natural history of flatfoot reconstructions in AAFD, over a period of 14-year, it was found that among 321 patients, 13.7% had diabetes and 3.7% had rheumatoid arthritis associated with AAFD. In our study it was found that, 36% of patients had type 2 diabetes mellitus and 10 percent had hypertension. In the present study, we found the mean value of calcaneal pitch angle in the AAFD was higher (14.05 ± 4.80), which was statistically non- significant ($p = 0.5$). In a study done by Lo *et al.* (11), among young Taiwanese male military recruits, states that, the calcaneal pitch angle with a cut off value of 12.06° was the best predictor of AAFD. In contrast to the above study, we found, the lateral-talar 1st metatarsal angle, talar uncoverage angle and the talar-1st metatarsal angle in AP view were more specific in diagnosing AAFD. However, our study includes a wider age group and both genders.

In our study, we found that the lateral talar 1st-metatarsal angle (Meary's angle), with a P-value of 0.001 with the mean value of (15.16 ± 6.56) on AAFD compared to normal feet (10.68 ± 5.16), which was correlating with a study done by Lebel and Karasik (12), who had also evaluated weight bearing lateral radiographs in 30 patients with surgically proven posterior tibial tendon tear induced AAFD with tenosynovitis, found that the lateral talar 1st-metatarsal angle was increased in 47% of patients. Lalevée *et al.* (13), also reported that Meary's angle was significantly higher ($p = 0.037$) in case of AAFD with posterior tibial tendon deficit. In our study, the medial column height with a P-value of 0.159, and the mean value (1.59 ± 0.25) was higher in the normal side, in comparison to side with AAFD. However, this had no significance in diagnosing AAFD. This result was comparable to study done by Kang *et al.* (14), who had studied the lateral and medial column lengths in patients with AAFD and found that there was no statistical significance with the medial column height when comparing patients with flatfoot and normal foot with a mean value of 1.08 cm.

In our study, the radiographic parameter, 5th metatarsal to medial cuneiform height was higher in the side with flatfoot (0.44 ± 0.21) than the normal side (0.41 ± 0.16). However, this measurement was found with no statistical significance. This was comparable to the study done Younger *et al.* (4), who also found that the 5th metatarsal to medial cuneiform height with a (P-value of < 0.0001) was significant to diagnose AAFD. The lateral column height, in our study with a P-value of 0.16 on the right side and 0.22 on the left side had no significance in diagnosing AAFD or predicting the symptoms. These results were correlating with an observation by Kang *et al.* (14), who did a study amongst 85 feet having AAFD and they concluded that the lateral column height was not a statistically significant parameter. This conclusion was similar to our study. Based on these findings it is evident that, the lateral column height is not an accurate predictor of AAFD.

The talar uncoverage angle also known as the talo-navicular coverage angle. In our study, we found that this radiographic measurement was statistically significant parameter and the mean talar uncoverage angle was higher in AAFD (15.77 ± 7.58) compared to normal foot (10.23 ± 7.47). The difference in talar uncoverage angle was also found to be significant statistically (P-value < 0.05). The talar uncoverage angle had a sensitivity of 82% which was higher amongst all the radiological parameters measured. This shows that the talar uncoverage angle can be used as a screening tool in outpatients, to predict AAFD due to its high sensitivity. Filardi *et al.* (15) states that talonavicular uncoverage angle of greater than 7° indicates, lateral talar subluxation and forefoot abduction. This parameter can be a reliable diagnostic tool in patients with AAFD. Moreover, this observation is correlating with our study, as even our mean value of talar uncoverage angle in flatfoot patients was more than 7°. Knutson *et al.* (16) identified the relevant radiographic measures which were correlating with the articular coverage areas of clinical interest, possibly aiding to the better quantification of progressive collapsing foot deformity.

In our study, the mean value of calcaneo-fifth metatarsal angle was lower in flat foot (160.094 ± 6.53) in comparison to normal foot (161.93 ± 6.53), which was not significant statistically (P-value > 0.05). This result was in accordance with the study by Younger *et al.* (4), who also found that the calcaneo fifth metatarsal angle is not significant. Hence, we can conclude that the calcaneo-fifth metatarsal angle is not a reliable parameter in diagnosing the AAFD. In our study, the mean value of talar 1st metatarsal angle, measured in AP view, was higher in flatfoot (12.61 ± 5.26) compared to normal foot (9.00 ± 4.25). The difference in talar 1st meta-

tarsal angle was found to be significant statistically (P-value < 0.05). This observation was similar to the study done by Younger *et al*. (4).

A cross-sectional study conducted in Spanish population, estimated the prevalence of flatfoot as 26.62% in the patients over the age of 40, with a higher incidence in older patients (17). In another Japanese study (18), there was identical results in comparison to the Spanish study as there was a prevalence of 26.5% in patients aged 60 and above. However, these patients were neither hospitalized nor disabled and were performing their regular activities (18). Almaawi *et al*. (19) used three different footprint parameters, Clark's angle, Chippaux-Smirak index, and Staheli index in Saudi Arabian population to define the foot arch. They were able to observe wide variations between the results of each parameter in their study. However, the Chippaux-Smirak and Staheli indices exhibited a significant concordance in diagnosing the flatfoot with kappa value > 0.8 and P-value < 0.05. In Indian population, a cross-sectional study (20) was done with 500 healthy participants, who were aged between 18-21 years and the flatfoot prevalence were determined as 13.6%. In males, it was 12.8% and 14.4% in females (20). The difference in frequency of prevalence in these studies with respect to Indian population is due to the fact that the authors used different methods.

There are few clinical studies (20-23), which are available in the literature about the flatfoot in Indian population. Rao and Joseph (23) observed a higher prevalence (8.6%) of flatfoot in Indian children, who used closed shoe footwear. This was higher with respect to the children who were predominantly using the sandals or barefooted. Sachithanandam and Joseph (22) observed an association between the duration of footwear usage and the flatfootness. However, the literature search did not reveal radiological studies with respect to the clinical diagnosis of the AAFD in Indian population. Hence, this aspect is being highlighted in the title and the abstract of this research. This radiological study is novel in the scientific literature and can be further performed in the other population as well. The data of this study can be considered as a morphological database for the Indian population.

CONCLUSIONS

From our study we can conclude that, three radiologic parameters, the talar 1st metatarsal angle (lateral view), talar uncoverage angle (AP view) and the talar-1st metatarsal angle (AP view) can be used as a reliable diagnostic tool to diagnose AAFD in Indian population. We also conclude that the talar uncoverage angle certainly has a higher sensitivity of 82% to predict the symptomatic AAFD.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

YGK: data collection, writing – original draft. HS: data interpretation, data analysis. MN: supervision, data interpretation, data analysis. PRK: supervision, writing – review & editing. KDH: morphometry, images interpretation. YLR, BVM: writing – review & editing.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. Hansen ST. Functional reconstruction of the foot and ankle. Lippincott Williams & Wilkins; 2000, p. 370.
2. Khan F, Chevidikunnan MF, Alsobhi MG, et al. Diagnostic accuracy of various radiological measurements in the evaluation and differentiation of flatfoot: a cross-sectional study. Diagnostics (Basel). 2022;12(10):2288. doi: 10.3390/diagnostics12102288.
3. Agoada D, Kramer PA. Radiographic measurements of the talus and calcaneus in the adult pes planus foot type. Am J Phys Anthropol. 2020;171(4):613-27. doi: 10.1002/ajpa.23994.
4. Younger AS, Sawatzky B, Dryden P. Radiographic assessment of adult flatfoot. Foot Ankle Int. 2005;26(10):820-5. doi: 10.1177/107110070502601006.
5. Yang CH, Chou KT, Chung MB, Chuang KS, Huang TC. Automatic detection of calcaneal-fifth metatarsal angle using radiograph: a computer-aided diagnosis of flat foot for military new recruits in Taiwan. PLoS One. 2015;10(6):e0131387. doi: 10.1371/journal.pone.0131387.
6. Chadha H, Pomeroy G, Manoli A 2nd. Radiologic signs of unilateral pes planus. Foot Ankle Int. 1997;18(9):603-4. doi: 10.1177/107110079701800915.
7. Flores DV, Mejía Gómez C, Fernández Hernando M, Davis MA, Pathria MN. Adult acquired flatfoot deformity: anatomy, biomechanics, staging, and imaging findings. Radiographics. 2019;39(5):1437-60. doi: 10.1148/rg.2019190046.

8. Padulo J, Oliva F, Frizziero A, Maffulli N. Muscles, Ligaments and Tendons Journal - Basic principles and recommendations in clinical and field Science Research: 2016 Update. Muscles Ligaments Tendons J. 2016;6(1):1-5. doi: 10.11138/mltj/2016.6.1.001.
9. Vulcano E, Deland JT, Ellis SJ. Approach and treatment of the adult acquired flatfoot deformity. Curr Rev Musculoskelet Med. 2013;6(4):294-303. doi: 10.1007/s12178-013-9173-z
10. Goss M, Stauch C, Lewcun J, et al. Natural history of 321 flatfoot reconstructions in adult acquired flatfoot deformity over a 14-year period. Foot Ankle Spec. 2021;14(3):226-31. doi: 10.1177/1938640020912859.
11. Lo HC, Chu WC, Wu WK, et al. Comparison of radiological measures for diagnosing flatfoot. Acta Radiol. 2012;53(2):192-6. doi: 10.1258/ar.2011.110387.
12. Lebel E, Karasik M. Massive allograft of the tibia for a child with McCune-Albright syndrome: case presentation and surgical intervention. J Pediatr Orthop B. 2010;19(2):177-80. doi: 10.1097/BPB.0b013e32832c3509.
13. Lalevée M, Barbachan Mansur NS, Schmidt E, et al. Does tibialis posterior dysfunction correlate with a worse radiographic overall alignment in progressive collapsing foot deformity? A retrospective study. Foot Ankle Surg. 2022;28(7):995-1001. doi: 10.1016/j.fas.2022.02.004.
14. Kang S, Charlton TP, Thordarson DB. Lateral column length in adult flatfoot deformity. Foot Ankle Int. 2013;34(3):392-7. doi: 10.1177/1071100712465738.
15. Filardi V. Flatfoot and normal foot a comparative analysis of the stress shielding. J Orthop. 2018;15(3):820-5. doi: 10.1016/j.jor.2018.08.002.
16. Knutson K, Peterson AC, Lisonbee RJ, Hintermann B, Krähenbühl N, Lenz AL. Joint coverage analysis in progressive collapsing foot deformity. J Orthop Res. 2023;41(9):1965-73. doi: 10.1002/jor.25543.
17. Pita-Fernandez S, Gonzalez-Martin C, Alonso-Tajes F, et al. Flat foot in a random population and its impact on quality of life and functionality. J Clin Diagn Res. 2017;11(4):LC22-7. doi: 10.7860/JCDR/2017/24362.9697.
18. Otsuka R, Yatsuya H, Miura Y, et al. Association of flatfoot with pain, fatigue and obesity in Japanese over sixties. Nihon Koshu Eisei Zasshi. 2003;50(10):988-98.
19. Almaawi A, Alotaibi N, Alsubaie M, et al. Flatfoot prevalence in Riyadh city Saudi Arabia and its association with obesity, using three footprint indices; Clark's angle, chippaux-smirak index, and staheli index. Orthop Rheumatol Open Access J. 2019;15:52-8. doi: 10.19080/OROAJ.2019.15.555909.
20. Aenumulapalli A, Kulkarni MM, Gandotra AR. Prevalence of flexible flat foot in adults: a cross-sectional study. J Clin Diagn Res. 2017;11(6):AC17-20. doi: 10.7860/JCDR/2017/26566.10059.
21. Pandey S, Pal CP, Kumar D, Singh P. Flatfoot in Indian population. J Orthop Surg (Hong Kong). 2013;21(1):32-6. doi: 10.1177/230949901302100110.
22. Sachithanandam V, Joseph B. The influence of footwear on the prevalence of flat foot. A survey of 1846 skeletally mature persons. J Bone Joint Surg Br. 1995;77(2): 254-7. doi: 10.1302/0301-620x.77b2.7706341.
23. Rao UB, Joseph B. The influence of footwear on the prevalence of flat foot. A survey of 2300 children. J Bone Joint Surg Br. 1992;74(4):525-7. doi: 10.1302/0301-620X.74B4.1624509.