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ESTABLISHING CONCURRENT VALIDITY BETWEEN CHIPPAUX-SMIRAK INDEX AND FOOT POSTURE INDEX IN ASYMPTOMATIC FLATFOOT INDIVIDUALS: A CORRELATION STUDY

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ABSTRACT

Introduction: There are various methods used to assess flat foot in the individuals. Foot posture index-6 (FPI-6) is a qualitative as well as a quantitative tool for assessing flat foot. Chippaux-Smirak index (CSI) is a quantitative method that can be calculated using the ink foot prints. Both of them are reliable methods but foot posture index is very commonly used. Thus, there arises a need to replace foot posture index with a new tool which is purely quantitative. Purpose**:** To establish concurrent validity between CSI and FPI-6 in asymptomatic flatfoot individuals. Methods: A total of 140 participants of Parul university, Vadodara, Gujarat between the age group of 18-25yrs with no history of pain or injury within last one year were assessed for asymptomatic flexible flatfoot. The CSI and FPI-6 were used to evaluate all individuals for asymptomatic flat foot. Participants were characterised as having flat foot if their CSI and FPI-6 score were equal to or greater than 45% and 6+ to 12+ respectively. Results: The CSI and the FPI-6 have a Spearman rho correlation value of 0.62 ($p<0.05$) indicating a moderate positive correlation among the two indices. Conclusion: As there is a moderate positive correlation of CSI with FPI-6, it can be used to assess the foot posture in asymptomatic flat foot individuals.

Keywords: pes planus, foot posture index-6, ink foot prints, flatfoot, Chippaux-Smirak index

INTRODUCTION:

The human foot can be categorized based on the height of the medial longitudinal arch (MLA) into three types: normal arch (pes rectus) with an average height of 2.57 ± 0.14 cm, low arch (pes planus) with an average height of 1.86 ± 0.23 cm, and high arch (pes cavus) with an average height of 3.26 ± 0.16 cm **[1]**. Pes planus or commonly known as flatfoot is identified by a reduction or flattening of the medial longitudinal arch. It is associated with misalignment of the foot, marked by significant pronation, rearfoot valgus, and midfoot abduction on the rearfoot **[2]**.

According to prior research, the prevalence of flat feet in the general population is roughly 25%. This incidence tends to be higher among females, those with a higher body mass index (BMI), and those with bigger feet. The incidence of flat feet reduces considerably with advancing age; it is 54% at 3 years, 24% at 6 years, and 11.25% at 18-25 years **[1]**.

Flat foot can be classified as rigid flat foot and flexible flatfoot. Rigid flat foot is defined as a reduction of arch height that may be seen in both non-weight bearing and weight bearing situations. Flexible flat foot occurs when a normal MLA height is present in non-weight bearing state and collapses with weight bearing **[1]**.

Acquired flat foot can be attributed to various factors, including aging, obesity, and the absence of footwear during early childhood. Moreover, the improper functioning of both extrinsic and intrinsic foot muscles either from birth or later in life has been identified as a contributing factor **[1]**.

Changes in MLA height might increase the incidence of lower limb injuries such as foot discomfort, toe deformities, ankle injuries, tibial stress syndrome, knee osteoarthritis, iliotibial band syndrome, patellofemoral syndrome, and noncontact anterior cruciate ligament injuries. Thus, evaluating the MLA is crucial in both clinical practice and for research purposes **[3]**.

There are various methods used to assess flat foot in individuals which included (a) non-quantitative visual inspection, (b) anthropometric measurements such as resting calcaneal stance position (RCSP) angle, navicular drop (ND) test, and medial longitudinal arch angle, (c) various footprint-based analyses like Chippaux–Smirak index (CSI), Staheli arch index (SI), Clarke angle (CA) etc., and (d) radiological examinations utilizing methods such as MRI, ultrasound, and laser scanners **[4][5]**. Previous research by Banwell *et al*. has shown that the FPI-6 is a reliable test for measuring foot position, which has contributed to its growing popularity over time **[4]**. Numerous footprint-based techniques including SI and CSI are

suggested for screening for flatfoot since they are regarded as reliable measures to assess the development of the arch by the researchers **[4]**. Compared with radiographic measures, it had been seen that FPI-6 has a moderate to excellent inter and intra- rater reliability of 0.94 and 0.57 respectively **[6] [7]**. The inter and intra-rater reliability of CSI was seen to be 0.848-0.958 and 0.940-0.990 respectively **[1]**.

Both being reliable methods, FPI-6 is a very commonly used one. Despite both being quantifiable measurements, there is little research on the relationship between the CSI and the FPI-6. Thus, there arises a need to replace FPI-6 with a new tool which is purely quantitative. Thus, this study aimed to establish concurrent validity between CSI and FPI-6 in asymptomatic flatfoot individuals.

MATERIALS AND METHODS:

The sample size was calculated using G*power (version 3.1.9.2). A total of 140 (total feet=280) participants were included in the study. The inclusion criteria were students studying in Parul University, Vadodara, Gujarat aged between 18-25years. The exclusion criteria for the study were 1) any injury or surgery of lower limb within one year, 2) presence of pain around the ankle and foot complex, 3) any connective tissue disorder, 4) previous or current inflammatory arthritis, 5) any neuromuscular or musculoskeletal disorders of foot other than flat foot and 6) any severe foot deformities. Informed consent was taken from all the participants prior to the study and approved by the Institutional Research Review Committee of the University. All the participants were assessed with FPI-6 score for foot posture and CSI calculated from the ink foot prints.

FPI-6 is a short version index of FPI-8 which comprises of six components rather than eight which needs to be assessed to differentiate between normal foot and pes planus or pes cavus. The participants were instructed to stand in their relaxed standing position with their arms by the side and looking forward. The six components checked were 1) Talar head palpation, 2) curves above and below the lateral malleolus, 3) inversion/eversion of the calcaneus, 4) prominence in the talonavicular joint, 5) congruence of the medial longitudinal arch, and 6) abduction/adduction forefoot on rearfoot. The scoring of each component is given from -2 to +2. The total calculated score between 0 to +5 is considered normal whereas +6 to +9 is considered as pronated foot and greater or equal to +10 as highly pronated foot which is seen in flatfoot **[5][8][9]**.

CSI was obtained by dividing the minimal distance of the midfoot by the maximum distance of the forefoot **[10]**. These variables were obtained from the ink foot prints. Five

categories are described for the medial longitudinal arch classification according to CSI: 0%: foot with elevated arch; 0.1–29.9%: foot with a morphological normal arch; 30–39.9%: intermediate foot; 40–44.9%: foot with a lowered arch; and 45% or higher flatfoot **[4]**.

Individuals having FPI-6 score + 6 to +12 and CSI score of 45% or more were considered as having flatfoot and enrolled in the study. FPI-6 and CSI scores were calculated in all the participants.

Statistical analysis was performed with IBM SPSS Statistics for Windows software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp.). CSI scores were in decimal whereas the FPI-6 scores were discrete and in whole numbers. Thus, the data did not follow the normality and hence, non-parametric test measures were used to find the correlation. Spearman rho's correlation coefficient was calculated with the level of statistical significance set at $p<.05$. The descriptive analysis included means± standard deviations (SD) of age of the participants.

RESULTS AND DISCUSSION:

The mean age was 21.5yrs. Spearman rho's correlation coefficient was calculated between FPI-6 score and CSI score. The Spearman rho correlation coefficient was 0.62 at $p<.05$. This indicated that there is a moderate positive correlation between CSI and FPI-6.

The purpose of this study aimed to determine the concurrent validity for the CSI and FPI-6 scores in individuals with asymptomatic flatfoot. In concurrent validity testing, the emphasis is on the consistency of findings and the relative strength of the associations observed rather than the *p*-value associated with each correlation coefficient as an inferential evaluation **[11]**. The current study found a correlation coefficient of 0.62, indicating a moderate positive association between CSI and FPI-6.

A previous study by Kanna Kato *et al*. found a positive correlation between force, strength, thickness and hardness of the masseter muscle using the qualitative and quantitative tool to measure the respected measures **[12]**. Similarly, in this study, CSI is a quantitative method whereas FPI-6 is both a qualitative and a quantitative metric to identify the foot pronation.

This good correlation indicates that both measurement methods are competent and correlated, therefore either may be used to determine the degree of foot pronation. As CSI is a more quantitative analysis, it can evaluate variances in decimal points with more precision, removing subjective bias.

Here, one of the reasons behind moderate correlation maybe the number of parameters used to calculate FPI-6 and CSI. FPI-6 has

six different parameters whereas CSI does not have any subjective parameter.

Another explanation for the moderate positive correlation is that CSI is uniplanar, which means it detects the foot type from just one plane, but FPI-6 is multiplanar, measuring the foot posture from all three planes and categorizes foot posture as pronated, supinated, or neutral **[4][5]**.

The most prevalent structural difference in flat foot is rear-foot varus, leading to excessive pronation of the foot. Additionally, observable changes such as a deepened navicular cup, widened talus articular surface, proximally faced talus, and higher positioned navicular articular surface may occur. These modifications result in the collapse of the medial longitudinal arch, causing a reduction in the arch height.**[1]** These structural changes are qualitatively expressed in FPI-6.

Table 1: Descriptive statistics, mean (SD)

Descriptive Statistics			
Characteristics	**N**	**Mean**	**Standard Deviation**
Age	**140**	**21.5000**	**1.78523**

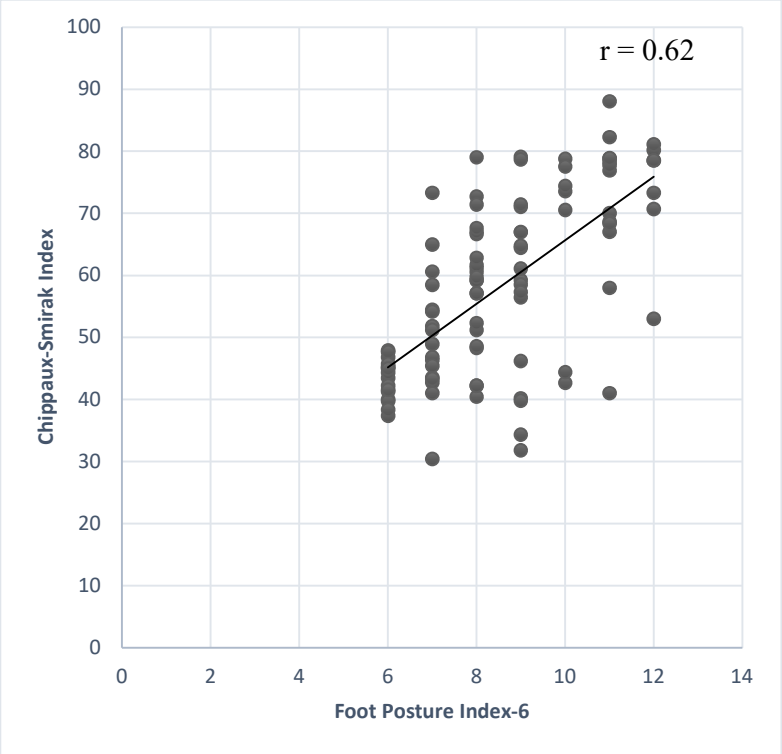

Figure 1: Spearman rho correlation found between Chippaux-Smirak index and Foot posture index-6, r=0.62, *p*<.05

CONCLUSION:

Henceforth, it can be concluded that as there was a moderate positive correlation between CSI and FPI-6, the former can replace the latter. These measurement tools can be used according to the purpose, scale and environment of the research.

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