Correlation Between Foot Posture Index and Radiographic Parameters

Yun Jae Cho
Hanil General Hospital
Jae Hee Lee
Seoul National University Hospital
Min Gyu Kyung
Seoul National University Hospital
Min Seok Shin
Seoul National University Hospital
Jay Hoon Park
Seoul National University Hospital
Dong Yeon Lee (leedy@snu.ac.kr)
Seoul National University Hospital https://orcid.org/0000-0001-8233-6285

Research

Keywords: Foot, Foot Posture Index, Radiographic parameters, Reliability, Correlation

Posted Date: July 7th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-40101/v1

Abstract

Background: The Foot Posture Index (FPI-6) is a validated and rapid clinical method for evaluating standing foot posture through assessing six individual criteria. Although it has been widely used without radiographic examination, evidences for correlation of FPI-6 with radiographic parameters remain scanty. The objective of this study is to investigate the correlation of FPI-6 with radiographic measurements and to assess the feasibility of FPI-6 for clinical evaluation of standing foot postures.

Methods: Sixty patients (M:F,33:27, mean age 62) of foot and ankle symptoms and 40 asymptomatic male volunteers (age, 20-28), were included in this study. FPI-6 scores were evaluated by 4 raters and inter-rater reliability of FPI-6 was assessed by intraclass correlation coefficient (ICC). Radiologic measurements including talo-first metatarsal angle (TMA), Meary's angle (MA), talonavicular coverage angle (TNCA), talocalcaneal angle (TCA), calcaneal pitch angle (CPA), and hindfoot alignment angle (HAA) were measured. For the correlation analysis between FPI-6 and radiographic parameters, statistical analysis was performed using Pearson's correlation test.

Results: Inter-rater reliability was 'high to excellent' among raters. However, FPI-6 score was more repeatable in patients group and in more experienced raters. In total group, FPI-6 score was correlated with TNCA, TMA, lateral TCA, MA, and HAA. Especially, TNCA and HAA were more strongly correlated among them. When we analyzed the subdomains of FPI-6, the congruence of the medial longitudinal arch and the prominence in the region of the talonavicular joint were most strong indicators for TNCA and HAA, respectively.

Conclusion: This study manifested that not only the feasibility of the FPI-6, but also its correlation to radiographic parameters, is significant for both the patients and the asymptomatic group. We assert that FPI-6 scoring system can be used as a first-line tool for foot posture assessment in clinics without radiographic evaluation if used carefully.

Background

Foot Posture Index(FPI) was developed to provide a rapid and reliable method for diagnosing static foot posture [1]. In the beginning, it was developed as 8 individual items called FPI-8, followed by the development of modified FPI, commonly known as FPI-6 [2]. Today, FPI-6 is considered as an assessment tool that reduces many of the reliability concerns present in traditional assessments owing to its quick, reliable, and easy assessment methods in all three planes in clinical settings to analyze foot posture variation [2, 3]. Based on three-dimensional observations, the FPI-6 consists of six evaluation criteria, each having a 5-point scale that ranges from − 2 to + 2, with negative numbers indicating a more supinated foot posture and positive numbers indicating a more pronated foot posture [4, 5]. Up to this point, there have been many works in research and clinical settings using FPI-6 to study risk factor for sports injury, foot posture associated plantar pressure, disease mobility, foot mobility, and foot kinematics [4, 6–9].

Although, FPI-6 provides a reliable description and enables the interpretation of foot posture, there are variable and conflicting results about inter-rater reliability of FPI studies as poor, moderate and good [10–12]. Also, many previous studies were only designed to examine total score of FPI-6 without analyzing individual score criteria of FPI-6, which is even focused in the same total score of FPI-6 [13, 14]. For decades, many studies correlating FPI-6 with radiographic measurements in patients suffering from foot and ankle deformity have been performed, but there are few clear studies exploring the correlation of FPI-6 with radiographic measurements in patients complaining foot and ankle symptom as well as in healthy people [15–17].

The objective of this study is to assess feasibility of FPI-6 for clinical evaluation of standing foot postures by (1) analyzing the reliability of FPI-6 in healthy people and patients with foot and ankle symptom, (2) investigating the correlation of each criteria of FPI-6 and total FPI-6 score with radiographic measurements. .

Methods

Participants

Participants comprised of asymptomatic subjects, who were categorized as Group A, and patients with foot and ankle symptoms, who were categorized as Group B. Group A were recruited from the population of asymptomatic men with non-pathological feet aged from 20 to 28(mean age 24). Prior to assembling participants, ethical approval was granted from the institutional review board of Seoul National University Hospital. The exclusion criteria were 1) subjective symptom while walking 2) history of fracture or surgery on the lower extremities 3) specific history of neuromuscular disease of foot and ankle 4) presence of another disorder causing difficulty to stand comfortably. After implementation of exclusion criteria, 40 asymptomatic participants were included in Group A.

For Group B, we reviewed the records of patients, who visited our hospital between August 2018 and May 2019 for the treatment of foot and ankle symptoms with pathologic deformity. The exclusion criteria were 1) history of surgery on the affected lower limb, 2) inability to stand independently due to lower limb impairment other than foot and ankle symptoms. Finally, 60 patients denominating group B (M:F,33:27, mean age 62) were included.

In addition , we further categorized the 60 patients with variable foot and ankle diseases by clinical symptoms and radiographic measurements; 5 cavus foot, 29 varus ankle osteoarthritis(varus OA), 9 flat foot, 4 valgus ankle osteoarthritis(valgus OA), 4 rheumatoid foot arthritis(RA) and 9 hallux valgus deformity(HV) .

FPI-6 measurement

FPI-6 was measured by 4 raters independently to minimize rater bias. Rater 1 was a physical therapist with the experience of more than 10 years in general orthopedic clinic and 4 months of measuring FPI-6.

Rater 2 was a physical therapist with the experience of 5 years in general orthopedic clinic and 4 months of measuring FPI-6. Rater 3 and 4 were inexperienced medical school students without much significant clinical experience. When measuring FPI-6, participants stood on both feet while staring ahead horizontally forward for about 1 minute. 6 individual criteria on a scale of -2, -1, 0, +1 or +2 were measured. In the anterior view, talar head palpation was measured. In the posterior view, supra/infra lateral malleolar curvature, inversion/eversion of calcaneus, bulging in talonavicular joint, congruence of the medial longitudinal arch and abduction/adduction of the forefoot on the rearfoot were measured(Fig. 1).

Radiographic measurements

Radiographic assessment was done by an orthopaedic surgeon (YJC) who independently measured the radiographs in a blinded manner. The radiographs from the patient's first visit were used for measurement. To limit the number of variables, we only analyzed the standing radiographs of the right foot in symptomless volunteers and the affected foot in patients. Seven Radiologic measurements including talo-first metatarsal angle (TMA), Meary's angle (MA), talonavicular coverage angle (TNCA), talocalcaneal angle in anteroposterior view and lateral view (TCA), calcaneal pitch angle (CPA), and hindfoot alignment angle (HAA) were measured (Fig. 2).

These measurement indices show excellent reliability and high discriminant validity [18].

Each radiographic parameter indicates the alignment of each segment of the foot. The CPA, HAA, and TCA were selected to describe hindfoot alignment. The TNCA and MA were used to explain the alignment of the midfoot. The TMA was measured to describe forefoot alignment [19].

Statistical methods

All data to elicit results were examined using Kolmogorv – Sminov tests and Shapro - Wilk tests to assess for normality. For the assessment of inter-rater reliability of FPI-6 in symptomless volunteers and patients, intraclass correlation coefficient (ICC) was analyzed. We interpreted ICC < 0.5 as suggesting poor repeatability, 0.5 ≤ ICC < 0.75 as good repeatability, and ICC ≥ 0.75 as excellent repeatability[20]. For analyzing correlation between FPI-6 and radiographic measurements, average FPI-6 values of two most experienced examiners was selected and evaluated using Pearson's correlation analysis. We interpreted the correlation coefficient ≥ 0.5 as suggesting low correlation, ≥0.75 as moderate correlation, and ≥ 0.9 as high correlation. Additionally, we analyzed each disease in patients group with foot and ankle symptom using descriptive statistics to evaluate the correlation with FPI-6 and radiographic measurement. Statistical analysis was performed using SPSS software (version 25.0, SPSS; Inc., Chicago, IL, USA).

Results

Reliability of FPI-6

In Group A, the range of mean total FPI-6 score in each rater was 0.73 to 1.15 (minimum value − 3, maximum value 10) which means nearly neutral in posture. In Group B, the range of mean total FPI-6 score in each rater was − 0.37 to 0.4, being broader as expected. Remarkably, in our studies, notable outliers were shown in Group A, unlike in Group B (Fig. 3).

In terms of inter-rater reliability, ICC of all raters in Group A was 0.608, indicating good repeatability, whereas ICC of all raters in Group B was 0.878 (95%CI; 0.821 to 0.921), showing excellent repeatability (Table 1). As shown by the ICC of each rater, most high reliability were shown of rater 1 and 2 who were most experienced in both group 0.787 (95%CI; 0.632 to 0.881) and 0.938 (95%CI; 0.899 to 0.963) respectively. In terms of most two experienced raters, the ICC of total 100 participants was 0.927 (95%CI; 0.894 to 0.951) showing excellent reliability.

Correlation between radiographic measurements and FPI-6

The total FPI-6 score of 100 participants were correlated to TNCA, TMA, lateral TCA, MA, and HAA with statistically significant difference. Especially, TNCA and HAA were more strongly correlated among them, while the two radiographic measurements showed low and moderate correlation 0.665 and -0.773 respectively (Table 2A).

When comparing individual FPI-6 scores with radiographic measurements, FPI 4 (bulging in talonavicular joint) correlated most strongly with HAA (ICC = -0.748) and FPI 5 (congruence of the medial longitudinal arch) demonstrated a correlation to TNCA (ICC = 0.686)

Although analysis of total patients showed several correlations between FPI-6 and radiographic measurements, Group B demonstrated higher correlated ICC values between FPI-6 and radiologic measurements compared to Group A (Table 2B, 2C).

Patients Group characteristics

When we analyzed Group B, consisting of 60 patients with foot and ankle symptom, according to specific diseases using descriptive statistics, not only the individual FPI-6 score but the total FPI-6 score yielded negative values in cavus foot, varus OA and RA, and positive values in flat foot, valgus OA and HV patients (Fig. 4).

Discussion

The FPI-6 was developed in response to a requirement for a quick, easy, and reliable method for measuring foot position in a variety of clinical settings, while minimizing the subjectivity of clinical evaluation methods [21]. It is a useful assessment tool and the only approach that captures information about standing foot postures in multiple foot segments using palpation and observation of deformity without a requirement for complex measurement techniques for clinicians [22]. Especially, each individual FPI-6 score is considered to be affinitive to radiologic findings due to its reliance on visualization or palpation of deformity. Hence, in this study, we presented that the assessment of foot posture using FPI-6

was reproducible in asymptomatic people and patients with foot and ankle symptom, and that FPI-6 scores were correlated with radiographic measurements, suggesting that FPI-6 measurement is an adequate alternative for clinical application of foot postures in the absence of radiographic examinations.

Based on the data presented in this study, the range of mean total FPI-6 score in each rater was 0.73 to 1.15 in asymptomatic people, which means nearly neutral and slightly pronated in foot posture. Consistent with our study, previous studies have confirmed this tendency towards normal feet as being pronated rather than completely neutral [23, 24]. Also employing a large sample indicates that in the normal sample, the mean FPI-6 score is 2.4 (SD = 2.3), confirming that a slightly pronated foot posture is the normal position at rest [22] The range of mean FPI-6 score in each rater was − 0.37 to 0.4 in patients with foot and ankle symptom. Since the patient group is composed of individuals with heterogenous disease related deformities, the FPI-6 range should not be interpreted to have significant clinical implications. Nevertheless, limiting value of each FPI-6 score in the patient group was broader than those of the healthy group as expected. Notably, in contrast to the patient group, some outliers were reported in the asymptomatic group, which demonstrated that the absence of symptoms does not always suggest normal posture of foot and ankle.

When comparing inter-rater reliability of FPI-6 in our study, the findings in the asymptomatic people group showed good repeatability (ICC; 0.608) as in line with the previous studies [25–27]. Whereas the result analyzed in the patient group demonstrated excellent inter-rater reliability (ICC; 0.878)

In hoc, there have been many studies of factors affecting the inter-rater discrepancy in asymptomatic people group and patient group, clinically. First, FPI-6 manual does not show example figures of intermediate scores. In addition, for item 4, the manual figure shows a foot part that is not exactly the talonavicular joint region, which may lower inter-rater reliability, especially in people without any deformity [3]. Also, one could hypothesize that the soft-tissue influence, which is indeed what the assessor is basing the FPI-6 score on, plays an integral and perhaps more important role than the underlying bony structure in normal population [28]. Another study explained the difficulty, as reported by examiners, of visualizing bony structures. The presence of calluses, bunions and edema is more common in elderly people [29]. Meanwhile, the group with neurogenic pes cavus (mean FPI logit score = -2.78, SD = 2.32) and idiopathic pes cavus (mean = -2.63, SD = 1.25) had FPI-6 scores significantly different from the normal population (mean logit score = + 2.4), indicating that the FPI-6 data was sensitive to disease-related postural changes [22]. Similarly, another article reported the high sensitivity of the FPI-6 to postural change associated with pathological pes planovalgus (median FPI raw score = + 12) [30].

There appears to be a scope for using FPI-6 scores and associated normative values to help identify groups with structural pathology and to assist in the clinical decision-making process. Hence, distinct characteristics of palpation as well as clear visual observation about morphological deformity can be demonstrated the higher inter-rater reliability in patient group.

Interestingly, inter-rater reliability was excellent in rater 1 and 2, who were most experienced in taking FPI measurements. Their knowledge of the musculoskeletal system, palpation skills and foot surface anatomy knowledge may have allowed them to discern the FPI-6 criteria with reproducible precision. Previous studies reported that even novice examiners who have a background in musculoskeletal assessment were able to produce reliable inter-examiner results using the FPI-6 with minimal training [27]. However, the current study demonstrated that inter-rater reliability was relatively lower in inexperienced examiner, showing that experience and training would be valuable for application in clinical situation.

Previously, there have been few studies about the correlation between FPI-6 and radiographic parameters. They reported that total FPI-6 demonstrated weaker correlations with the radiographic parameters (CPA, 0.36; calcaneal first metatarsal angle, 0.42) in older people [13]. In pediatric flatfoot, FPI-6 was correlated with the MA ($r = 0.422$, $p = 0.008$) and CPA (−0.411, $p = 0.01$)[31]. Inconsistent with previous studies, CPA was not correlated with total FPI-6 in our study. Instead, TNCA, TMA, lateral TCA, MA, and HAA were correlated with total FPI-6 with statistical significance. Especially, TNCA and HAA were more strongly correlated among them, having almost moderate correlation 0.665 and − 0.773 respectively.

More specifically, we compared individual FPI-6 scores with several radiographic parameters. This result was compatible with a previous study which reported that 4 individual components of the FPI score were poorly correlated with relevant radiographic parameters in young healthy subjects, with the exception of a moderate correlation between talar head palpation and the TNCA (0.42, $p < 0.001$) [28].

At first, we speculated that radiographic parameters which correspond to individual FPI-6 scores would exist, such as a relationship between congruence of the medial longitudinal arch and CPA. But, the bulging in talonavicular joint was most correlated with HAA (-0.748, $p < 0.001$) and the congruence of the medial longitudinal arch was correlated with TNCA (0.686, $p < 0.001$). Hence, although some radiographic parameters that were speculated to correspond with specific individual FPI-6 did show some correlation, the speculated match was not the most correlated as we expected.

When we compare the asymptomatic group and the patient group, the patient group exhibited higher correlation between FPI-6 and radiographic parameters. In general, in asymptomatic participants, distinct characteristics in radiographic parameters might not be present in contrary to the patients group. Furthermore, in the patients group, TNCA was highly correlated with talar head palpation, and HAA was highly correlated with inversion/eversion of calcaneus. This correlation demonstrates that some individual FPI-6 could be applied in midfoot and hindfoot assessment in clinical settings regarding foot and ankle deformities. When we specified each disease in 60 patients with foot and ankle symptom using descriptive statistics, not only the individual FPI-6 score but the total FPI-6 score were negative (supinated) in cavus foot, varus osteoarthritis and rheumatic arthritis, and the scores were positive (pronated) in flat foot, valgus osteoarthritis and hallux valgus patients

The primary limitation of this study is that gender and age were not controlled. Group A was composed only of men of young age, and Group B was relatively older, so there could be a limitation in the analysis of repeatability and correlation of this study. However, we think age was not an important issue because

we focused on the repeatability of FPI-6 scoring system rather than actual scores of each case. Second, the distribution of disease was uneven, having high number of varus OA patient. However, the purpose of our study was not only to identify correlation between FPI-6 and radiologic measurements in asymptomatic volunteers and patients with radiographic deformity separately, but also to confirm correlation of total 100 participants overall, regardless of whether or not a disease is present. Third, whereas repeatability of FPI-6 was confirmed by each 4 raters, radiographic parameter was only analyzed by 1 orthopedic surgeon, whereby reliability could be poor. Therefore, further research should be undertaken to evaluate the effect of these potential confounders and to overcome each limitation described above.

Conclusions

In, this study, we have analyzed reliability of FPI-6 and its correlation with radiographic parameters not only in asymptomatic volunteers, but also in patients with radiographic deformity. Although experience of raters does affect FPI-6 scores, repeatability of FPI-6 assessment was substantial, particularly in the patient group. Similarly, FPI-6 scores were weakly correlated with several radiographic parameters in asymptomatic volunteers, but were more strongly correlated in patients with radiographic deformity. Therefore, if FPI-6 measurement is used properly by trained examiners in clinical settings, it could be a one of the significant tools in the assessment of foot posture in the absence of radiographic evaluation.

Abbreviations

TMA: Talo-first Metatarsal Angle; MA: Meary’s angle; TNCA: TaloNavicular Coverage Angle; TCA: TalocalCaneal Angle; CPA: Calcaneal Pitch Angle; HAA: Hindfoot Alignment Angle; FPI: Foot Posture Index; ICC: Intraclass Correlation Coefficient; OA: osteoarthritis; RA: rheumatoid foot arthritis; HV: hallux valgus deformity

Declarations

Acknowledgements

Not applicable.

Authors’ contributions

YJC: Validation, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **MSS:** Conceptualization, Investigation, Data curation, Formal analysis, Writing - original draft. **JHL:** Visualization, Methodology, Data curation, Writing - original draft. **MGK:** Resources, Data curation, Formal analysis. **JHP:** Data curation, Formal analysis. **DYL:** Conceptualization, Data curation, Project administration, Supervision, Validation, Writing - review & editing.

Funding

This study was supported by a grant (NRF-2017M3A9E2063104) from the Bio & Medical Technology Development Program of the National Research Foundation (NRF) funded by the Ministry of Science & ICT, Republic of Korea.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was reviewed and approved by the Institutional Review Board of Seoul National University hospital (H-1809-015-969l) and the need for informed consent was waived.

Consent for publication

All participants consented to their data being used in publication.

Competing interests

The authors declared that they have no competing interests.

References

1. Evans, A.M., et al., *Reliability of the Foot Posture Index and Traditional Measures of Foot Position.* Journal of the American Podiatric Medical Association, 2003. **93**(3): p. 203-213.
2. Redmond, A.C., J. Crosbie, and R.A. Ouvrier, *Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index.* Clin Biomech (Bristol, Avon), 2006. **21**(1): p. 89-98.
3. Redmond, A., *The foot posture index: easy quantification of standing foot posture: six item version: FPI-6: user guide and manual.* University of Leeds, Leeds, UK, 2005.
4. Teyhen, D.S., et al., *Static foot posture associated with dynamic plantar pressure parameters.* J Orthop Sports Phys Ther, 2011. **41**(2): p. 100-7.
5. Keenan, A.M., et al., *The Foot Posture Index: Rasch analysis of a novel, foot-specific outcome measure.* Arch Phys Med Rehabil, 2007. **88**(1): p. 88-93.
6. Yates, B. and S. White, *The incidence and risk factors in the development of medial tibial stress syndrome among naval recruits.* Am J Sports Med, 2004. **32**(3): p. 772-80.
7. Nubé, V.L., L. Molyneaux, and D.K. Yue, *Biomechanical Risk Factors Associated with Neuropathic Ulceration of the Hallux in People with Diabetes Mellitus.* Journal of the American Podiatric Medical Association, 2006. **96**(3): p. 189-197.
8. Cornwall, M.W. and T.G. McPoil, *Relationship between static foot posture and foot mobility.* J Foot Ankle Res, 2011. **4**: p. 4.

9. Buldt, A.K., et al., *Are clinical measures of foot posture and mobility associated with foot kinematics when walking?* J Foot Ankle Res, 2015. **8**: p. 63.
10. Terada, M., A.M. Wittwer, and P.A. Gribble, *Intra-rater and inter-rater reliability of the five image-based criteria of the foot posture index-6.* Int J Sports Phys Ther, 2014. **9**(2): p. 187-94.
11. Cornwall, M.W., et al., *Reliability of the Modified Foot Posture Index.* Journal of the American Podiatric Medical Association, 2008. **98**(1): p. 7-13.
12. Lee, J.D., et al., *Reliability of the Foot Posture Index (FPI-6) for Assessment of Stroke Patients.* Journal of Korean Physical Therapy, 2015. **27**(5): p. 311-314.
13. Menz, H.B. and S.E. Munteanu, *Validity of 3 clinical techniques for the measurement of static foot posture in older people.* J Orthop Sports Phys Ther, 2005. **35**(8): p. 479-86.
14. Morrison, S.C. and J. Ferrari, *Inter-rater reliability of the Foot Posture Index (FPI-6) in the assessment of the paediatric foot.* J Foot Ankle Res, 2009. **2**: p. 26.
15. Perera, A. and A. Guha, *Clinical and radiographic evaluation of the cavus foot: surgical implications.* Foot Ankle Clin, 2013. **18**(4): p. 619-28.
16. Sensiba, P.R., et al., *Inter- and intraobserver reliability in the radiographic evaluation of adult flatfoot deformity.* Foot Ankle Int, 2010. **31**(2): p. 141-5.
17. Nosewicz, T.L., et al., *The reliability and validity of radiographic measurements for determining the three-dimensional position of the talus in varus and valgus osteoarthritic ankles.* Skeletal Radiol, 2012. **41**(12): p. 1567-73.
18. Lee, K.M., et al., *Reliability and validity of radiographic measurements in hindfoot varus and valgus.* J Bone Joint Surg Am, 2010. **92**(13): p. 2319-27.
19. Sanal, H.T., et al. *Radiographic Analysis Of Foot Deformities in Cerebral Palsy: Which Angles Should I Measure on Foot X-rays?* 2014. ESSR 2014 Annual Scientific Meeting.
20. Porteny, L.G., *Foundations of Clinical Research: Applications to Practice, 2nd Edition*. 2000. p. 752.
21. Barton, C.J., et al., *Relationships between the Foot Posture Index and foot kinematics during gait in individuals with and without patellofemoral pain syndrome.* Journal of foot and ankle research, 2011. **4**(1): p. 10.
22. Redmond, A.C., Y.Z. Crane, and H.B. Menz, *Normative values for the Foot Posture Index.* J Foot Ankle Res, 2008. **1**(1): p. 6.
23. Burns, J., A.-M. Keenan, and A. Redmond, *Foot type and overuse injury in triathletes.* Journal of the American Podiatric Medical Association, 2005. **95**(3): p. 235-241.
24. Cain, L.E., et al., *Foot morphology and foot/ankle injury in indoor football.* Journal of Science and Medicine in Sport, 2007. **10**(5): p. 311-319.
25. Aquino, M.R.C., et al., *Reliability of Foot Posture Index individual and total scores for adults and older adults.* Musculoskelet Sci Pract, 2018. **36**: p. 92-95.
26. Martinez, B.R., et al., *Translation, Cross-cultural Adaptation and Reliability of the Foot Posture Index (FPI-6) - Brazilian Version.* Physiother Theory Pract, 2019: p. 1-6.

27. McLaughlin, P., et al., *Inexperienced examiners and the Foot Posture Index: A reliability study.* Man Ther, 2016. **26**: p. 238-240.
28. Scharfbillig, R., et al., *Criterion validation of four criteria of the foot posture index.* Journal of the American Podiatric Medical Association, 2004. **94**(1): p. 31-38.
29. Shibuya, N., et al., *Prevalence of podiatric medical problems in veterans versus nonveterans.* Journal of the American Podiatric Medical Association, 2011. **101**(4): p. 323-330.
30. Burns, J. and J. Crosbie, *Weight bearing ankle dorsiflexion range of motion in idiopathic pes cavus compared to normal and pes planus feet.* The Foot, 2005. **15**(2): p. 91-94.
31. Lee, J.S., et al., *Correlation of foot posture index with plantar pressure and radiographic measurements in pediatric flatfoot.* Ann Rehabil Med, 2015. **39**(1): p. 10-7.

Tables

Table 1
Inter-rater reliability of FPI using ICC

	Group A (n = 40)	Group B (n = 60)
Rater1 vs Rater2	0.787	0.938
Rater1 vs Rater3	0.583	0.962
Rater1 vs Rater4	0.471	0.809
Rater2 vs Rater3	0.637	0.938
Rater2 vs Rater4	0.535	0.772
Rater3 vs Rater4	0.601	0.824
Total 1 vs 2 vs 3 vs 4	0.608	0.878
Abbreviations: VS, versus; FPI, Foot Posture Index; ICC, interclass correlation coefficient.		
All Significant difference between groups ($p < 0.05$)		

Table 2A. Correlation analysis results of total 100 participants

TCA	TNCA	Talo1st MTA	TCA lat	CPA	Meary A	HAA	
FPI 1	**0.136**	**0.620***	**0.492***	**0.399***	**-0.052**	**0.530***	**-0.713***
FPI 2	**0.109**	**0.602***	**0.398***	**0.317***	**-0.066**	**0.505***	**-0.738***
FPI 3	**0.127**	**0.583****	**0.339****	**0.356****	**0.002**	**0.467***	**-0.726****
FPI 4	**0.072**	**0.573****	**0.358****	**0.323****	**-0.052**	**0.485****	**-0.748****
FPI 5	**0.166**	**0.686****	**0.438****	**0.318****	**-.263****	**0.658****	**-0.664****
FPI 6	**0.168**	**0.597****	**0.503****	**0.346****	**-0.095**	**0.512****	**-0.658****
Total FPI	**0.140**	**0.665****	**0.453****	**0.369****	**-0.096**	**0.570****	**-0.773****

Note: Data results are presented as correlation coefficient between the FPI-6 and radiographic variables; Pearson correlation matrix

*p<0.05 **p<0.001

TCA(talocalcaneal angle), TNCA(talonavicular coverage angle), Talo1st MTA (talo-1st metatarsal angle), TCA lat(talocalcaneal angle in lateral view), CPA(calcaneal pitch angle), HAA(hindfoot alignment angle)

FPI 1; Talar head palpation FPI 2; supra/infra lateral malleolar curvature FPI 3; inversion/eversion of calcaneus FPI 4; bulging in talonavicular joint FPI 5; congruence of medial longitudinal arch FPI 6; Ab/adduction of forefoot on rearfoot

Table 2

B. Correlation analysis results of Group A (asymptomatic 40 volunteers)

	TCA	TNCA	Talo1st MTA	TCA lat	CPA	Meary A	HAA
FPI 1	-0.086	.381*	0.048	-0.255	– .337*	.328*	-0.267
FPI 2	0.031	0.159	-0.164	-0.124	-0.097	0.114	-0.134
FPI 3	-0.100	0.206	0.060	– .326*	– .369*	0.281	-0.177
FPI 4	-0.091	.320*	0.027	-0.091	-0.148	0.217	-0.171
FPI 5	-0.095	0.130	-0.176	-0.021	-0.144	0.228	-0.213
FPI 6	0.046	.560**	0.198	– .337*	– .487**	.518**	-0.268
Total FPI	-0.156	0.258	0.139	-0.101	-0.200	0.172	– .374*

Table 2
C. Correlation analysis results of Group B (60 patients)

	TCA	TNCA	Talo1st MTA	TCA lat	CPA	Meary A	HAA
FPI 1	0.160	.713**	.500**	.455**	-0.138	.605**	– .801**
FPI 2	0.136	.705**	.591**	.465**	-0.168	.601**	– .765**
FPI 3	0.122	.672**	.456**	.391**	-0.127	.556**	– .780**
FPI 4	0.143	.629**	.388**	.404**	-0.065	.514**	– .761**
FPI 5	0.080	.641**	.421**	.355**	-0.133	.526**	– .777**
FPI 6	0.192	.712**	.469**	.480**	-0.247	.678**	– .716**
Total FPI	0.237	.664**	.542**	.492**	-0.033	.544**	– .712**

Figures

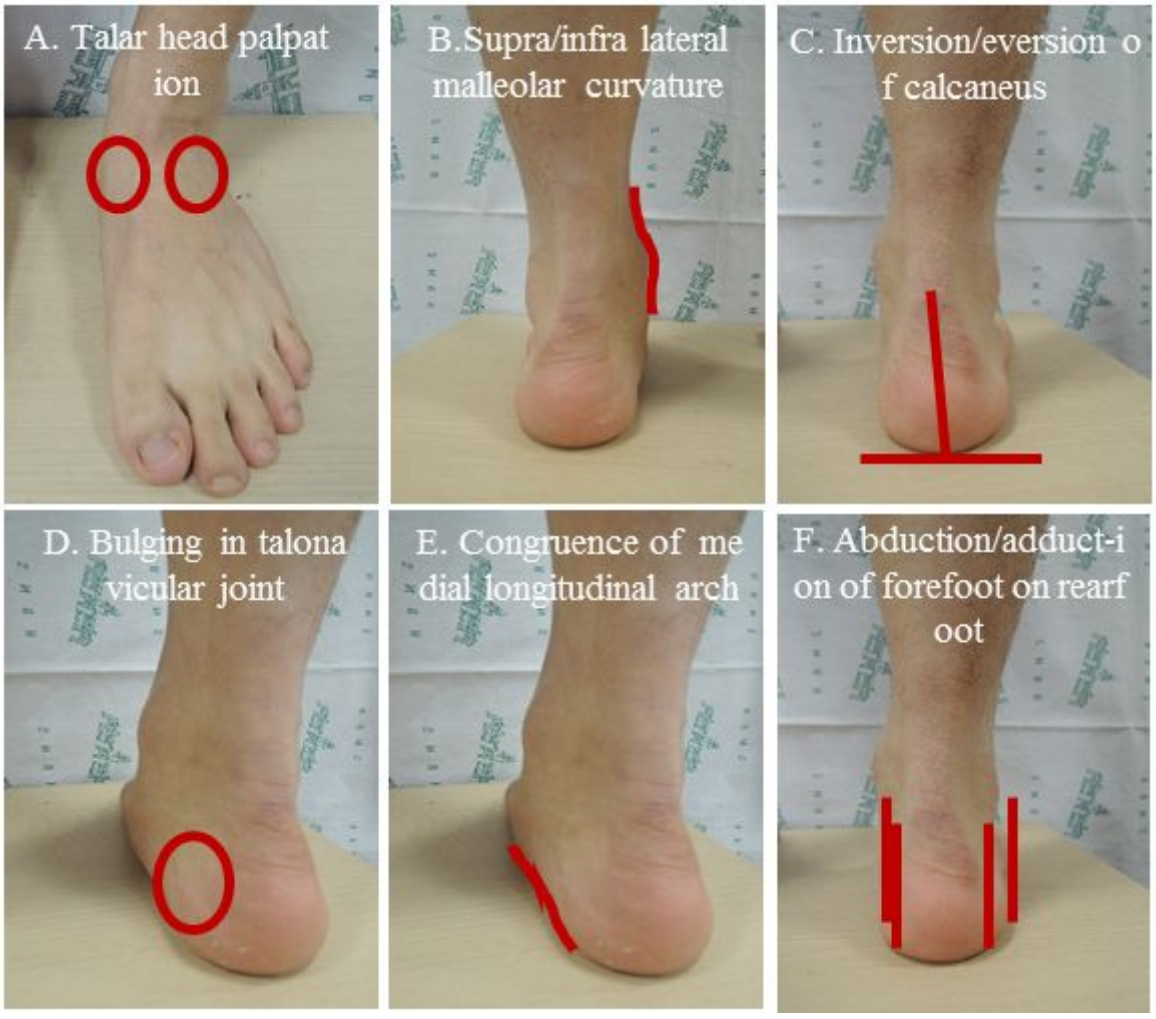

Figure 1

The six criteria of the Foot Posture Index. A. Talar head palpation; B. Supra & infra lateral malleolar curvature; C. Inversion/eversion of calcaneus; D. Bulging in talonavicular joint; E. Congruence of the medial longitudinal arch; F. Abduction/adduction of the forefoot on the rearfoot

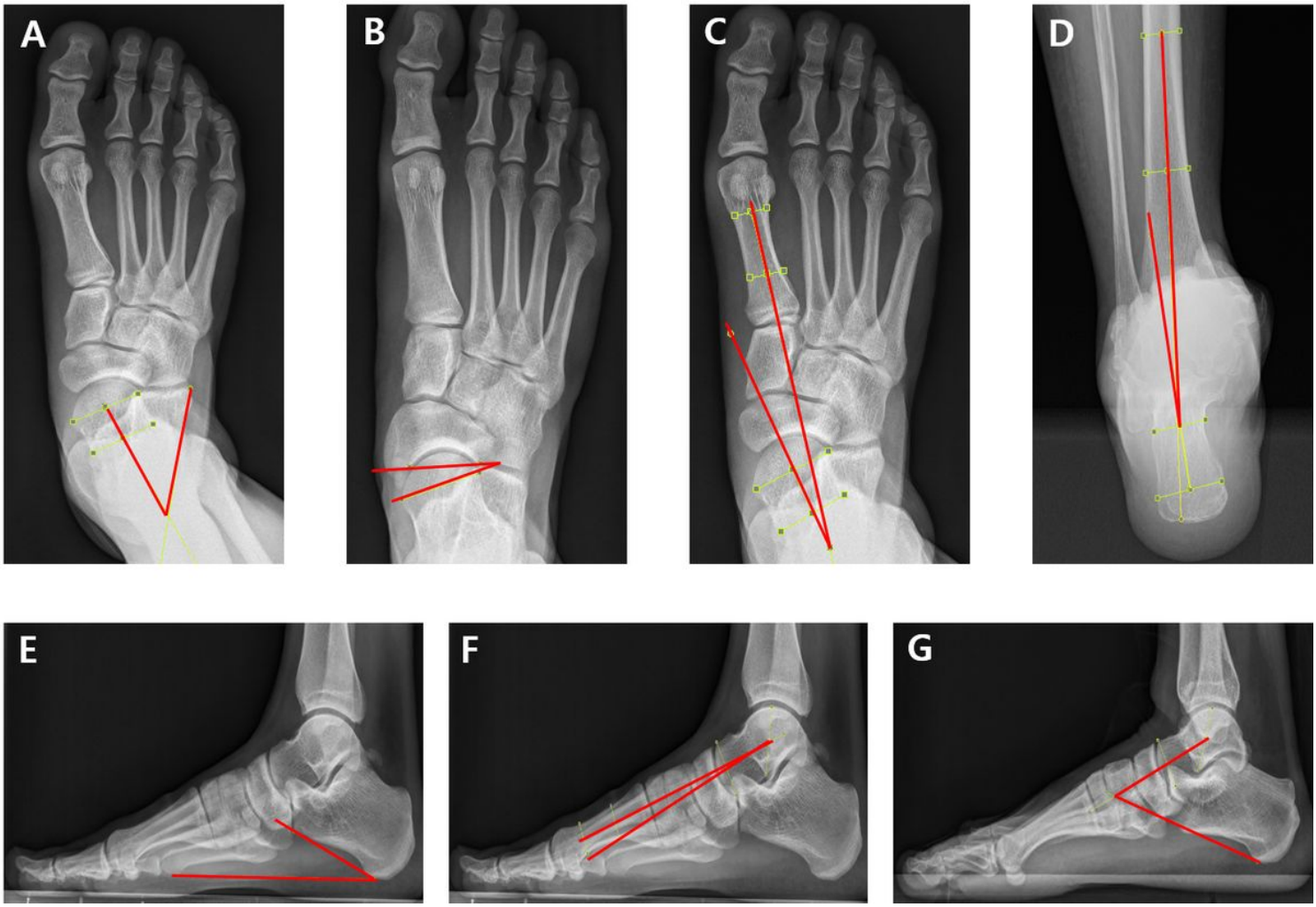

Figure 2

Radiologic measurements of the foot. A, Anteroposterior talocalcaneal angle: the angle a line bisecting the anterior surface of the talus and a line drawn along the lateral margin of the calcaneus. B, Talonavicular coverage angle: the angle between a line bisecting the anterior articular surface of the talus and a line bisecting the proximal articular surface of the navicular. C, Anteroposterior talo-first metatarsal angle: the angle between a line bisecting the anterior surface of the talus and the long axis of the first metatarsal bone. D, Hindfoot alignment angle: the angle between the long axis of tibia and the long axis of calcaneus. E, Calcaneal pitch angle: the angle between a line drawn along the edge of the plantar aspect of the soft tissue shadow and a line drawn along the lower margin of the calcaneus. F, Meary's angle: the angle between the long axis of talar head and the long axis of the first metatarsal bone. G, Lateral talocalcaneal angle: the angle between the long axis of talus and a line drawn along the lower margin of the calcaneus.

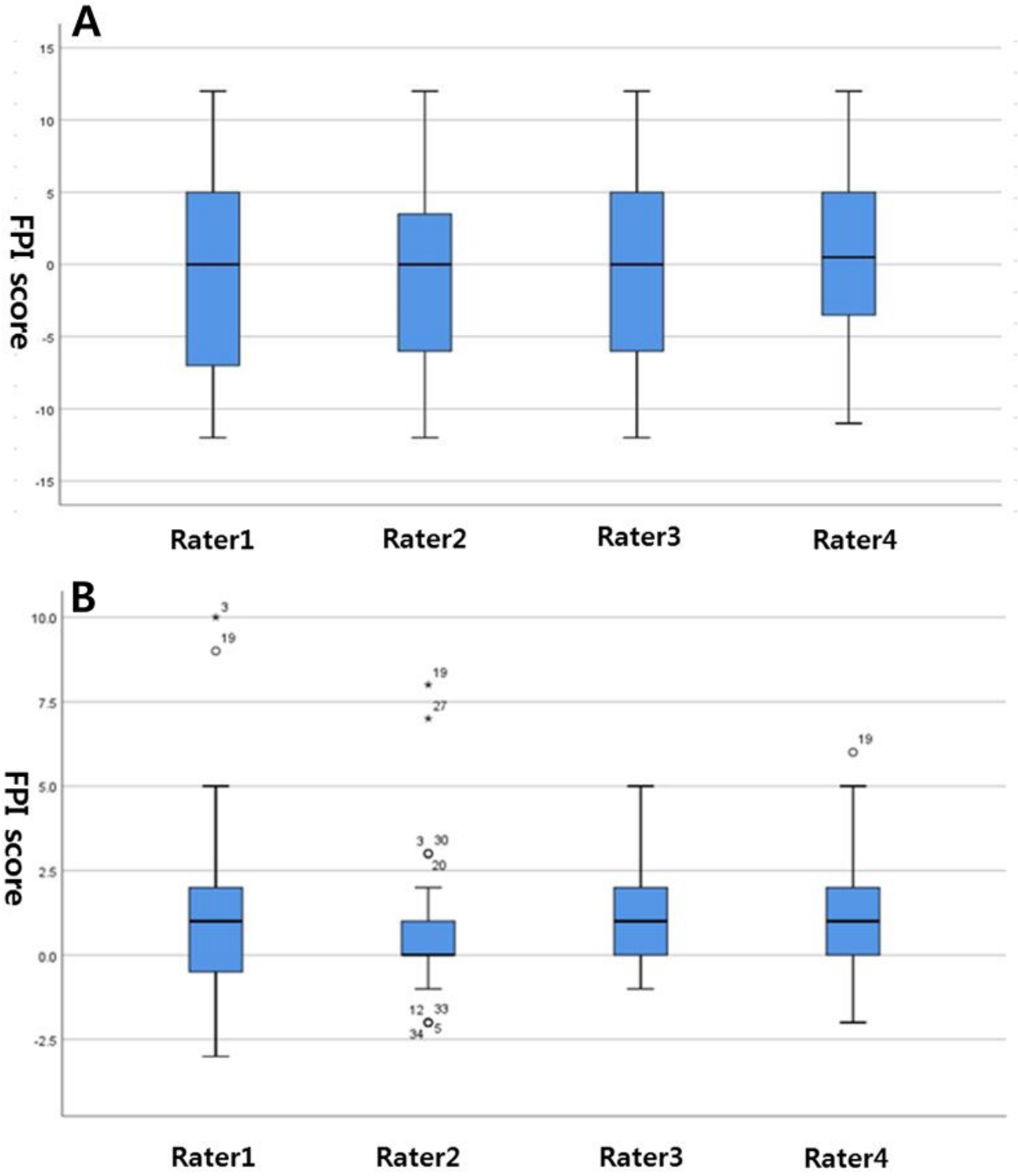

Figure 3

Five-number summary statistical analysis of FPI score in (A) Group A in (B) Group B.

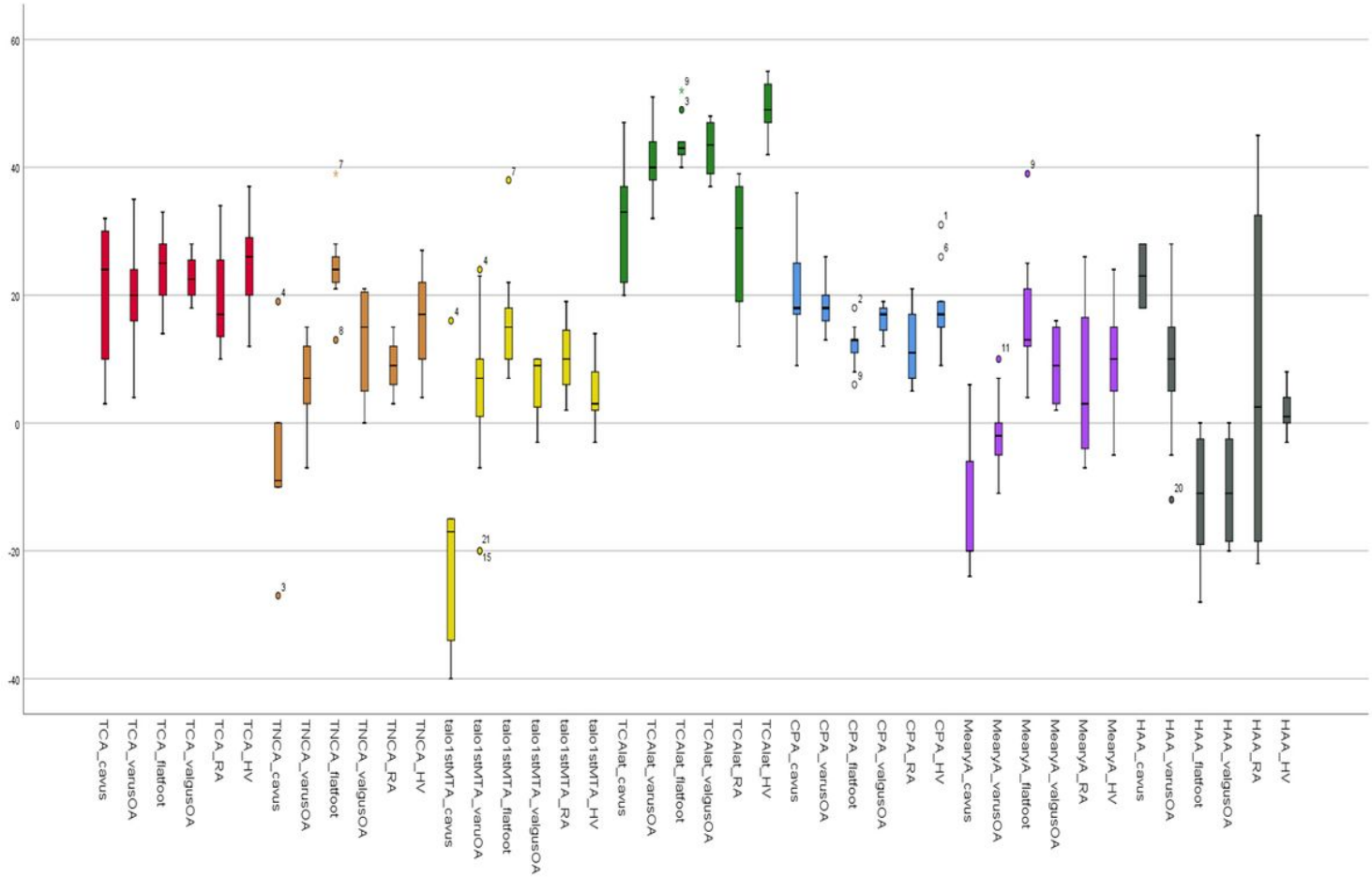

Figure 4

Five-number summary of FPI score in descriptive statistics by each disease at Group B.