JSKK (Jurnal Sains Keolahragaan dan Kesehatan)
Vol. 9 No. 2, Desember 2024, pp. 152-161
Web: http://journals.itb.ac.id/index.php/jskk/index

Variation in Foot Arch Types among Athletes from Various Sports Disciplines: Analysis and implications for athletic performance

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Diterima: 7 Oktober 2024; Diperbaiki: 5 Desember 2024; Diterima terbit: 30 Desember 2024

Abstract

The foot arch is one of the many parts of the leg that plays a crucial role in supporting and balancing body weight, as well as regulating body movement during walking and running. Despite this, research on the foot, particularly in college-athletes, remains limited. Therefore, this study aims to analyze the variations in arch types of the foot among collegiate-level from various sports disciplines. This study used an observational study method with a total of 40 collegiate-level athletes as participants, divided into 10 soccer athletes, 10 futsal athletes, 10 archery athletes, and 10 pencak silat athletes. Foot measurements are taken using the wet test, while height is measured with a stadiometer, and body weight and BMI are assessed using the Omron Carada Body Fat Scan. The results indicate that futsal and soccer athletes predominantly have normal foot arches, with 90% in each group, while only 10% exhibit flat arches. In contrast, archery and pencak silat athletes show a greater variation in arch distribution, with 30% and 40% having flat arches, and 70% and 60% having normal arches, respectively The study concludes that the majority of futsal and soccer players possess normal arches. In contrast, archery and pencak silat athletes exhibit greater variability in arch distribution.

Keywords: *foot, injury, athlete.*

INTRODUCTION

The foot is a complex and highly flexible system, allowing it to adapt to a variety of surfaces and conditions (Şahin et al., 2022). In addition, the foot plays a very important role in absorbing shocks during movement (Mckeon et al., 2014). The ability of the foot to adapt to shocks is important in maintaining postural

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DOI: http://dx.doi.org/10.5614/jskk.2024.9.2.1 e-ISSN: 2654-8860 . p-ISSN: 2477-1791

balance during movement (Welte et al., 2018) and supporting body weight during physical activity (Sativani & Pahlawi, 2020).

Previous studies have shown that the arch of the foot, which is part of the foot, plays an important role in supporting body weight and helping the body stay balanced, while making walking and running movements more efficient (Hillstrom et al., 2013). Furthermore, other research conclusions confirm that the arch of the foot also functions as a natural shock absorber that can distribute the weight of the human body evenly across the front, middle, and back of the foot. This helps the body move more smoothly and reduces pressure on our feet and soles (Mckeon et al., 2014).

The relationship between the structure of the foot arch and its role in movement and balance has been studied in several previous studies (Arachchige et al., 2019; Perwirawati et al., 2023; Sharma & Upadhyaya, 2016). Previous studies have shown that individuals with abnormal foot arches tend to experience balance problems, fatigue when walking long distances, and an increased risk of injury (Ramadhani & Romadhoni, 2024; Rosdiana et al., 2022). Additionally, other studies involving several athletes who were indicated to have foot problems showed that less than ideal foot conditions can have a negative impact on athletic performance, reduce movement efficiency, and increase the likelihood of recurrent injuries (Hillstrom et al., 2013; Şahin et al., 2022)

Measurement of foot arch depth is essential for athletes, especially those at the college level as they regularly face not only physical demands but also intense learning demands (Siramaneerat & Chaowilai, 2022; Wang et al., 2023). Previous studies examining athletes have shown that those with abnormal foot arches are more likely to experience performance problems and higher risk of injury due to uneven pressure distribution and biomechanical imbalances (Arachchige et al., 2019; Perwirawati et al., 2023; Sharma & Upadhyaya, 2016). Therefore, accurate measurement and analysis of foot arch depth can provide valuable insights to develop better training programs and reduce the risk of injury especially in collegiate athletes.

Measuring the foot arch in college athletes can provide important insights into improving training methods (Wu et al., 2022). In addition, it can further create

better sports equipment based on the condition of the foot. Therefore, by understanding the differences in foot arch structure, coaches and health professionals can determine the unique needs of each athlete and tailor interventions accordingly (Karki et al., 2021).

Therefore, the purpose of this study was to analyze the arch shape of the foot in college athletes. By conducting comprehensive measurements, our study is expected to provide an overview of the arch shape of the foot in college athletes so that it can be used as a recommendation to improve performance and reduce the risk of injury among athletes.

METHODS

Design

The method employed in this study is an observational design, where subjects do not undergo additional interventions, allowing for data collection to occur only once. Subject selection was conducted based on specific inclusion criteria: participants were collegiate athletes aged 19 to 23 years who had competed at least once in regional or national sports competitions, were free from a history of cardiovascular diseases and asthma, did not smoke, and were in good health. Conversely, the exclusion criteria included individuals who were not students and those with a history of cardiovascular diseases and asthma.

Participants

This study involved 40 collegiate athletes, comprising 10 athletes from futsal, 10 from soccer, 10 from archery, and 10 from pencak silat. Prior to the commencement of the research, both verbal and written explanations were provided to all participants. This explanation included the study's objectives, procedures, and potential risks associated with participation. If participants chose to take part in this research, they were required to complete an informed consent form. The research protocol received ethical approval from the Research Ethics Committee of Universitas Negeri Jakarta, under the reference number No: 516/UN39.14/PT.01.05/VI/2024.

Instrument

In this study, foot measurements were conducted using a wet test, which has been utilized and developed in previous research (Rahim et al., 2018; Sativani & Pahlawi, 2020). During this procedure, the foot's shape is identified by immersing it in water and then pressing it onto a sheet of paper, thereby creating a footprint (Imam & Untung, 2022; Munawarah et al., 2021). Participants' height was measured using a stadiometer, while body weight and Body Mass Index (BMI) were assessed using the Xiaomi mi smart scale 2 pro.

Data Analysis

The data collected were processed and analyzed utilizing Microsoft Excel software. Subsequent to the analysis, descriptive statistics including frequency counts and percentages were generated. These results were systematically organized and presented in tabular format to enhance clarity and facilitate interpretation. This approach ensures that the findings are easily comprehensible, allowing for informed conclusions to be drawn from the data.

Table 1 presents the anthropometric data of the participants with details of age, weight, height, and Body Mass Index (BMI). Anthropometric data are very important to obtain a comprehensive understanding of the physical characteristics of the participants.

Table 1. Anthropometric Characteristics of Participants by Sport Discipline

Sport Discipline	Number of Participants (n)	Mean ± SD			
		Age (years)	Weight (kg)	Height (cm)	BMI (kg/m²)
Football	10	20,21 ± 2,34	62,57 ± 6,21	172,85 ± 3,02	20,9 ± 1.2
Futsal	10	21,18 ± 1,83	59,57 ± 4,73	169,71 ± 7,27	20,7 ± 2.1
Archery	10	20,87 ± 2,02	63,16 ± 8,56	168,16 ±3,86	22,3 ± 1.8
Pencak silat	10	21,87 ± 2,23	69,63 ± 3,57	172,66 ± 2,34	23,4 ± 2.9

Additionally, Table 1 shows that all participants have a similar age range, with differences in average weight, height, and BMI. Pencak Silat participants have the highest BMI compared to other sports, while Futsal participants tend to have

lower height and weight.

Table 2 presents the distribution of foot arch conditions among participants, categorized by their respective sports disciplines. Table 2 shows the distribution data of the participants' foot arch types, the majority of participants from all sports have normal foot arches, with the highest proportion found in Football and Futsal (90% each) compared to Archery (70%) and Pencak Silat (60%). Participants with flat foot arches were more common in Archery (30%) and Pencak Silat (40%) compared to Football and Futsal, which only had 10% each. No participants from the four sports had high foot arches. These data show variations in foot arches between sports, with a tendency for normal arches to dominate.

Table 2. Data on Foot Arch Types Among Participants by Sport Discipline

Sport Discipline	Flat Arch (%)	Normal Arch (%)	High Arch (%)
Football	10%	90%	0%
Futsal	10%	90%	0%
Archery	30%	70%	0%
Pencak silat	40%	60%	0%

DISCUSSION

Our study aims to analyze the characteristics of foot arch among university-level athletes. This investigation is believed to be one of the first comprehensive analyses focusing on the foot arch characteristics of collegiate athletes. The distribution of foot arch types among collegiate-level across various sports disciplines reveals significant variations that reflect the unique physical and biomechanical demands inherent to each sport.

In this study, we found that the majority of futsal and soccer athletes exhibited a normal foot arch, accounting for 90% of the participants, while only 10% demonstrated a flat arch, with no individuals showing a high arch. We speculate that these findings indicate that a normal foot arch confers biomechanical advantages in sports characterized by frequent running and rapid changes in direction. A normal foot arch may enhance stability and facilitate more effective load distribution during intense physical activities (Bednarczyk et al., 2024)

Previous research corroborates these findings, indicating that a normal foot arch is the most prevalent among athletes engaged in high-demand sports, such as

basketball, badminton, soccer, and futsal (Gisladottir et al., 2023; Karki et al., 2021). A normal foot arch is considered optimal for shock absorption and stability during movement, which are critical for athletic performance in these sports (Moreno-Barriga et al., 2023). Furthermore, athletes with a normal foot arch tend to exhibit a lower risk of injury compared to those with flat or high arches (Bednarczyk et al., 2024).

In the sport of archery, the distribution of foot arch types reveals that 30% of athletes possess flat arches while 70% exhibit normal arches, with no athletes having high arches. Archery is a discipline that emphasizes stability and precision rather than extensive running or rapid directional changes (Ertan et al., 2021). Consequently, we hypothesize that variations in foot arch type may not significantly impact performance in this sport. Athletes with flat arches may still achieve competitive success in archery, provided they possess adequate stability and strength to maintain their posture during shooting. Therefore, further discussion and detailed analysis are warranted to explore the phenomena observed in this study.

Pencak silat is a martial art that incorporates various foot movements, including kicks and rapid motions (Syaifullah & Lingsir Maghribi, 2023). The athletes participating in our study demonstrated a more diverse distribution of foot arch types, with 40% exhibiting flat arches and 60% possessing normal arches. Previous research indicates that variations in foot arch types may be more prevalent in sports that demand complex dynamic movements (Prvulović et al., 2021) . Normal foot arches may confer advantages in terms of balance and stability (Moreno-Barriga et al., 2023). However, the existing literature also suggests that flat arches can be acceptable in certain contexts, particularly when athletes possess strong technique and adequate muscular strength to compensate for any biomechanical disadvantages (Prvulović et al., 2021).

The data from this study align with previous findings that suggest foot arch types can vary significantly depending on the specific biomechanical demands of different sports (Karki et al., 2021; Zdunek et al., 2020). Research has consistently shown that athletes with normal arches tend to exhibit superior biomechanical performance and face lower injury risks compared to those with flat or high arches (Karki et al., 2021; Wu et al., 2022; Zdunek et al., 2020). Identifying the dominant

foot arch type within each sport is therefore crucial for designing more tailored training programs and implementing effective injury prevention interventions.

The systematic implementation of foot arch measurement in athletes can provide substantial benefits in athletic health management. By identifying the distribution of foot arch types, coaches and sports health professionals can design training programs tailored to the individual needs of each athlete. For example, athletes with flat arches may require targeted exercises to strengthen foot and ankle muscles, as well as the use of orthotics to enhance stability. Conversely, athletes with high arches may benefit from exercises focused on improving flexibility and promoting even pressure distribution across the foot.

The limitations of this study primarily stem from the restricted sample, which only includes collegiate-level athletes from select sports disciplines, potentially limiting the generalizability of the findings to a broader athletic population. Furthermore, while the foot arch measurement method employed in this research is accurate, it relies on visual interpretation, introducing potential subjectivity that may impact the consistency of results. Additionally, the study does not account for other variables that may influence foot arch structure and athletic performance, such as genetic factors, age, sex, and injury history. Therefore, future research with larger, more diverse samples, advanced measurement technologies, and multivariate analysis is required to provide a more comprehensive understanding of the impact of foot arch variations on athletic performance.

CONCLUSSION

The results of foot arch measurements among collegiate-level athletes indicate that the majority of futsal and soccer players possess normal arches. In contrast, archery and pencak silat athletes exhibit greater variability in arch distribution. These findings suggest that while a normal foot arch is prevalent across athletes, the variation in arch types may reflect the specific biomechanical demands and training patterns associated with each sport.

ACKNOWLEDGMENT

We would like to express our deepest gratitude to LPPM of Universitas Negeri Jakarta (UNJ) for their financial support, which was instrumental in the

successful execution of this research. Without the invaluable funding provided by LPPM UNJ, this study would not have been possible. Additionally, we extend our heartfelt thanks to all the participants who took part in this research. Their involvement and collaboration were crucial in obtaining accurate and relevant data, contributing significantly to the overall outcomes of this study. We sincerely appreciate the support and participation of everyone involved, which has enabled the successful completion of this research."

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