



## Full length article

## The relationship between foot posture index and resting calcaneal stance position in elementary school students

Yongjin Cho, Jin-Woo Park, Kiyeun Nam\*

Department of Physical Medicine and Rehabilitation, Dongguk University Ilsan Hospital, 27 Dongguk-ro, Ilsandong-gu, Goyang-si, Gyeonggi-do 10326, Republic of Korea

## ARTICLE INFO

## Keywords:

Resting calcaneal stance position  
Foot posture index  
Flat foot  
Foot orthosis  
Foot assessment  
Pediatric flat foot

## ABSTRACT

**Background:** Static foot assessment is commonly performed in clinical practice to classify foot type for prescribing therapeutic interventions. Foot posture index is known to be a reliable indicator for foot position. Resting calcaneal stance position angle is used widely to determine foot posture and manufacture orthoses for pediatric flat foot patients. However, the relationship between foot posture index and resting calcaneal stance position angle in elementary school students is currently unclear.

**Research question:** To investigate the relationship between foot posture index and resting calcaneal stance position angle in elementary school students.

**Methods:** Between January 2016 and December 2017, 208 elementary school students (average age, 10.3 years; range, 8–13 years) were enrolled for this study. All students were examined physically by one practitioner to measure foot posture index and resting calcaneal stance position angle. Age, gender, and body mass index were analyzed for factors associated with flat foot prevalence. This study was conducted as a retrospective comparative study. Associations between foot posture index and resting calcaneal stance position angle were determined by Pearson's correlation analysis.

**Results and Significance:** When measured by foot posture index and resting calcaneal stance position angle, the overall prevalence of flatfoot was 29% and 24% in the right foot and 26% and 23% in the left foot, respectively. Resting calcaneal stance position angle and foot posture index score showed moderate correlation in Pearson's correlation analysis (left side foot: kappa value = 0.710; right side foot: kappa value = 0.704).

**Conclusion:** There is a moderate correlation between foot posture index and resting calcaneal stance position angle in elementary school students. Thus, both foot posture index with proven validity and reliability and resting calcaneal stance position widely used in the manufacture of insoles can be used as important biomechanical evaluation tools for feet in clinical settings.

## 1. Introduction

Static foot assessment is commonly performed in clinical practice to classify foot type for identifying possible etiological factors related to injury and prescribing therapeutic interventions [1]. Many practitioners use a variety of assessment tools to evaluate foot posture in the clinic [2]. The commonly used imaging modalities include pedograph, radiographs, three-dimensional measurement systems or scanners, ultrasound, and laser surface scanner [3]. However, these methods require special equipment with expensive cost or risk of exposure to radiation. On the other hand, static foot measurement tools such as foot posture index (FPI) and resting calcaneal stance position (RCSP) can be simply and quickly used in clinical setting.

The six-item FPI described by Redmond et al. [4] is known to be a reliable test for measuring foot position [2,4,5]. RCSP angle is also used widely to determine foot posture and manufacture orthoses for pediatric flat foot patients [6,7]. It is not only one of traditional foot assessment methods, but also still used by many practitioners [6,8].

There are several reports on the high reliability of FPI [4,5,8]. A recent study has shown its correlation with radiologic parameter of flat foot [2]. However, foot biomechanical studies on the validity and reliability of RCSP angle are relatively less common than those of FPI.

Flatfoot is a common presentation in children and a frequent concern for parents [9]. Volpon has reported that most infants rapidly develop a normal plantar arch and can expect spontaneous resolution of a flat foot between 2 and 6 years of age [10]. After this age, any

**Abbreviations:** FPI, foot posture index; RCSP, resting calcaneal stance position; BMI, body mass index

\* Corresponding author.

E-mail addresses: [pigboom@hanmail.net](mailto:pigboom@hanmail.net) (Y. Cho), [jinwoo.park.md@gmail.com](mailto:jinwoo.park.md@gmail.com) (J.-W. Park), [rus198@hanmail.net](mailto:rus198@hanmail.net) (K. Nam).

<https://doi.org/10.1016/j.gaitpost.2019.09.003>

Received 30 November 2018; Received in revised form 6 August 2019; Accepted 4 September 2019

0966-6362/ © 2019 Elsevier B.V. All rights reserved.

significant modifications are less likely to occur [10]. Because of this, in our study, inclusion criteria were set for elementary school students after rapid progression of the plantar arch. In addition, the relationship between FPI and RCSP in elementary school students is currently unclear. Therefore, the purpose of this study was to investigate the relationship between RCSP angle and FPI for foot position in elementary school students.

A few studies disputed the relationship between the prevalence of flat foot and demographic characteristics including age, gender and body weight [11–13]. Thus, we also analyzed the correlation between age, gender, body mass index (BMI) and prevalence of flat foot diagnosed with FPI and RCSP.

Results of this study could provide information on whether RCSP could be used as a clinical measuring tool for pediatric flat foot. This is the first study to reveal a correlation between FPI and RCSP angle.

## 2. Methods

### 2.1. Participants

Between January 2016 and December 2017, a total of 208 participants (116 boys and 92 girls) with a mean age of  $10.3 \pm 1.95$  years (range, 8–13 years) were enrolled for this retrospective comparative study. Participants visited the hospital for foot examination with or without pain. We obtained information for age, sex, body weight, height, underlying disease, and others. Participants were considered underweight if BMI was less than 18.5, normal weight if BMI was between 18.5 and 24.9, and overweight if BMI was 25 or greater [11].

Patients who were diagnosed with rigid flatfoot, spastic flatfoot, or posttraumatic flatfoot were excluded. RCSP was first measured by one practitioner with many years of experience for all participants. FPI was then done in one hour. Anthropometric data of the study group are summarized in Table 1. Approval from the Institutional Review Board was obtained before conducting the study. (Dongguk university ilsan hospital, 2018-03-024)

### 2.2. Clinical measurements

#### 2.2.1. FPI

FPI was evaluated in standing position for children using the original protocol with the following six items [4,14]: 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, and 6) abduction/adduction of the forefoot on the rearfoot (Fig. 1).

Each item was scored on a scale of  $-2, -1, 0, +1, +2$  (0 for neutral,  $-2$  for clear signs of supination, and  $+2$  for clear signs of pronation). All scores were summed (Table 2). The final score ranged from  $-12$  to  $+12$ , with a larger positive value indicating a more pronated foot. Reference values are as follows: normal = 0 to  $+5$ , pronated =  $+6$  to  $+9$ , highly pronated =  $10+$ , supinated =  $-1$  to  $-4$ , and highly supinated =  $-5$  to  $-12$  [15].

#### 2.2.2. RCSP

RCSP was assessed based on the method described by Root et al. [16]. Briefly, participants were asked to lie face-down on a bed parallel

**Table 1**  
Characteristics of participants.

	Value
Age (yr)	$10.30 \pm 1.95$ (8–13)
Gender (male:female)	116:92
Weight (kg)	$40.48 \pm 11.87$ (20.5–83)
Height (cm)	$147.01 \pm 13.18$ (121.1–176.4)
Body mass index (kg/m <sup>2</sup> )	$18.34 \pm 2.93$ (12.81–26.67)

to the ground with their feet over the edge of the bed. An investigator examined their feet manually and put three dots on the upper, middle, and lower parts of the calcaneus to draw a bisection line regardless of fat around the calcaneus. RCSP was measured when individuals were standing with their feet fist-width apart. The angle between the bisector of the calcaneus and the perpendicular line to the ground was measured. Flat foot was defined when either of the feet had greater than four degrees valgus of RCSP angle [6] (Fig. 2).

### 2.3. Data analysis

All statistical analyses were performed using SPSS Statistics for Windows, version 19.0 (IBM Corp, Armonk, NY, USA). Associations between FPI and RCSP were determined by Pearson's correlation analysis. A p-value  $< 0.05$  was considered significant. A correlation coefficient  $R^2$  closer to 1 or  $-1$  indicated a strong correlation whereas a correlation coefficient  $R^2$  closer to 0 indicated weak or no correlation.  $R^2$  is a statistical measure of how close the data are to the fitted regression line. One-way analysis of variance (ANOVA) (Bonferroni test for multiple comparisons with post hoc analysis) was performed to assess differences in prevalence related to age and BMI. Pearson chi-square analysis was conducted to detect significant differences between males and females and the prevalence of flatfoot diagnosed with FPI and RCSP. All values are presented as average value with standard deviation.

## 3. Results

### 3.1. Participant characteristics

When measured by FPI, the overall prevalence of flatfoot was 29% in the right foot and 26% in the left foot. When measured by RCSP, the prevalence of flatfoot was 24% in the right foot and 23% in the left foot. From 8–13 years of age, flatfoot prevalence did not increase or decrease when it was measured by FPI or RCSP (Right flat foot using FPI,  $p = 0.438$ ; Left flat foot using FPI,  $p = .802$ ; Right flat foot using RCSP,  $p = .331$ ; Left flatfoot using RCSP,  $p = .551$ ). When measured by FPI, the prevalence of flatfoot in boys vs. girls was 29% vs. 28% ( $p = .868$ ) in right foot and 26% vs. 26% ( $p = .971$ ) in left foot. When measured by RCSP, the prevalence of flatfoot in boys vs. girls was 22% vs. 25% ( $p = 0.662$ ) in right foot and 19% vs. 27% ( $p = 0.160$ ) in left foot. There was no statistically significant association of BMI with FPI or RCSP ( $p = .206$  for right flat foot using FPI,  $p = 0.316$  for left flat foot using FPI,  $p = .728$  for right flat foot using RCSP, and  $p = .629$  for left flatfoot using RCSP) (Table 3).

### 3.2. Correlation of RCSP angle and FPI score

RCSP angle and FPI score showed moderate correlations based on Pearson's correlation analysis (kappa value: 0.710 for left foot and 0.704 for right foot). Quantitative analysis using Pearson correlation between RCSP angle and FPI showed a linear relationship (Fig. 3).  $R^2$  value was 0.363 in the left foot and 0.266 in the right foot.

## 4. Discussion

Many assessment tools can be used to evaluate foot posture in clinics. Among them, static foot measurement tools such as FPI and RCSP are often used because they are easy, fast, and cost-effective.

FPI described by Redmond consists of six specific criteria [4]. It is a clinical tool that quantifies the degree to which a foot is pronated or supinated [2,4]. FPI is a relatively simple and rapid method with good reliability [5]. RCSP angle was introduced in the 1970s. It is one of the traditional foot assessment methods [16]. Studies on normal biomechanics of foot and ankle through the calcaneal bisection line have been actively performed since the 1980s [17]. This RCSP angle has been

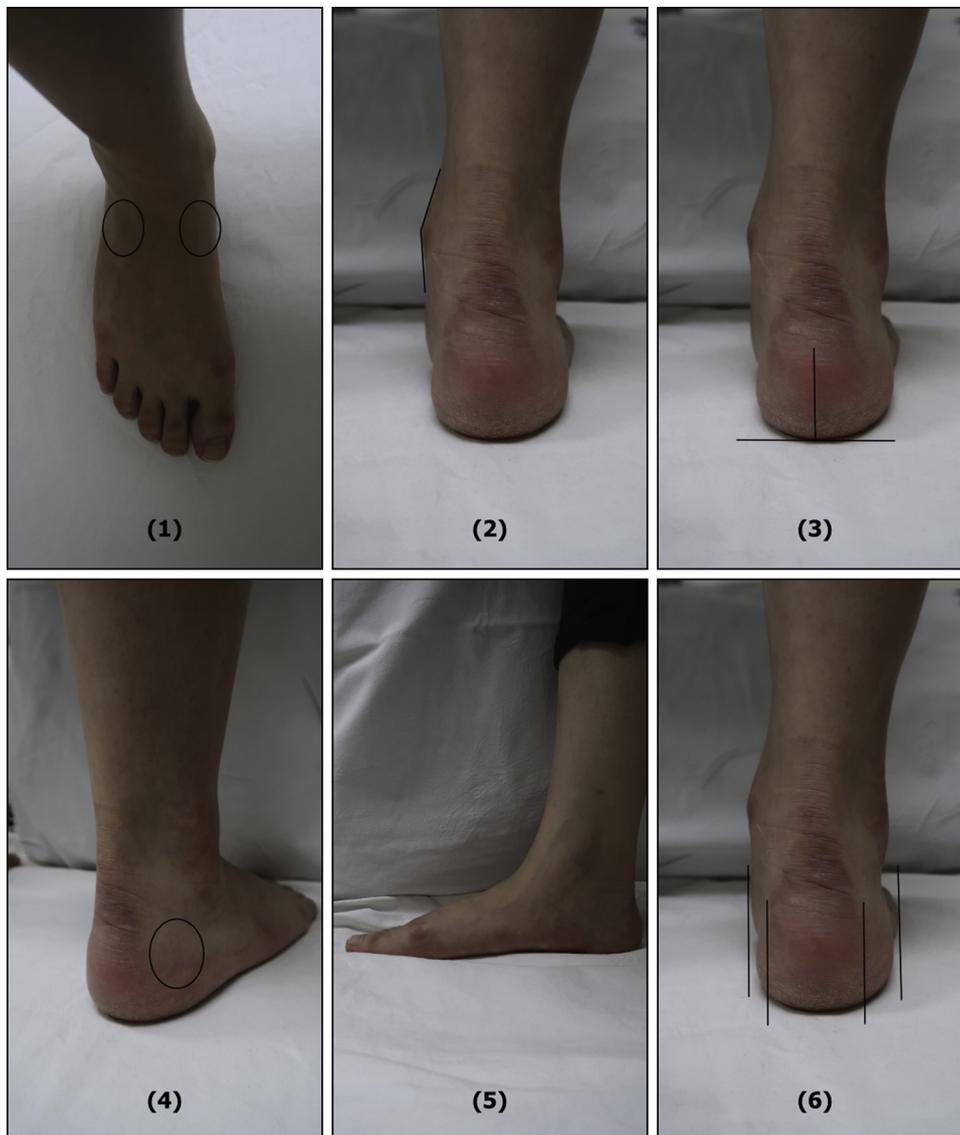


Fig. 1. Six items of the Foot Posture Index (FPI).

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, and 6) abduction/adduction of the forefoot on the rearfoot.

used extensively in the examination and treatment of pediatric and adult flatfoot [7].

Foot orthoses are frequently prescribed interventions for flexible flatfoot [18]. Such devices are preferred treatment method for a majority of biomechanically induced pathologies in the feet and lower extremities [19].

Rearfoot position is frequently used to guide the manufacture of most foot orthoses and their prescription variables (e.g. modified Root style devices [20], Blake devices [21], Medial heel skive [19]) and therefore needs to be measured reliably. There are limited studies using RCSP as a tool to confirm the diagnosis of flatfoot and the effect of foot orthosis [7,22].

In a pediatric foot clinic, the RCSP angle is a common biomechanical parameter to diagnose flatfoot. Dahle et al. [23] have studied the reliability of RCSP measurement between three examiners and found a moderate inter-tester reliability of 0.7. Sobel et al. [7] have reported that there is no significant difference between intra-tester reliability and inter-tester reliability. However, studies on the correlation of RCSP with footprint, pedograph, and radiographs are limited. There is a limit to measure stereoscopic 3D structure of flatfoot because RCSP is 2D

cross-sectional diagnosis.

The most recent scale developed for foot assessment is FPI. In 2006, Redmond et al. [4] introduced FPI-6 scoring system which consisted of six components. The FPI (six item version) has been studied for intra and inter-rater reliability and validity [4,5,8].

According to a recent systematic review focusing on psychometric properties of foot posture measures used in paediatric populations, there is not a universally accepted criterion for diagnosing abnormal paediatric flat foot within 27 articles [24]. In that study, FPI – 6, Staheli arch index, or Chippaux-Smirak index should be the preferred method of paediatric foot posture measurement in future research [24].

In our study, RCSP angle and FPI showed moderate correlations. In addition, since RCSP is a classic and traditional method, many practitioners have been using it for a long time. Thus, it can be used potentially interchangeably with FPI considering practitioner's proficiency.

The reported prevalence of flatfoot ranges from approximately 0.6% to 77.9% [25]. The prevalence of flatfoot has been reported to be 37 to 59.7% in age group of 2 to 6 years and 4 to 19.1% in age group of 8 to 13 years [25]. These last results compare with our study, where 17 to 35% of children at a similar age were also determined to have flat feet.

**Table 2**  
Foot Posture Index scoring.

	-2	-1	0	1	2
<b>Talar head palpation</b>	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
<b>Supra and infra lateral malleolar curvature</b>	Curve below the malleolus either straight or convex	Curve below the malleolus concave, but flatter/more than the curve above the malleolus	Both infra and supra malleolar curves roughly equal	Curve below the malleolus more concave than curve above malleolus	Curve below the malleolus markedly more concave than curve above malleolus
<b>Calcaneal frontal plane position</b>	More than an estimated 5° inverted (varus)	Between vertical and an estimated 5° inverted (varus)	Vertical	Between vertical and an estimated 5° everted (valgus)	More than an estimated 5° everted (valgus)
<b>Prominence in the region of the talonavicular joint (TNJ)</b>	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
<b>Congruence of the medial longitudinal arch</b>	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
<b>Abduction/adduction of the forefoot on the rare foot</b>	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

In a study by Alfonso et al. [9], targeting 1032 children in 2018, children’s flat foot posture using FPI trended to be more neutral as age increases. The authors reported that appreciation of developing foot posture could reduce overdiagnosis and unnecessary treatment of paediatric flatfeet [9]. In that study, children were divided into three groups: 5 to 7 years, 7–9 years, and 9–11 years. Within each group, FPI scores were significantly reduced after three years. However, in cross-sectional observation, the prevalence rate of flat foot was 21.2% in age group of 5–7 years, 29.6% in age group of 7–9 years, and 21.6% in age group of 9–11 years [9], similar to results of our study.

Several reports have shown that overweight and obesity may affect foot structure in children and adults [26]. However, some researchers have reported that there is no significant relationship of flatfeet with obesity [9,12]. Aenumulapalli et al. [12] have found that the prevalence of flatfeet is 13.6% in people aged 18–21 years. They found that there was no significant difference in prevalence of flatfeet according to gender. There was no correlation between BMI and arctic indices either. Alfonso et al. [9] have reported that there is a minimal relationship of flatfoot with weight, height, and BMI. In our study, there was no relationship between flatfoot diagnosed by RCSP or FPI and BMI ( $p = .206$  for right flatfoot using FPI,  $p = .316$  for left flatfoot using FPI,  $p = .728$  for right flatfoot using RCSP, and  $p = .629$  for left flatfoot using RCSP).

Gijon-Nogueron et al. [27] have reported normative foot posture index values for pediatric population by cross-sectional study. Their study included 1762 school children aged 6–11 years. By gender, average values for the right foot were slightly higher in boys than in girls, with values of 3.93 (SD 2.99) versus 3.61 (SD 2.86). Mean value for the left foot was 4.00 (SD 2.96) in boys and 3.74 (SD 2.87) in girls. A report have shown that males are twice more prone to have flatfoot than females [13]. In another study, however, the prevalence of flatfoot in girls is higher than that in boys probably due to smaller bones and less bulky muscles in girls [28]. Our study showed no correlation of flatfoot with boys or girls ( $p = .868$  between boys and girls for right flatfoot using FPI,  $p = 0.971$  for left flatfoot using FPI,  $p = .662$  for right flatfoot using RCSP, and  $p = .160$  for left flatfoot using RCSP). Thus, the relationship of flat foot with gender and BMI appears to be controversial in elementary school students.

This study had the following limitations. First, all measurements were performed by the same practitioner. Thus, measurement was not average FPI or RCSP values measured by several practitioners, but one measurement. In addition, intra-rater reliability was not confirmed in FPI or RCSP measurements in this study. There are several reports on the high reliability of FPI [4,5,8]. According to Evan et al. [8], RCSP intra-rater reliability of the children group (aged 4 to 6 years) and the adult group (aged 20 to 50 years) showed moderate reliability of 0.699 (ICC, 95% CI) and 0.533 (ICC, 95% CI), respectively. However, the intra-rater reliability of RCSP was moderate to good in the adolescent group (aged 8 to 15 years, 0.706 ICC, 95% CI), including participants of our study. Diamond et al. [23,29] have reported that RCSP can be measured with good intra-rater reliability. In a study from Sobel et al. [7], the intra-class correlation coefficient of RCSP for three examiners also ranged from 0.61 to 0.90.

We cannot say precisely that our study method performed by one practitioner is an accurate measure. The intra-rater reliability test should be performed to ensure accuracy. Unfortunately, it could not be performed. However, as reviewed above, previous FPI and RCSP intra-rater reliabilities were moderate to good for participants at elementary school age range.

Second, our study results may not represent general characteristics of elementary school students due to its small sample size. In pediatric population, flatfoot diagnosis using RCSP has not been studied in large-scale yet. Further studies are needed.

Third, we did not diagnose flatfoot via radiological evaluation due to radiation risk for elementary school students. More studies are required in future, based on radiological parameters of flatfoot to



Fig. 2. Measurement of the Resting Calcaneal Stance Position (RCSP) angle.

evaluate the correlation between RCSP and radiological diagnosis.

Finally, the interval of one hour between measures might be insufficient to not bias the result. However, due to the nature of school-aged participants who had difficulty revisiting the clinics, we took a maximal interval of up to one hour. Bias was reduced by using FPI measurement at 1 h after completely erasing the bisection line of calcaneus which was marked with a water-soluble pen.

### 5. Conclusions

Our study is the first one to reveal a correlation between FPI and RCSP in elementary school students. Thus, both FPI with proven validity and reliability and RCSP widely used in the manufacture of insoles can be used as important biomechanical evaluation tools for feet in clinical settings.

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Availability of data and material

Not applicable.

### Funding

This work was supported by a grant (< GN1 > NRF-2017R1C1B5018006) < /GN1 > of the National Research Foundation (NRF) funded by the Ministry of Science, ICT & Future Planning(MSIP), Republic of Korea.

Table 3

Association between personal characteristics and prevalence of flat foot diagnosed with FPI or RCSP.

Personal characteristic	FPI		RCSP		P value (FPI)		P value (RCSP)	
	Right	Left	Right	Left	Right	Left	Right	Left
Age								
8 (n = 47)	13 (28%)	10 (21%)	11 (23%)	9 (19%)	.438	.802	.331	.551
9 (n = 65)	23 (35%)	21 (32%)	19 (29%)	19 (29%)				
11 (n = 12)	3 (25%)	3 (25%)	2 (17%)	2 (17%)				
12 (n = 43)	9 (21%)	9 (21%)	9 (21%)	9 (21%)				
13 (n = 41)	12 (29%)	11 (27%)	8 (20%)	8 (20%)				
Sex								
Male (n = 116)	34 (29%)	30 (26%)	26 (22%)	22 (19%)	.868	.971	.662	.160
Female (n = 92)	26 (28%)	24 (26%)	23 (25%)	25 (27%)				
BMI								
< 18.5, slimming (n = 113)	29 (26%)	29 (26%)	29 (26%)	28 (25%)	.206	.316	.728	.629
18.5-24.9, normal (n = 87)	27 (31%)	22 (25%)	16 (18%)	17 (20%)				
> 25, overweight (n = 8)	4 (50%)	3 (38%)	4 (50%)	2 (25%)				
Total (n = 208)	60 (29%)	54 (26%)	49 (24%)	47 (23%)				

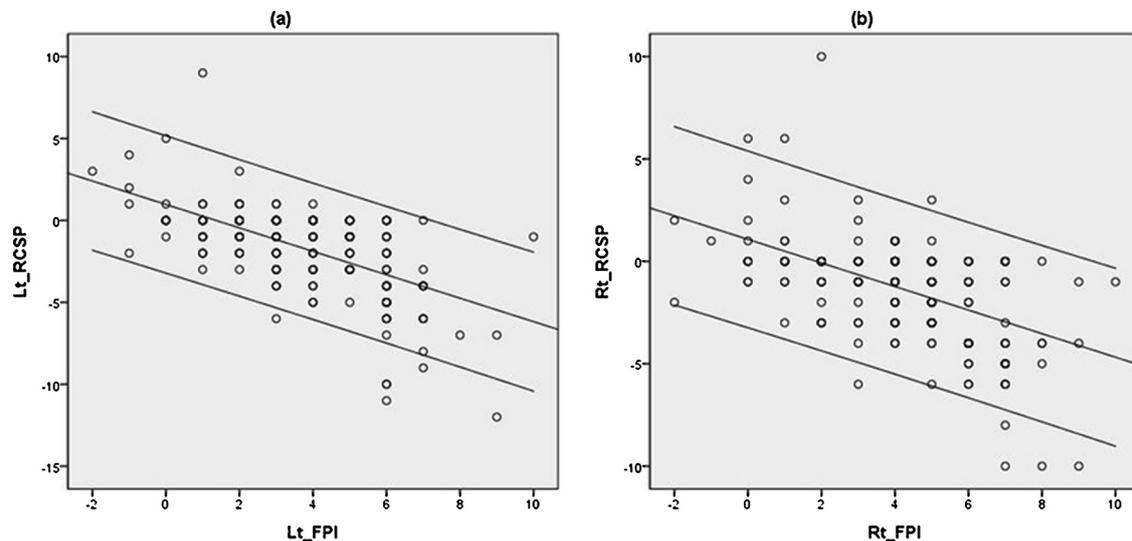


Fig. 3. Pearson correlation graph by quantitative analysis of FPI and RCSP.

### Declaration of Competing Interest

The authors declare that they have no competing interests.

### Acknowledgments

The authors certify that they have no affiliations or involvement with any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

### References

- [1] M. Razeghi, M.E. Batt, Foot type classification: a critical review of current methods, *Gait Posture* 15 (3) (2002) 282–291 <https://www.ncbi.nlm.nih.gov/pubmed/11983503>.
- [2] J.S. Lee, K.B. Kim, J.O. Jeong, N.Y. Kwon, S.M. Jeong, Correlation of foot posture index with plantar pressure and radiographic measurements in pediatric flatfoot, *Ann. Rehabil. Med.* 39 (1) (2015) 10–17 <https://www.ncbi.nlm.nih.gov/pubmed/25750866>.
- [3] S. Stolzman, M.B. Irby, A.B. Callahan, J.A. Skelton, Pes planus and paediatric obesity: a systematic review of the literature, *Clin. Obes.* 5 (2) (2015) 52–59 <https://www.ncbi.nlm.nih.gov/pubmed/25808780>.
- [4] A.C. Redmond, J. Crosbie, R.A. Ouvrier, Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index, *Clin. Biomech. Bristol Avon (Bristol, Avon)* 21 (1) (2006) 89–98 <https://www.ncbi.nlm.nih.gov/pubmed/16182419>.
- [5] S.C. Morrison, J. Ferrari, Inter-rater reliability of the Foot Posture Index (FPI-6) in the assessment of the paediatric foot, *J. Foot Ankle Res.* 2 (2009) 26 <https://www.ncbi.nlm.nih.gov/pubmed/19845961>.
- [6] S.Y. Ahn, S.K. Bok, B.O. Kim, I.S. Park, The effects of talus control foot orthoses in children with flexible flatfoot, *J. Am. Podiatr. Med. Assoc.* 107 (1) (2017) 46–53 <https://www.ncbi.nlm.nih.gov/pubmed/28271943>.
- [7] E. Sobel, S.J. Levitz, M.A. Caselli, M. Tran, F. Lepore, E. Lilja, et al., Reevaluation of the relaxed calcaneal stance position. Reliability and normal values in children and adults, *J. Am. Podiatr. Med. Assoc.* 89 (5) (1999) 258–264 <https://www.ncbi.nlm.nih.gov/pubmed/10349290>.
- [8] A.M. Evans, A.W. Copper, R.W. Scharfbillig, S.D. Scutter, M.T. Williams, Reliability of the foot posture index and traditional measures of foot position, *J. Am. Podiatr. Med. Assoc.* 93 (3) (2003) 203–213 <https://www.ncbi.nlm.nih.gov/pubmed/12756311>.
- [9] A. Martinez-Nova, G. Gijon-Noguero, P. Alfageme-Garcia, J. Montes-Alguacil, A.M. Evans, Foot posture development in children aged 5 to 11 years: a three-year prospective study, *Gait Posture* 62 (2018) 280–284 <https://www.ncbi.nlm.nih.gov/pubmed/29604617>.
- [10] J.B. Volpon, Footprint analysis during the growth period, *J. Pediatr. Orthop.* 14 (1) (1994) 83–85 <https://www.ncbi.nlm.nih.gov/pubmed/8113378>.
- [11] M. Pourghasem, N. Kamali, M. Farsi, N. Soltanpour, Prevalence of flatfoot among school students and its relationship with BMI, *Acta Orthop. Traumatol. Turc.* 50 (5) (2016) 554–557 <https://www.ncbi.nlm.nih.gov/pubmed/27760696>.
- [12] A. Aenumulapalli, M.M. Kulkarni, A.R. Gandotra, Prevalence of flexible flat foot in adults: a cross-sectional study, *J. Clin. Diagn. Res.* 11 (6) (2017) AC17–AC20 <https://www.ncbi.nlm.nih.gov/pubmed/28764143>.
- [13] J.H. Chang, S.H. Wang, C.L. Kuo, H.C. Shen, Y.W. Hong, L.C. Lin, Prevalence of flexible flatfoot in Taiwanese school-aged children in relation to obesity, gender, and age, *Eur. J. Pediatr.* 169 (4) (2010) 447–452 <https://www.ncbi.nlm.nih.gov/pubmed/19756732>.
- [14] A.M. Keenan, A.C. Redmond, M. Horton, P.G. Conaghan, A. Tennant, The Foot Posture Index: rasch analysis of a novel, foot-specific outcome measure, *Arch. Phys. Med. Rehabil.* 88 (1) (2007) 88–93 <https://www.ncbi.nlm.nih.gov/pubmed/17207681>.
- [15] A. Redmond, *Foot Posture Index - User Guide and Manual*, University of Leeds, 2005.
- [16] M.I. Root, Biomechanical examination of the foot, *J. Am. Podiatry Assoc.* 63 (1) (1973) 28–29 <https://www.ncbi.nlm.nih.gov/pubmed/4682653>.
- [17] R.A. Donatelli, Normal biomechanics of the foot and ankle, *J. Orthop. Sports Phys. Ther.* 7 (3) (1985) 91–95 <https://www.ncbi.nlm.nih.gov/pubmed/18802279>.
- [18] H.A. Banwell, S. Mackintosh, D. Thewlis, Foot orthoses for adults with flexible pes planus: a systematic review, *J. Foot Ankle Res.* 7 (1) (2014) 23 <https://www.ncbi.nlm.nih.gov/pubmed/24708560>.
- [19] K.A. Kirby, The medial heel skive technique. Improving pronation control in foot orthoses, *J. Am. Podiatr. Med. Assoc.* 82 (4) (1992) 177–188 <https://www.ncbi.nlm.nih.gov/pubmed/1597827>.
- [20] M.L. Root, Development of the functional orthosis, *Clin. Podiatr. Med. Surg.* 11 (2) (1994) 183–210 <https://www.ncbi.nlm.nih.gov/pubmed/8205507>.
- [21] R.L. Blake, Inverted functional orthosis, *J. Am. Podiatr. Med. Assoc.* 76 (5) (1986) 275–276 <https://www.ncbi.nlm.nih.gov/pubmed/3712254>.
- [22] S.P. Baitch, R.L. Blake, P.L. Fineagan, J. Senatore, Biomechanical analysis of running with 25 degrees inverted orthotic devices, *J. Am. Podiatr. Med. Assoc.* 81 (12) (1991) 647–652 <https://www.ncbi.nlm.nih.gov/pubmed/1804954>.
- [23] L.K. Dahle, M.J. Mueller, A. Delitto, J.E. Diamond, Visual assessment of foot type and relationship of foot type to lower extremity injury, *J. Orthop. Sports Phys. Ther.* 14 (2) (1991) 70–74 <https://www.ncbi.nlm.nih.gov/pubmed/18796826>.
- [24] H.A. Banwell, M.E. Paris, S. Mackintosh, C.M. Williams, Paediatric flexible flat foot: how are we measuring it and are we getting it right? A systematic review, *J. Foot Ankle Res.* 11 (2018) 21 <https://www.ncbi.nlm.nih.gov/pubmed/29854006>.
- [25] F. Halabchi, R. Mazaheri, M. Mirshahi, L. Abbasian, Paediatric flexible flatfoot; clinical aspects and algorithmic approach, *Iran. J. Pediatr.* 23 (3) (2013) 247–260 <https://www.ncbi.nlm.nih.gov/pubmed/23795246>.
- [26] A.M. Dowling, J.R. Steele, L.A. Baur, Does obesity influence foot structure and plantar pressure patterns in prepubescent children? *Int. J. Obes. Relat. Metab. Disord.* 25 (6) (2001) 845–852 <https://www.ncbi.nlm.nih.gov/pubmed/11439299>.
- [27] G. Gijon-Noguero, J. Montes-Alguacil, P. Alfageme-Garcia, J.A. Cervera-Marin, J.M. Morales-Asencio, A. Martinez-Nova, Establishing normative foot posture index values for the paediatric population: a cross-sectional study, *J. Foot Ankle Res.* 9 (2016) 24–31 <https://www.ncbi.nlm.nih.gov/pubmed/27468312>.
- [28] R.O.M. Eluwa, T. Kpela, T. Ekanem, A. Akpantah, The incidence of pes planus among Akwa Ibom state students in the university of calabar, *Internet J. Forensic Sci.* 3 (2) (2009), <http://ispub.com/IJFS/3/2/5228>.
- [29] J.E. Diamond, M.J. Mueller, A. Delitto, D.R. Sinacore, Reliability of a diabetic foot evaluation, *Phys. Ther.* 69 (10) (1989) 797–802 <https://www.ncbi.nlm.nih.gov/pubmed/2780806>.