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Research article

Pes Planus Level and Foot Pain Affect Selected Performance Parameters: A Study on Team Sport Athletes

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Abstract: Aims to investigate the relationship between pes planus (PP) with foot pain (FP) and performance in team sport athletes. Correlational research was adopted to reveal the relationship between PP with FP and performance. There were 84 athletes were involved in this research. Measurement of PP with footprint test (FT), FP with knee pain intensity-visual analogue scale (KPI-VAS) and performance with items 30m sprint (30ms), modified agility t-test (MATT), counter movement jump (CMJ), standing stock balance test (SSBT). We observed that FT-PP variable has a moderate negative correlation with FP-KPI-VAS ($p = 0.003$), which shows that PP significantly causes foot pain. In CMJ ($p = 0.035$) and SSBT ($p = 0.004$) there is a moderate negative correlation, which shows that the PP level reduced the level of power and balance. Meanwhile, there is a moderate positive correlation with 30mS ($p < .001$), and MATT ($p < .001$), which shows that the level of PP will reduce the level of running speed and agility. At the same time, FP-KPI-VAS had a small negative correlation with 30mS ($p = 0.017$), MATT ($p = 0.017$) and CMJ ($p = 0.048$). Finally, FP-KPI-VAS was found to have a large positive correlation with SSBT ($p < .001$). Thus, we confirm that PP is significantly correlated with FP and performance related to 30ms, MATT, CMJ, SSBT in team sports athletes.

Keywords: Foot Pain; Pes Planus; Motor-performance fitness; Team Sport

1. Introduction

Body anatomy such as the head, neck, trunk, hands and feet are very important in team sports [1]. The foot is an anatomical structure of the body that has a major contribution to athletes, because it has the function of carrying out various sports movements such as running, changing direction, jumping, landing or kicking [2]. Based on data from previous studies, it was found that there are several types of feet, namely normal arch (NA), pes cavus (PC), and flat foot (FF) [3, 4, 5]. Among these three types, FF or also known as pes planus (PP) is one of the musculoskeletal disorders of the feet [6], which has gain concern from several sports coaches today [7, 8]. PP is a condition that indicate by the absence of medial longitudinal arch angle (MLA) of the feet sole [9, 10, 11, 6]. This is as explained by Febriyanti et al. [12] PP occured due to a decrease or absence of MLA on foot, so the results in this part of the foot getting closer or in contact with the ground. According to a recent study, it is estimated that 25% of the world's population has PP [13], and most PP often occurs in children and adolescents who are boys compared to girls [14]. Based on previous reports, PP causes foot pain [15], or discomfort when standing or walking for a long

time [16, 17]. In addition, PP can cause a decrease in normal foot function, thus having a negative impact on athletes' performance when exercising [18]. According to Igbinedion et al. [19] PP could cause foot pain, foot injuries, foot stress and cause training process is not optimal.

In recent decades, PP has been claimed to be related to physical fitness [20, 21]. According to a previous study, PP had the potential to cause foot balance issue, which has an important role in various movements in team sports such as jumping, running and kicking [4]. Other research showed that athletes suffering from PP experienced decreased muscle strength endurance, balance [22], and gait disturbance [23]. Meanwhile, Alahmri et al. [24] reported that PP had lower muscle power and more easily tired than NA. However, another study showed that PP in basketball athletes was not affect jumping performance [25]. In fact, Tudor et al. [26] also emphasized that PP could not affect motor performance in vertical jumps, sprinting and balance. Based on inconsistent findings in previous studies, further research is needed to reveal the relationship between PP and foot pain and selected performance among athletes.

To the best of our knowledge, there is little research investigating the relationship between PP and foot pain as it relates to competitive performance among team athletes (e.g., Football, Handball, Futsal). Thus, this study aims to investigate the relationship between PP levels with foot pain and selected performance parameters among team athletes.

Materials and Methods

Participants

This research was carried out in February 2024 at the gynasium of Surabaya State University (Indonesia) which was fully approved by the Local Ethics Committee with number: B/40947/UN38.6/LT.02.02/2024. In addition, the research complies with the 2013 Helsinki Declaration. G*Power analysis (version 3.1.9.4, University Kiel, Germany) was used to determine the minimum sample requirements for correlational research with parameters correlation = 0.3, α err prob = 0.05, power (1- β err prob) = 0.80, and calculation result showed that the required sample was 84 athletes.

Based on the calculations above, we involved 84 athletes from team sports at the Faculty of Sports and Health Sciences, Surabaya State University (Indonesia). A letter of consent from the athlete's parents was obtained by the research team. They were selected based on the inclusion criteria: (i) having flat feet, (ii) male athletes, and (iii) team sports athletes. Meanwhile, the exclusion criteria was athletes who experienced leg pain and lower extremity injuries in the previous 6 months. Participant characteristics can be seen in Table 1.

Table 1. Participant characteristics

Parameter	Football (n = 34)	Handball (n = 20)	Futsal (n = 30)
Age (years)	19.6 ± 1.66	19.8 ± 1.67	19.9 ± 1.68
Weight (kg)	56.9 ± 1.60	57.0 ± 1.73	57.2 ± 1.88
Height (cm)	159 ± 2.68	160 ± 2.74	160 ± 2.80
Body mass index (kg/m^2)	21.9 ± 1.12	22.0 ± 1.10	22.0 ± 1.08
Sports experience (years)	2.81 ± 0.61	2.52 ± 0.54	2.56 ± 0.68

Study and Procedures

This study aims to investigate the relationship between PP levels and foot pain and selected performance parameters among team athletes through a correlational design [27]. This research was conducted in 3 test sessions on the same day (08/02/2024). The first test session was held at 08.00-09.00 am, the second test session was held at 10.00-11.00 am and the last test session was held at 13.00-15.00 pm. A schematic of the test session is shown in Figure 1.

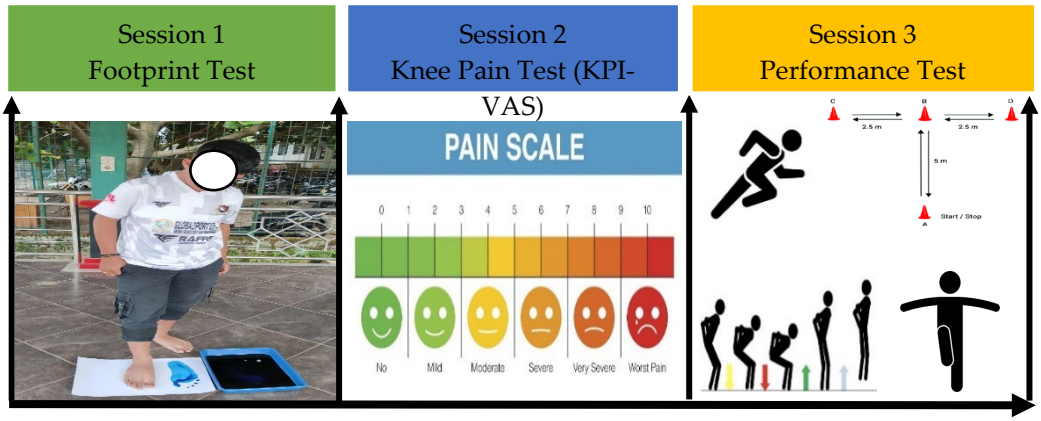

Figure 1. Schematic of the test session

Measurements

Footprint Test (FT)

PP can be measured using the Footprint Test (FT). Participants were instructed to stand up, then participants put their left and right feet into a container containing water or colored ink, and in the next stage the participant's feet were pressed as hard as possible on a piece of white paper (Fig. 1). As a result of the pressure on the feet, sole marks will be visible which can be used as an indication whether the participant has an abnormality in their feet or not. To classify the severity of PP it can be categorized into: grade I (medial edge of the plantar surface is still concave which towards the medial side of the foot axis), grade II (medial edge of the plantar surface is straight and does not cross the median axis of the foot) and grade III (medial edge of the plantar surface is convex and crosses the axis of the foot) [12].

Knee Pain Intensity-Visual Analogue Scale (KPI-VAS)

Knee Pain Intensity-Visual Anlogue Scale (KPI-VAS) was used to measure the foot pain [28, 29]. Participants were instructed to stand up and the research team pressed on the soles of their feet. Participants expressed the level of pain by choosing the score from 0 = no pain to 10 = very painful (Fig. 1).

Performance Test

Research, performance testing on athletes includes the selected motor-performance fitness (MPF) parameters:

30m Sprint (30mS)

30mS was to measure an athlete's running speed [30]. Participants were instructed to stand at the start line and after the whistle sounds, participants were required to run quickly towards the finish line. Participants had 3 trials. Assessments was carried out by recording the total time that was needed by athletes to run from the start line to the finish. This research took the best running time out of 3 trials.

Modified Agility T-Test (MATT)

MATT was used to measure the level of agility among athletes [31]. First, participants stood up in a straight position at cone A (star), and after the whistle sounded, participants run as fast as possible to cone B, and continue by running sideways to cone C. Then, participants run sideways to cone D, run sideways again to cone B and run backwards towards cone A (stop) (Fig. 1).

Counter Movement Jump (CMJ)

CMJ is an appropriate measurement tool for assessing leg muscle power [32]. First, participants stood up in a straight postition, hands placed on their hips and gaze facing forward. After the whistle sounded, participants bent their knees to 90 degrees and then immediately pushed their feet to jump as high as possible. Participants were given 3 trials and the highest jump was recorded and selected for analysis.

Standing Stork Balance Test (SSBT)

The SSBT had been used by a previous study to measure the balance level of athletes [33]. Initially, participants stood in an upright position, then participants were instructed to lift one leg and raise both arms beside the body. Then, the stopwatch started counting. If the participants were not able to maintain that position, or their feet fall on the floor, then the stopwatched would be stopped. Participants were given 3 trials and the best time was recorded for statistical analysis purposes.

Statistical Analysis

Jamovi statistics application (v.2.3.28) was chosen to analyze all data. First, descriptive statistical testing was carried out by researcher. Second, Shapiro-Wilk was used to determine the normality data from all variables. Third, product moment Pearson Correlation testing was used to test the relationship between PP variables and foot pain and performance. Pearson correlation coefficient was used to measure the linear relationship between two continuous variables. Correlation coefficient (r) values were calculated to determine the direction and strength of the relationship between variables. The intensity of relationship was determined by following these formula: <0.1 (trivial), <0.1–0.3 (small), <0.3–0.5 (moderate), <0.5–0.7 (large), <0.7–0.9 (very large) [27]. All analyzes used a significance level of 0.05.

Results

The results of descriptive statistical calculations are presented and at the same time all variables are proven to have normal data ($p > 0.05$) (see Table 2).

Table 2. Descriptive statistics of all test variables

Parameters	n	Mean	SD	SW
FT-PP (score)	84	2.08	0.56	0.121
FP-KPI-VAS (score)	84	2.51	0.70	0.212
30mS (s)	84	9.13	1.82	0.065
MATT (s)	84	9.14	1.79	0.057
CMJ (cm)	84	32.5	4.15	0.094
SSBT (s)	84	2.52	0.73	0.358

Note: FT: footprint test; PP: pes planus; FP: foot pain; KPI-VAS: knee pain intensity-visual analogue scale; 30ms: 30m sprint; MATT: modified agility t-test; CMJ: counter movement jump; SSBT: standing stork balance test; SD: standard deviation; SW: shapiro-wilk.

Based on Table 3, the FT-PP variable has a moderate negative correlation with FP-KPI-VAS ($r = -0.322$, $p = 0.003$), which shows that PP significantly causes foot pain. In CMJ ($r = -0.230$, $p = 0.035$) and SSBT ($r = -0.310$, $p = 0.004$) there is a moderate negative correlation, which shows that the PP level reduced the level of power and balance. Meanwhile, there is a moderate positive correlation with 30mS ($r = 0.401$, $p < .001$), and MATT ($r = 0.405$, $p < .001$), which shows that the level of PP will reduce the level of running speed and agility.

At the same time, FP-KPI-VAS had a small negative correlation with 30mS (r = -0.261, p = 0.017), MATT (r = -0.260, p = 0.017) and CMJ (r = -0.190, p = 0.048). Finally, FP-KPI-VAS was found to have a large positive correlation with SSBT (r = 0.990, p < .001) (See Table 3 and Figure 2).

Table 3. The correlation analysis of right foot pes planus (PP), foot pain (FP) and performance (N = 84)

Parameters		FT	KPI-VAS
FT-PP	Pearson's r	—	
	df	—	
	p-value	—	
FP-KPI-VAS	Pearson's r	-0.322 **	—
	df	82	—
	p-value	0.003	—
30mS	Pearson's r	0.401 ***	-0.261 *
	df	82	82
	p-value	< .001	0.017
MATT	Pearson's r	0.405 ***	-0.260 *
	df	82	82
	p-value	< .001	0.017
CMJ	Pearson's r	-0.230 *	-0.190 *
	df	82	82
	p-value	0.035	0.048
SSBT	Pearson's r	-0.310 **	0.990 ***
	df	82	82
	p-value	0.004	< .001

Note. FT: footprint test; PP: pes planus; FP: foot pain; KPI-VAS: knee pain intensity-visual analogue scale; 30ms: 30m sprint; MATT: modified agility t-test; CMJ: counter movement jump; SSBT: standing stork balance test. * p < .05, ** p < .01, *** p < .001.

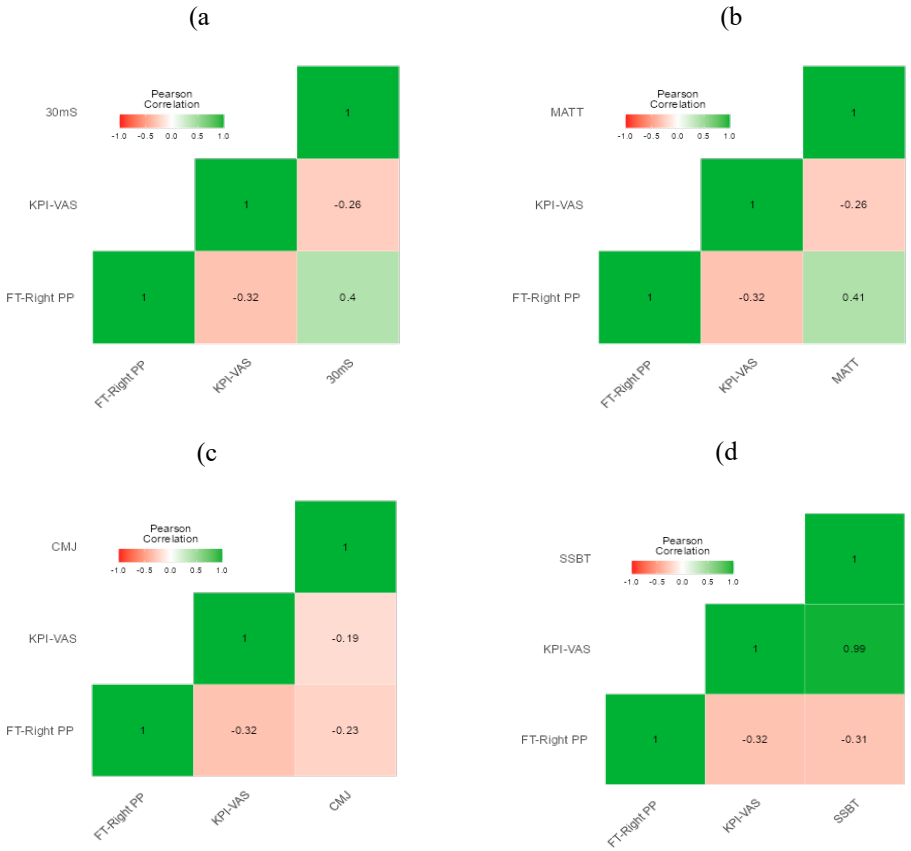

Figure 2. (a) Correlation between FT-PP and KPI-VAS on 30mS, (b) Correlation between FT-PP and KPI-VAS on MATT, (c) Correlation between FT-PP and KPI-VAS on CMJ, (d) Correlation between FT-PP and KPI-VAS on SSBT.

Discussion

Our research aims to investigate the relationship between PP levels with FP-KPI-VAS and selected performance parameters (30mS, MATT, CMJ, SSBT) among team athletes.

Our main finding shows that PP and FP-KPI-VAS has a correlation with performance parameters. This result is in line with and support previous studies, which mentioned that PP level could initiate foot pain [15], or discomfort when standing for a long time [17]. In addition, PP induced decreased foot function which impacted towards athletes' performance during training [18]. According to a study conducted by Igbinedion et al.[19], PP level could cause foot injuries, stress on the feet and ultimately affecting the non-optimal training process. In addition, recent studies report that someone with PP disorder can experience pain in the lower extremities such as plantar heel pain [34], plantar fasciitis, patella femoral pain syndrome and posterior tibial stress syndrome [13]. Majority of athletes with PP were standing unstable, which could cause muscles, tendons and ligaments to work hard and lead to high risk of injury [12, 10], and significant fatigue [35]. On the other hand, previous research explained that athletes with PP produced less pressure on the forefoot and more pressure on the midfoot, so this has a higher risk of injury such as fractures [36, 37]. Meanwhile, another finding reported that PP also correlated with performance parameters related to stability and vertical jumps, where increasing PP levels could reduce the level of stability and jump height [4]. Similar results from Ho et al. [25], the countermovement jump (CMJ) and standing broad jump (SBJ) were reported lower than normal legs. Finally, Romanova et al. [38] revealed that PP disorders had

a high chance of having a negative impact on the musculoskeletal system and reducing physical performance.

Finally, a number of important limintations need to be considered. First, the sample was only covered athletes from one department, namely the Faculty of Sports and Health Sciences, Surabaya State University in Indonesia. Second, this study only used one measuring tool, namely the footprint test, to evaluate PP. Future research needs to involve several athletes from other state universities in Indonesia. Apart from that, in the future it is expected that we will be able to provide other PP measuring tools such as fleet feet sports by using 3D scanner. In our opinion, with the presence of PP among athletes, it is needed to conduct evaluation of athletes as early as possible, to prevent the risk of PP getting worse and carry out training to reduce PP disorders in athletes.

5. Conclusions

Existing research concludes that PP levels are associated with or influence foot pain and reduce physical performance outcomes such as 30mS, MATT, CMJ and SSBT. This research provides important information to athletes, coaches and team personnel on the risks of PP disorders that need to be considered and corrected through an educational approach to optimise athlete performance in team sports. Furthermore, this research can be analysed in different team or individual sports as a prerequisite for optimising the required performance parameters. Based on the results of this study, although the relationship between PP and performance was analysed, the possible effects of medial longitidunal ligament tension on performance can be investigated by analysing the level of pes cavus and some performance parameters in future studies.

Author Contributions: Conceptualization, IF, HS and FJM; methodology, IF, HNM, KG and ES; software, IF; check, FJM; formal analysis, IF, FRK, AK and ES; investigation, IF, FN; resources, HS, AY; data curation, IF, FDK; writing - rough preparation, IF, HS and ES; writing - review and editing, IF, HS, AT and ES; visualization, FJM; supervision, HS; project administration, FJM.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this research are available at Surabaya State University. Data are not publicly available due to the privacy of the included subjects.

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Conflicts of Interest: The authors declare no conflict of interest.

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