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Prevalence of Pronation Distortion Syndrome and Anterior Pelvic Tilt in Relation to Body Stability among Amateur Athletes

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ABSTRACT

Background: Pronation was defined as simultaneous calcaneal eversion, foot abduction, and dorsiflexion. Pronation was necessary for stability when walking and standing; however, having too much ROM for this action might contribute to overpronation. Good postural balance was required to improve voluntary movement control in sports. **Objective:** To determine the prevalence of pronation distortion syndrome and anterior pelvic tilt among amateur athletes and to observe the correlation between pronation distortion syndrome and body stability in this population. **Methods:** In this cross-sectional study convenience sampling was used. The sample size of this study was 117 amateur athletes. Data were collected from Aleem Dar Cricket Academy, Green Cricket Academy, and Ideal Cricket Club. The tools used to conduct the study were a navicular drop test, handheld inclinometer, and Functional Movement Screening (FMS) Questionnaire. **Results:** The findings of this study demonstrated a 35.9% prevalence of pronation distortion syndrome and a 16.2% prevalence of anterior pelvic tilt. Additionally, this study found a positive association between PDS and FMS (p-value = 0.004), as well as between feet type and tilt (p-value = 0.007). However, a negative association was observed between anterior pelvic tilt and FMS (p-value = 0.184), and between anterior pelvic tilt and PDS (p-value = 0.141). **Conclusions:** This study concluded that amateur athletes exhibited a notable prevalence of pronation distortion syndrome and sixteen percent of amateur athletes were suffering from anterior pelvic tilt presenting poor body stability. Significant association was observed between body stability and both pronation distortion syndrome and anterior pelvic tilt.

INTRODUCTION

Lower body pronation distortion syndrome is one of the common abnormalities that may cause pain in feet and may result in deterioration of the anatomical structure of the talus as well as distal and proximal parts of the foot. Individuals with this syndrome have an internal rotation of the hip, a flat feet deformity, and knee valgus as a result of excessive foot pronation, and worsening lumbar lordosis [1]. The anterior portion of the leg is affected by the postural distortion of the lower extremity mainly referred to as Pronation Distortion Syndrome (PDS). Flat feet are caused by the rotation of the navicular bone and head of the talus downward and inward which causes this abnormality. Moreover, pressure is elevated on the medial aspect of the first and second MTP joints, and a bunion is associated with it [2]. Individuals who have flexible flat feet are more susceptible to suffering pronation distortion syndrome. In pronation distortion syndrome, the victim's longitudinal arch collapses in the center of the foot, increasing the inclination to supinate and pronate [3]. Pronated feet disrupt kinematic coupling owing to unacceptable walk pace technicalities, resulting in inconsistent coordination and a deviation from typical joint angles. This eventually disrupts joint synchronization, which typically specifies mobility. As a result, the glutes are under-activated due to tight hip and ankle muscles[4]. In addition to the gastrocnemius, the iliotibial band provides tension that

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influences knee stability, while the hamstrings and vastus medialis are crucial for maintaining proper alignment and patellar tracking. Pronation distortion syndrome could create tension in the iliotibial band and cause lateral pull to the patella resulting in genu valgus [5] .Foot overpronation can cause compensations throughout the kinetic chain. Foot overpronation causes the client's hips to adduct and internally rotate, resulting in an excessive inward angle of the femur and an excessive anterior pelvic tilt [6]. An excessive anterior pelvic tilt occurs when the pelvis tilts more than what is deemed normal when the person is standing. The tilt often occurs from tight hip flexors and lumbar spine hyperlordosis. The excessive tilt is also associated with LBP and knee discomfort leading to compensatory movement patterns [7] . Measurements of pelvic tilt derived from radiographic images are applied in research evaluations and surgical planning. The anterior pelvic tilt reference value in the normal healthy population is approximately 8 degrees. In the clinical setups, pelvic tilt is evaluated using an inclinometer, which is the angle between a line connecting the anterior and posterior superior iliac spine (ASIS and PSIS). Static deviations like pronated foot can trigger harmful postural imbalances throughout the kinetic chain affecting knees, tilting hips and upper spine as well if not treated [8]. However, as the literature does not define excessive anterior pelvic tilting with a set cutoff point, the current study defined excessive anterior pelvic tilt as an anterior angle higher than 8 degrees [9]. Successful athletic performance necessitates an exceptional capacity to maintain bodily equilibrium over an extended period. Different sorts of sports, to differing degrees, help trainees acquire the ability to maintain bodily equilibrium [10]. Using this approach to compare hallux valgus with controls, they discovered a significant prevalence of hyperpronation (87.3%) in the HV group. This study had significant implications for the ankle and foot community [11]. Screening of foot posture in amateur athletes is especially important as it substantially impacts biomechanics and general performance. Any deviation from the normal arch structure of the foot may change the kinematics of gait, and force distribution, and increase the likelihood of injuries like plantar fasciitis, and patellofemoral pain syndrome. Knowledge of foot position reveals specific abnormalities that requires therapeutic procedures like orthotics and exercises to improve biomechanics. This is through screening to address these issues that would otherwise lead to injuries or hinder the force transmission through the lower extremities for maximum athletic performance. Excessive pronation can cause higher soft tissue tension and alterations in total lower limb posture, putting the individual at risk for lower extremity injury. Excessive rear foot pronation may result in unusual tibia internal rotation, which may cause increased stress on the knee structure and disrupt patella tracking [12]. A common chronic illness “Pes Planus” affects 2 to 23 percent of the adult population and is distinguished by calcaneal eversion and lower medial longitudinal arch. The most prevalent issue is overpronation during weight-bearing exercises with pes planus [13] The incidence of retroversion of acetabular is understudied and it may be related to an increase in “anterior pelvic tilt”. The frequency of unilateral or bilateral acetabular retroversion in the general population was 24%, with 18% for all hips [14]. In amateur athletes, non-contact injuries are often linked to overuse, where tissues weakens from repetitive stress without adequate recovery time. Similarly PDS can misalign the hip leading to general hip pathologies [15].

The current study aimed at establishing the extent to which amateur athletes are affected by pronation distortion syndrome with an emphasis on lower extremity distortions, muscle imbalance and anterior pelvic tilt as athletes require proper body mechanics and kinetic chain to maintain their body stability during sudden accelerated motions and reflexes. Amateur athletes are often neglected in screening process that's why the study specifically targets them. These studies sought to enhance screening, training, and rehab in relation to foot biomechanical and body stability characteristics so as to enhance athletes' performance and minimize injuries among both amateur and elite athletes.

METHODS

A cross-sectional study design was used to explore pronation distortion syndrome and anterior pelvic tilt about body stability among amateur athletes. The study was approved by the ethical committee board of the University of Management and Technology, Lahore (RE-083-2024). A sample size of 117 was selected by the WHO calculator with a confidence interval of 95%, a true proportion of 0.917, and a margin of error of 0.05 [16] . The participants were selected through the convenience sampling method due to their practicality and ease of access to a specific group of amateur athletes for this study. Written consent was taken from participants before data collection. The time frame to complete this study was 3 months. Inclusion criteria consisted of amateur athletes with the age group of 18-35 years, both male and female gender were included [17]. Participants were regular tournament-playing athletes, participating in at least one tournament per month [18]. Individuals who used particular footwear, previously diagnosed foot abnormalities like clubfoot, and claw foot, and athletes who had a history of using performance-enhancing drugs were excluded from the study. A navicular drop test was used to assess pronation distortion syndrome. For checking body stability, functional movement screening was used. Anterior pelvic tilt was checked by using an inclinometer. Data collection tools used was a navicular drop test to evaluate participants'

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hyperpronation, which was still the most popular and simple exam. This test value reflected the height disparities between the navicular tuberosity in the sitting position and the upright posture. Values greater or equal to 10mm were considered positive tests. The sensitivity and specificity of the navicular drop test were 86% and 75%, respectively [19]. It was performed by measuring the height difference of the navicular bone from a fixed reference point (anatomical landmark) in both a neutral position and after the participant performed a weight bearing. The height difference was measured by a ruler, with a threshold of 10mm established based on previous research indicating that this value correlates with functional issues related to foot biomechanics [20]. An inclinometer was one of the tools that were developed to assess pelvic tilting. The instrument displayed the angle between the horizontal or vertical and the line connecting the two arms of the inclinometer. The physician palpates both the anterior as well as posterior superior iliac spine, then sets the device on them and gets a measurement. Pelvic tilt was evaluated using an inclinometer with test-retest reliability that was equal to between (0.88-0.95) [21]. The functional movement screening was an assessment instrument that was used to assess seven key patterns of movement in people who do not have a current history of ache problems or injuries to the MSK system to assess their body stability. Seven movement patterns are; deep squat, in-line lunge, hurdle step, trunk push-up, shoulder mobility, rotatory stability, and active straight leg raise [22]. Data analysis was conducted using Statistical Product for Social Sciences (SPSS) version 25.0 by applying the chi-square test to show the relationship between variables.

RESULTS

The table 1 displays the demographic profile of each variable, including gender, feet type, and BMI, in terms of frequency and percentage of the sample population in research study. The total percentage in each category was 100% showing the total number of participants who were 117. Out of 117 amateur athletes 68 athletes were with normal feet, 7 with flat feet and 42 with flexible flat feet.

Table 1: Demographics of Amateur Athletes

Variables	Frequency (%)
Gender	
Male	73 (62.4%)
Female	44 (37.6%)
Feet Type	
Normal Feet	68 (58.1%)
Flat Feet	7 (6.0%)
Flexible Flat feet	42 (35.9%)
BMI	
0-18.4 (Underweight)	23 (19.7%)
18.5-24.9 (Normal)	77 (65.8%)
25-29.9 (Overweight)	12 (10.3%)
30 above (Obese)	5 (4.3%)
Total	117 (100%)
Age	
Minimum	18
Maximum	35

The figure illustrates that among participants with a positive navicular drop test (>10 mm), 15 (12.82%) exhibited a positive FMS, indicating impaired body stability, while 27 (23.08%) had a negative FMS, suggesting normal body stability. In contrast, among participants with a negative navicular drop, 14 (11.97%) had a positive FMS, while 61 (52.14%) had a negative FMS score (Figure 1).

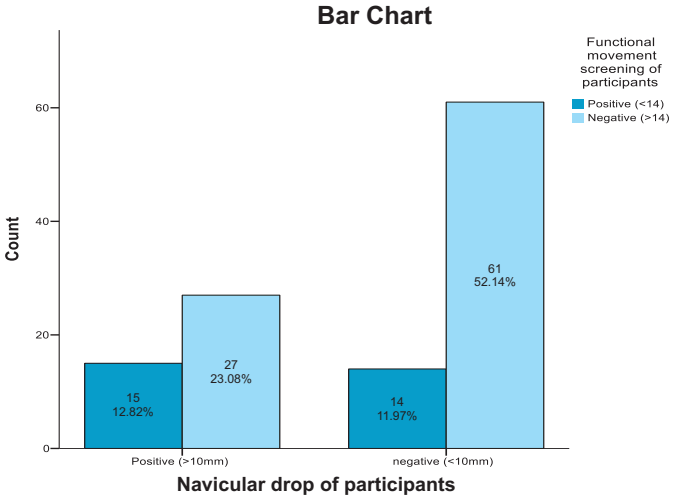

Figure 1: Association between Navicular Drop and FMS

From the table 2, data shows 42 athletes among 117 participants have a navicular drop measurement more than 10 mm thus exhibiting 35.9% prevalence of pronation distortion syndrome. On the other hand, 75 participants (64. 1%) have measurement below 10 mm defined that they exhibit better mechanics of their feet.

Table 2: Navicular Drop of Amateur Athletes

ND	Frequency (%)
Positive (>10mm)	42 (35.9%)
Negative (<10mm)	75 (64.1%)
Total	117 (100%)

Table 3 shows the anterior pelvic tilt of amateur athletes which was measured by inclinometer. Out of 117, 19 participants (16.2%) have pelvic angle greater than normal which indicated that they have anterior pelvic tilt and 98 participants (83.8%) showed that they have normal pelvic tilt.

Table 3: Anterior Pelvic Tilt of Amateur Athletes

Tilt	Frequency (%)
Positive	19 (16.2%)
Negative	98 (83.8%)
Total	117 (100%)

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Table 4 describes the FMS score of athletes. Participants having FMS score less than 14 out of 21 have affected body stability which were 29(24.8%)while 88 participants having FMS score more than 14 have normal body stability. Table 5 showed cross tabulation of feet type of participants and anterior pelvic tilt that illustrated significant association as $p<0.05$.

Table 4: Functional Movement Screening of Participants

FMS Score	Frequency (%)
Positive (<14)	29 (24.9%)
Negative (>14)	88 (75.2%)
Total	117 (100%)

Table 5 shows the association between feet type, anterior pelvic tilt of participants, among 68 participants with normal feet 11 participants had positive anterior pelvic tilt, 7 participants with flat feet out of which 4 had positive anterior pelvic tilt as well as out of 42 participants with flexible flat feet 4 had positive anterior pelvic tilt.

Table 5: Cross Tabulation of Feet type of Participants and Anterior Pelvic Tilt Measurement by Inclinometer

Statistical Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.003[a]	2	0.007
Likelihood Ratio	7.637	2	0.022
Linear-by-Linear Association	0.540	1	0.463
Number of Valid Cases	117		

Table 6 shows that there was a relationship ($p < 0.05$) between Functional Movement Screen (FMS) scores and the navicular drop among 117 participants signifying strong association between pronation distortion syndrome and FMS.

Table 6: Cross Tabulation for Navicular Drop of Athletes and Functional Movement Screening

Statistical Tests	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-Sided)	Exact Significance (1-Sided)
Pearson Chi-Square	4.197[a]	1	0.040	0.047	0.035
Continuity Correction	3.332	1	0.068		
Likelihood Ratio Fisher's Exact Test	4.084	1	0.043		
Linear-by-Linear Association	4.161	1	0.041		
Number of Valid Cases	117				

In table 7 the results of the chi-square test, which relate the navicular drop and the BMI among 117 respondents, had a p-value of 0.067 and the likelihood ratio test gave greater significance with a p-value of 0. 044. Overall, it seems BMI could affect navicular drop with the presence of a linear regression at a statistical level of 95% (p = 0. 016).

Table 7: Chi-Square Test Navicular Drop of Participants and BMI of Participants

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.167[a]	3	0.067
Likelihood Ratio	8.088	3	0.044
Linear-by-Linear Association	5.850	1	0.016
Number of Valid Cases	117		

DISCUSSION

This was a cross-sectional study to explore the prevalence of Pronation distortion syndrome and anterior pelvic tilt about body stability among amateur athletes. The data collection tools that were used in this study include Navicular Drop, Inclinometer, and Functional Movement Screening. Ikuta Y et al., in 2022 conducted a study that concluded that excessive rear foot valgus and navicular drop of > 10 mm significantly impact postural stability in adolescent athletes. Compromised postural stability was observed via single-leg standing. In this study, FMS was used for investigation of body stability and there was a significant association present between navicular drop and body stability. Thus, the results of this study are aligned with previous studies [23]. Handheld Inclinometer was used for the measurement of pelvic angle. We placed an inclinometer on the participant's ASIS prominence in the sagittal plane while the participant was in a standing position. The center of the displaced colored fluid was taken from caliber as the reading of pelvic angle tilting. Brekke AF et al., in 2022 measured anterior Pelvic Tilt with acetabular retroversion. The general population was taken as a participant. The study found out 24% prevalence of anterior pelvic tilt with acetabular retroversion. This study supported this study as the prevalence of Anterior pelvic tilt found by this study was 16.2% while this study was taken among amateur athletes [14]. Functional Movement screening test was the key tool for the measurement of body stability which has a cut of value 14. The body stability was linked with our body kinematics and symmetry of pelvic angle. In this study, Functional Movement Screening (FMS) was used for the body stability in Amateur athletes. From seven movements 4 of the movements (Inline Lunge, Hurdle Step, Rotatory Stability, and Shoulder Mobility) were majorly affected in the regular amateur athletes. Meanwhile, Boratino AV in 2022 in a study also used the Functional Movement Screening (FMS) test as a screening indicator or tool of body kinematics and stability in a sports setting. The results indicated four affected movements: single leg squat, inline lunge, deep squat, and hurdle step. Overall, body kinetics was the key factor in total body stability [24]. Body stability in this study was measured with the Functional Movement Screening (FMS). In this Screening test 7 functional movements were performed by the participants with just a single repetition and a score was given according to their body movement and compensations with it. The main purpose of this study was

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to find out the association between pronation distortion syndrome and anterior pelvic tilt with dynamic body balance. In this study navicular drop test was used for pronation distortion syndrome and the Functional Movement Screening Test was used to find out the body stability. Results showed a Positive association between navicular drop and body balance. In contrast to this study a study conducted on Foot posture, body balance, and Pelvic tilt by Pradhan D et al., in 2021. In which they conduct a study on healthy recreational runners. They used the foot posture index and Star Excursion balance test as tools. They found a poor correlation between body stability and foot posture (r=0.23) [25]. Normal pelvic symmetry was important for the athletes to prevent injuries. For this, a study was conducted on pelvic symmetry and the range of pelvic movement by Nowak B et al., in 2020. In that study Pelvic symmetry was assessed among young football players and non-playing peers. Results concluded that there was no difference in the value of pelvic symmetry among the two groups and a greater range of pelvic rotation was found. Moreover, they found significant posterior pelvic tilting in young football players. In contrast to that study, this study focused on drawing the results of anterior pelvic tilt among amateur Athletes. A negative association was found between anterior pelvic tilt and navicular drop [26].

CONCLUSIONS

This study concludes there was a notable prevalence of Pronation distortion syndrome and anterior pelvic tilt in amateur athletes. The study further showed a positive relationship between pronation distortion syndrome, functional movement screening and foot type. A significant relation was observed between anterior pelvic tilt and body stability. These findings underscore the impact of Pronation distortion syndrome and anterior pelvic tilt on body stability highlighting the need for proper interventions and enhancement in biomechanical properties of amateur athletes.

Authors Contribution

Conceptualization: HSM, GH
Methodology: AUHC, MAS, AM
Formal analysis: HSM
Writing, review and editing: AH, GH, MAS, AM, MS

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

All the authors declare no conflict of interest.

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