International Journal of Yoga, Physiotherapy and Physical Education
ISSN: 2456-5067; Impact Factor: RJIF 5.24
Received: 02-01-2019; Accepted: 05-02-2019
www.sportsjournal.in
Volume 4; Issue 2; March 2019; Page No. 04-10

Comparison of foot posture and plantar arch among: Adolescent wearers and non-wearers of high heeled shoes

Pooja Ashok Sonawane[1], Dr. Radha Bhattad[2]
[1] PES Modern College of Physiotherapy, Shivajinagar, Pune, Maharashtra, India
[2] Associate Professor, PES Modern College of Physiotherapy, Shivajinagar, Pune, Maharashtra, India

Abstract
The stages of child development are closely linked to variation in posture that arise as a response to the balance derived from changes in body proportion. Adolescents also face this challenge, which renders the pre pubertal and post pubertal phases crucial to the formation and structuring of posture. Several factors can influence the formation of good posture during this stage including longer school hours from age ten, therefore longer periods of time in the sitting position and heavier loads of notebooks in the children's backpacks. The type of shoe worn is an external factor that can influence the posture of the distal extremity (foot and ankle), gait and the type of plantar arch. In this respect, the habit of wearing high-heeled shoes must be highlighted, as it has become increasingly more common among teenagers from an earlier age. Although high-heeled shoes are important accessories in women's apparel, the main concern is the improper wear which compromises the health of feet, legs, and spine.
Considering that the target population of the present study consisted of middle aged adolescent, the detection of these postural data, alongside the characteristics of the type of foot, may support therapy procedures and be particularly preventive in this population. Therefore, the study aimed to investigate the relationship between the foot posture and the plantar arch of adolescent high-heel wearers and non-wearer.

Keywords: foot posture, plantar arch, high heeled shoes

Introduction
The stages of child development are closely linked to variation in posture that arise as a response to the balance derived from changes in body proportion [1]. Adolescents also face this challenge, which renders the pre pubertal and post pubertal phases crucial to the formation and structuring of posture [2, 3]. Several factors can influence the formation of good posture during this stage including longer school hours from age ten, therefore longer periods of time in the sitting position and heavier loads of notebooks in the children's backpacks [4]. The type of shoe worn is an external factor that can influence the posture of the distal extremity (foot and ankle), gait and the type of plantar arch. In this respect, the habit of wearing high-heeled shoes must be highlighted, as it has become increasingly more common among teenagers from an earlier age [6-8]. Although high-heeled shoes are important accessories in women's apparel, the main concern is the improper wear which compromises the health of feet, legs, and spine [12].
Recent studies [6, 7] have shown that high-heeled shoes shift the center of the body mass forward, placing the ankle in plantar flexion, causing an overload on the forefoot and transferring the pressure peaks from the 3rd, 4th, and 5th metatarsal heads to the 1st and 2nd metatarsals.
According to Mathieson, Upton and Prior [9] and to Neumann [10], biomechanical changes in the plantar fascia and the muscles that sustain it can bring about changes in the plantar arch. When the fascia is elongated and/or the muscles are weakened, the medial longitudinal arch collapses, a condition known as flat foot. According to the same authors, when this condition is combined with excessive pronation of the subtalar joint, the rear foot becomes valgus.
Conversely, when the fascia and/or the muscles are tense or shortened, there will be an increase in the plantar arch called cavus foot, and when this is combined with supination of the subtalar joint, the rear foot becomes varus.
Considering that the target population of the present study consisted of middle aged adolescent, the detection of these postural data, alongside the characteristics of the type of foot, may support therapy procedures and be particularly preventive in this population. Therefore, the study aimed to investigate the relationship between the foot posture and the plantar arch of adolescent high-heel wearers and non-wearers.

Need of Study
- The type of shoe worn is an external factor that can influence the posture of the distal extremity (foot and ankle), gait and the type of plantar arch. In this respect, the habit of wearing high-heeled shoes must be highlighted, as it has become increasingly more common.
- Recent studies have shown that high-heeled shoes shift the center of the body mass forward, placing the ankle in plantar flexion, causing an overload on the forefoot and transferring the pressure peaks from the 3rd, 4th, and 5th metatarsal heads to the 1st and 2nd metatarsals.
- The present study detection of the postural data, alongside the characteristics of the type of foot, may support therapy procedures and be particularly preventive in this population.
- Therefore, the study aimed to investigate the relationship between the foot posture and the plantar arch of adolescent high-heel wearers and non-wearers.

Aim and Objective
Aim
- To compare the foot posture and plantar arch among adolescent wearer and non-wearer of high heeled shoes.

Objectives
- To find the foot posture and plantar arch among the adolescent high heel wearers.
- To find the foot posture and plantar arch among the adolescent non high heel wearers.
- To compare the foot posture and planter arch among high heel and non-high heel wearers.

Hypothesis
Null Hypothesis
- There is no significant difference between the foot posture and plantar arch among adolescent wearer and non-wearer of high heeled shoes.

Alternative Hypothesis
There is difference between the foot posture and plantar arch among adolescent wearer and non-wearer of high heeled shoes

Materials
- White Paper.
- Pen, pencil.
- Blue Ink.
- Measuring scale.
- Foot Posture Index (FPI-6).
- Chippaux-Smirak Inex (CSI).

Criteria
Inclusion Criteria
- Age – 13to 20 years
- Gender – Females.
- Adolescent high heel wearers (more than a1 year).
- Adolescent non high heel wearers (more than 1 year).
- Wearing high-heeled shoes at least four times a week for four
- Consecutive hours.

Exclusion Criteria
- Subjects with lower limb fractures, history of congenital diseases which involved lower limb affection, traumatic or neuromuscular lesions, musculoskeletal diseases which involved lower limb deformity.

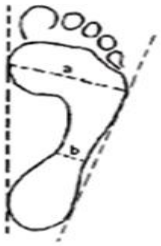
Methodology
- Study design: Observational Study.
- Study Setting: Subjects in and around Pune.
- Sampling Technique: Simple Random Sampling / Purposive sampling.
- Study population: 13 to 20 years
- Study Sample: 50(25 in each group)

Procedure
- The study was conducted after the ethical clearance was obtained from the ethical committee of physiotherapy.
- The subjects categorized according to inclusion and exclusion criteria into two Groups
  - Group A: Non wearers of high heels.
  - Group B: Wearers of high heels.

- Assessment of foot posture done using foot posture index.
- Assessment of type of medial longitudinal arch done using chippaux-smirak index.
- The foot posture and longitudinal arch of both the groups compared.

Outcome Measures
- Chippaux-Smirak Index (CSI).
- Foot Posture Index (FP1-6).

1. Chippaux-Smirak Index (CSI).



CSI= b/a; a=widest section of the metatarsal head region, b=narrowest section of the longitudinal arch region.

Fig 1: Representation of the straight line segments used to calculate the CSI

For this index, the reference values were: 0 cm - cavus foot; 0.01 to 0.29 cm - normal foot; 0.30 to 0.39 cm - intermediate foot; 0.40 to 0.44 cm - lowered foot; and 0.45 cm or more

Assessment of Plantar Arch
Chippaux-Smirak Index
This assessment is carried out by means of a foot impression obtained on a white paper. A single impression was taken of both feet while standing, with bilateral weight bearing. The Chippaux-Smirak Index (CSI) as described by Forriol and Pascual25 was used to collect the anthropometric measures of the feet and to analyze the medial longitudinal arch. To calculate this index, two tangents were drawn: one through the most medial points and another through the most lateral points of the regions of the metatarsal heads and calcaneus. Next, two parallel straight lines were drawn: the first between the most medial and the most lateral points of metatarsal head region, thus obtaining the widest section of the impression (segment a); and the second over the narrowest section of the medial longitudinal arch (segment b). Both segments were measured, and the value of b was divided by a.

2. Foot Posture Index -6 (FPI-6)

Table 1: Reference Values for FPI-6

Factor		Score 1 Date_____ Comment____		
		Plane	**Left (-2 to +2)**	**Right (-2 to +2)**
Rear foot	Tatar head palpation			
	Curves above and below lateral malleolus.			
	Inversion/eversion of the calcaneus			
Fore foot	3Uge in the region of the TN)			
	Congruence of the medial longitudinal arch			
	Abd/adduction of fore foot on rear foot (too-many toes).			
	Total			

- Normal = 0 to +5
- Pronated = +6 to +9
- Highly Pronated= 10+
- Supinated = -1 to -4
- Highly Supinated = -5 to12

Assessment of Foot Posture

Foot Posture Index-6

Foot posture index (FPI-6) is a diagnostic clinical tool aimed at quantifying the degree to which a foot can be considered to be in a pronated, supinated or in neutral position. It is intended to be a simple method of scoring the various features of foot posture into a single quantifiable result, which in turn gives an indication of the overall foot posture. The foot posture index rates weight bearing posture according to a series of predefined criteria.

The six clinical criteria employed in the FPI-6:

- 1.Talar head palpation
- 2.Supra and infra lateral malleolar curvature
- 3.Calcaneal frontal plane position
- 4.Prominence in the region of the talonavicular joint
- 5.Congruence of the medial longitudinal arch
- 6.Abduction / Adduction of the forefoot on rearfoot

1. Talar head palpation

This is the only criterion that relies on palpation rather than observation. The head of the talus is palpated on the medial and lateral side of the anterior aspect of the ankle, according to the standard method described variously by Root, Elveru and many others. Diagram showing the position of the fingers when palpating of the head of the talus. The circles indicate the precise point of palpation on the medial and lateral side

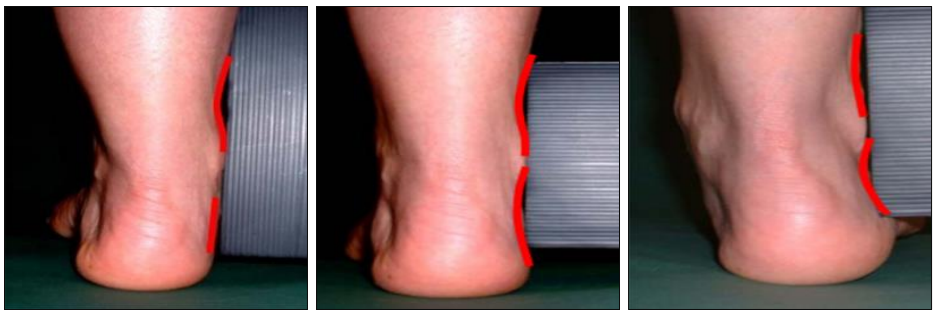
Fig 2

Table 2

score	-2	-1	0	1	2
	Talar head palpable on lateral side /but not on medial side.	Talar head palpable on lateral side /slightly palpable on medial side	Talar head equally palpable on lateral and medial side	Talar head slightly palpable on lateral side/palpable on medial side	Talar head not palpable on lateral side/but palpable on medial side

2. Supra and infra lateral malleolar curvature

In the neutral foot it has been suggested that the curves should be approximately equal. In the pronated foot the curve below the malleolus will be more acute than the curve above due to abduction of the foot and eversion of the calcaneus. The opposite is true in supinated foot.



Supination (-2) **Neutral (0)** **Pronation (+2)**

Fig 3: Diagram showing curves below and above the lateral ankle malleoli

Table 3

Score	-2	-1	0	1	2
	Curve below the malleolus either straight or convex	Curve below the malleolus concave, but flatter/more shallow than the curve above the malleolus	Both supra and infra malleolar curves roughly equal	Curve below malleolus more concave than curve above malleolus	Curve below malleolus markedly more concave than curve above malleolus.

3. Calcaneal frontal plane position

- This is an observational equivalent of the measurements often employed in quantifying the relaxed and neutral calcaneal stance positions. With the patient standing in the relaxed stance position, the posterior aspect of the calcaneus visualised with the observer in line with the long axis of the foot.
- Angular measurements are not required for the FPI, the foot is graded according to visual appraisal of the frontal plane position.

Supinated (-2) **Neutral (0)** **Pronated (+2)**

Fig 4: Diagram showing inversion and eversion of the calcaneus

Table 4

score	-2	-1	0	1	2
	More than an estimated 5 inverted (varus)	Between verticle and an estimated 5 inverted (varus)	Verticle	Between verticle and an estimated 5 everted (valgus)	More than an estimated 5 everted (valgus)

4. Bulging in the region of the talonavicular joint

Supinated (-2) **Neutral (0)** **Pronated (+2)**

Fig 5: Diagram showing bulging in the region of the talonavicular joint

Table 5

Score	-2	-1	0	1	2
	Area of TNJ markedly concave	Area of TNJ slightly, but definitely concave	Area of TNJ flat	Area of TNJ bulging slightly	Area of TNJ bulging markedly

5. Height and congruence of the medial longitudinal arch

While arch height is the strong indicator of foot function, the shape of the arch can also be equally important. In a neutral foot the curvature of the arch should be relatively uniform, similar to a segment of the circumference of a circle when a foot is supinated the curve of the MLA becomes more acute at the posterior end of the arch. In the excessively pronated foot the MLA becomes flattened in the centre as the midtarsal and lisfranc's joints open up.

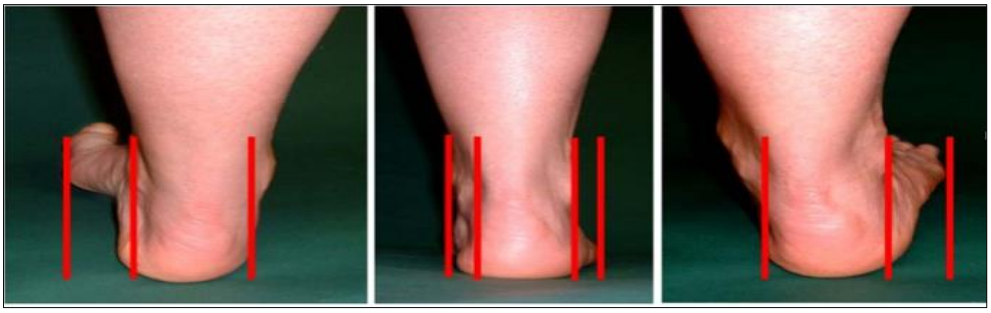
Neutral (0) **Supinated (-2)** **Pronated (+2)**

Fig 6

Table 6

Score	-2	-1	0	1	2
	Arch high and acutely angled towards the posterior end of the medial arch	Arch moderately high and slightly acute posteriorly	Arch height normal and concentrically curved	Arch lowered with some flattening in the central portion	Arch very low with severe flattening in the central portion-arch making ground contact

6. Abduction/Adduction of the forefoot on the rear foot
When viewed from directly behind, and in-line with the long axis of the heel (not the long axis of the whole foot), the neutral foot will allow the observer to see the forefoot equally on the medial and lateral sides. In the supinated foot the forefoot will adduct on the rear foot resulting more of the foot causes the forefoot to abduct resulting in more of the forefoot being visible on the lateral side.



Supinated (-2) **Neutral (0)** **Pronated (+2)**

Fig 7

Table 7

SCORE	-2	-1	01	1	2
	No lateral toes visible. medial toes clearly visible	Medial toes clearly more visible than lateral	Medial and lateral toes equally visible	Lateral toes clearly more visible than medial	No medial toes visible. Lateral toes clearly visible

Data Analysis

- Total number of participants 40
- Group A involved adolescent wearers of high heels. Their foot posture were assessed by FPI-6 and plantar arch were assessed by CSI.
  Total no of participants: 20
- Group B involved adolescent Non wearers of high heels. Their foot posture were assessed by FPI-6 and plantar arch were assessed by CSI.
  Total no of participate: 20

Statistics Analysis

- For the statistical analysis we used the software 'Instat'. A paired t-test was used to verify the equality between the right and left sides. The equality was confirmed (p>0.05),thus the both sides were analyzed together as a single sample, comprising 20 feet in the wearers group and 20 feet in the non-wearers group.

Table 8: Foot posture of Group A on FPI-6

Group A	
FPI-6	-3.75 (Supinated Feet)

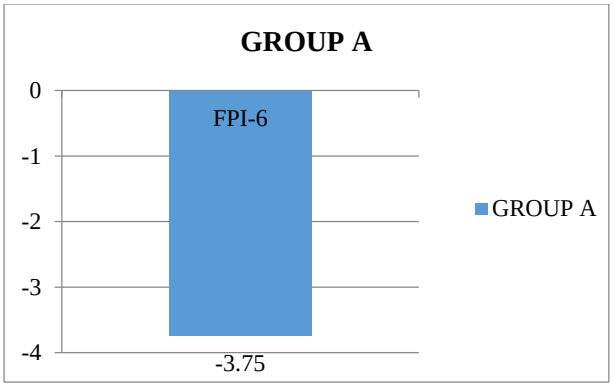


Fig 8: Foot posture of Group A on FPI-6.

Table 9: Plantar arch of group A on CSI

Group B	
CSI	0.20 (Normal Feet)

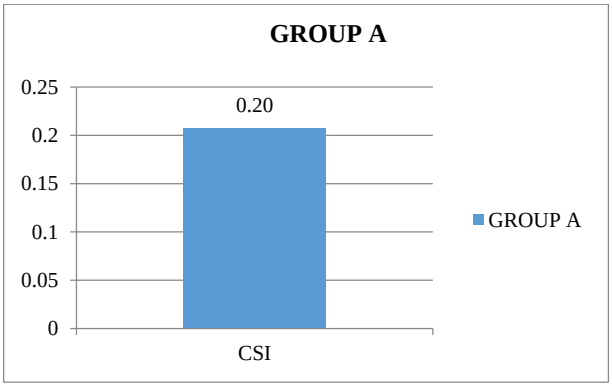


Fig 9: Plantar arch of Group A on CSI

Table 10: Foot posture of group B on FPI-6

Group B	
CSI	+3.25 (Normal Feet)

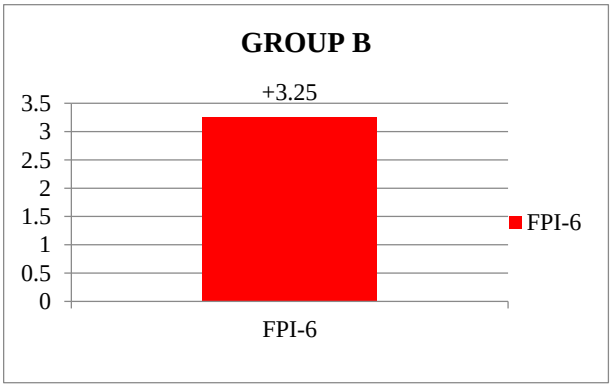


Fig 10: Foot Posture of Group B on FPI-6

Table 11: Plantar Arch of Group B on CSI

Group B	
CSI	0.24(Normal Feet)

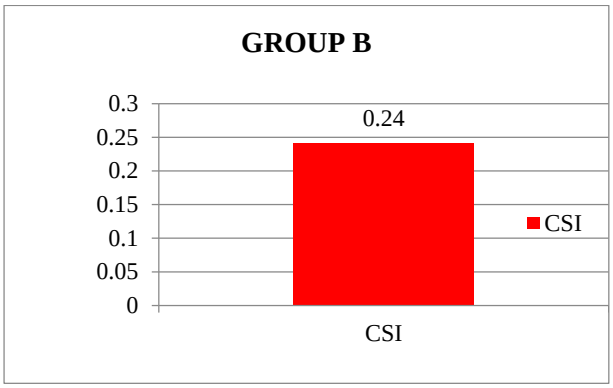


Fig 11: Plantar arch of Group B on CSI

Table 12: Comparison of Foot Posture and Plantar Arch on FPI-6 and CSI – Group A Vs Group B

	FPI-6	CSI
Group A	-3.75 (Supinated Feet)	0.20 (Normal Feet)
Group B	+3.25 (Normal Feet)	0.24 (Normal Feet)

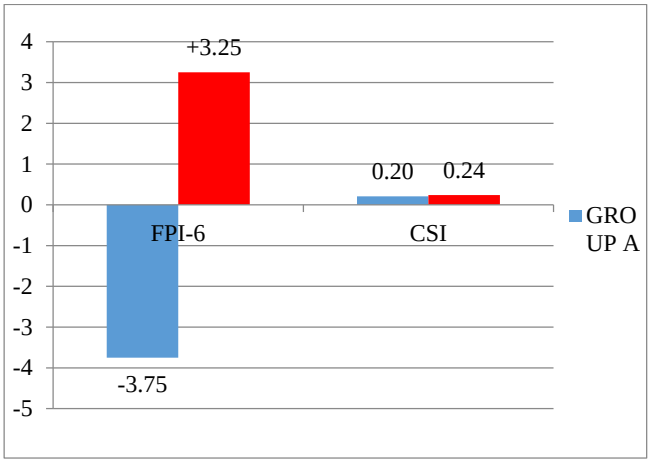


Fig 12

Table 13: Classification of the Chippaux-Smirak Index for the Plantar Arches of the Female Adolescent of Non-Wearer and Wearer of High Heels.

Classification	Wearers Group A		Non wearers Group B	
	QTY	%	QTY	%
Cavus	2	10%	0	0.0%
Intermediate	1	5.0%	4	20.0%
Normal	17	85.0%	15	75.0%
Lowered	0	0.0%	1	5.0%

Result

- The present study was conducted to compare the foot posture and plantar arch among female adolescent wearers and non-wearers of high heeled shoes.
- Group A had supinated feet on FPI-6; with the mean value of -3.75 whereas GROUP B had normal feet with the mean value of +3.25.
- Group A had normal feet on CSI; with the mean value of 0.20.wheras GROUP B had normal feet with the mean value 0.24.

Discussion

- The study aim was to compare the foot posture and the plantar arch of adolescent female with wearers and non-wearers of high-heeled shoes. According to the present study there was no correlation between the foot posture and the plantar arch index
- As we found supinated feet in adolescent wearers of high heeled shoes on FPI-6; this is because of the high-heeled shoes keep the ankle and the foot in a position that causes the extensors and invertors to shorten, which may explain the varus position assumed by the ankle for better stabilization and balance.
- The data showed that the high-heeled shoe wearers had a lower values for the plantar arch on CSI thus indicating higher plantar arch compared to the non-wearers, which suggests a tendency toward cavus foot. In adolescent age group the feet suffer changes when submitted to the previously mentioned muscle shortening and possible posture disorders caused by prolonged high-heeled shoe wear. This suggests that these shoes could affect the normal development of the plantar arch.
- This study and data suggests that prolonged high-heeled shoe wearing, especially during the developmental phase, may lead to an inadequate foot alignment and, ultimately, less efficiency in the mechanics of the movement and hence deviation from normal foot posture and plantar arch.

Conclusion

- The study concluded that the subjects of adolescent high heel wearers had SUPINATED FEET on FPI-6 and NORMAL FEET on CSI, whereas the subjects of adolescent non high heel wearers had NORMAL FEET on FPI-6 and NORMAL FEET on CSI.

Limitations

- It must be admitted that possible differences could have been evinced in adolescents non high heels wearers ; if the number of participants had been greater.
- It must also be considered that high-heeled shoes are present in the apparel of most of the adolescent wearers and non-wearers at some point during the week, even if they have been wearing the shoes for less than one year.

Future Scope of Study

- Future studies with larger sample size are recommended.
- The study was done only to compare the difference; interventions can be done to prevent the deformities.
- The study can be done in different population groups.
- The study can be done using different outcome measures.

Reference

1. Patricia AO, Pezzan, *et al*. Foot posture and classification of plantar arch among adolescent wearer and non-wearer of high heeled shoes, 2009.
2. Magee DJ. Orthopedic physical assessment. 3ª ed. Philadelphia: WB SaunMageeders Company, 1997.
3. Grimmer KA, Williams MT, Gill TK. The associations between adolescent head-on-neck posture, backpack weight, and anthropometric features. Spine. 1999; 24(21):2262-7.
4. Opila KA, Wagner SS, Schiowitz S, Chen J. Postural alignment in barefoot and high-heeled stance. Spine. 1988; 13(5):542-7.

5. Opila Correia KA. Kinematics of high-heeled gait. Arch Phys Med Rehabil. 1990; 71(5):304-9.
6. De Lateur BJ, Giaconi RM, Questad K, Ko M, Lehmann JF. Footwear and posture: Compensatory strategies for heel height. Am J Phys Med Rehabil. 1991; 70(5):246-54. Links]
7. Esenyel M, Walsh K, Walden JG, Gitter A. Kinetics of high-heeled gait. J Am Podiatr Med Assoc. 2003; 93(1): 27-32.
8. Yung-Hui L, Wei-Hsien H. Effects of shoes inserts and heel height on foot pressure, impact force, and perceived comfort during walking. Appl Ergon. 2005; 36(3):355-62. [Links]
9. Mathieson I, Upton D, Prior TD. Examining the validity of selected measures of foot type: a preliminary study. J Am Podiatr Med Ass. 2004; 94(3): 275-81.
10. Watson AW, MacDonncha C. A reliable technique for the assessment of posture: assessment criteria for aspects of posture. J Sports Med Phys Fitness. 2000;40(3):260-70
11. Forriol F, Pascual J. Footprint analysis between three and seventeen years of age. Foot Ankle. 1990;11(2):101-4