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Relationship between foot muscle morphology and flat foot posture with functional stability and incidence of ankle sprain in athletes

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ABSTRACT

Background: An ankle sprain is the most common injury in athletes, and the relationship between foot muscle morphology and flat foot posture with functional stability and the incidence of ankle sprain in athletes is an interesting topic in the world of sports. This study aimed to determine the relationship between foot muscle morphology and flat foot posture with functional stability and the incidence of ankle sprain.

Methods: This study used a literature review method. By using secondary data in the form of research journals obtained from various database sources on the internet. The search for literature articles was carried out online on PubMed and Google Scholar sites using the keywords "ankle sprain," "flat foot posture," "functional stability," and "morphology muscles."

Results: After reviewing four articles, it was found that ultrasonography (USG) was a reliable diagnostic method to examine the morphology of muscles (peroneus), which serve as ankle stability. In addition to muscle morphology, athletes with flat foot posture also have a higher risk of ankle sprain due to uneven load distribution and low functional stability.

Conclusion: There is a relationship between foot muscle morphology and muscle activity in athletes with pes planus (flat foot) conditions with functional stability and the risk of ankle sprain in athletes.

Keywords: athlete, ankle sprain, flat foot posture, functional stability, muscle morphology

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Introduction

Ankle sprains are a common musculoskeletal injury that both the general public and athletes experience frequently. Exercise accounts for about 40% of all severe ankle injuries.[1] During a five-year span in the United States, almost 3 million people with ankle sprains visited emergency rooms. Athletes accounted for over half of all ankle sprain incidents that were recorded during this time. The most prevalent type of ankle sprain, according to the most latest injury tracking statistics from the National Collegiate Athletic Association moments, is lateral ankle sprain (LAS).[2]

Physical activity also improves children's cognitive and non Ankle sprain conditions are often triggered by failure to maintain ankle stability during sporting activities. Functional stability of the ankle is critical for athletes.[3] Recent research has shown that individuals with flat feet have a higher risk of injury, especially injuries such as ankle sprain.[4] Athletes with flat foot posture will tend to experience changes in foot mechanics that will lead to uneven load distribution during physical activity, increased stress on certain structures, and decreased postural stability.[3,4] Foot muscle morphology, especially the size and strength of the peroneus longus (PL) and peroneus brevis (PB) muscles, plays an important role in ankle stability. In addition, these muscles also contribute to the dynamic stability complex in lateral ankle sprain when contracting eccentrically during supination. In particular, these muscles may be able to slow down the supination component of plantar flexion and thus prevent injury to the lateral ligaments (ankle sprain).[5] found a correlation between low PL and high PB muscle activity and decreased stability in lateral ankle sprain (LAS). Ultrasonography (US) is an effective diagnostic tool for ankle ligament injuries with 95%

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sensitivity and 99% specificity, offering a reliable alternative when MRI is not available.[6]

The precise causes of these stability issues are deficits in ankle strength, proprioception, neuromuscular control, and postural control.[5] The peroneal longus and brevis muscles are essential for controlling hindfoot supination and preventing lateral ankle sprains, in addition to the complex muscles at the ankle which also contribute to dynamic stability. Better dynamic stability may also be facilitated by the lower leg muscles of the anterior compartment, including the tibialis anterior, extensor digitorum longus, extensor digitorum brevis, and peroneus tertius, in addition to the peroneals. [5,7] Exercise programs that include strengthening of the foot's intrinsic muscles and proprioceptive exercises may also improve functional stability and reduce the incidence of ankle sprain.[18] These programs aim to increase the strength and endurance of the foot muscles, which support the arch of the foot and improve postural stability.[21] A 10-15% increase in foot muscle strength can reduce the incidence of ankle sprain by 20% in athletes. Sports injuries, especially athletic sports, require special training and activities without putting excessive pressure on the injured area.[8] In addition to foot muscle morphology and flat foot posture other factors also contribute to the incidence of ankle sprain in athletes factors such as unsuitable sports shoes, poor field conditions, and muscle fatigue can also increase the risk of injury in athletes.[22]

Methods

This research used the literature review method. The preparation of this study used secondary data in the form of research journals obtained from various sources of scientific journal databases on the internet relating to the relationship between foot muscle morphology and flat foot posture with functional stability and the incidence of ankle sprain in level 1 athletes. The search for literature articles was conducted online through PubMed and Google Scholar sites using the keywords "ankle sprain", "flat foot posture", "functional stability", "morphology muscles", and "pes planus". The literature used was selected based on inclusion and exclusion criteria. The inclusion criteria used in this study are literature published by credible institutions, literature published no more than the last 10 years. The exclusion criteria in this study are literature that is not related to ankle sprain and functional stability, literature that has no relationship with the state of ankle sprain and flat foot posture, the number of samples in the library is less than 10 subjects. The libraries used in the literature review have met the inclusion criteria set by the author.

Results

Based on the results of the literature search, there are four literatures related to the title of the research that has been written. The results of table 1 are as follows:

Based on findings from studies carried out by Arima, et al. The cross-sectional area of the peroneus muscle on the LAS side differed significantly from that of the non-LAS side and the control leg in the distal 75% (p = 0.008). This was demonstrated by displaying the values of the intraclass correlation coefficient (ICC) for the peroneus muscle (CSA), muscle echogenicity, and muscle activity of the peroneus longus (PL) and peroneus brevis (PB). Echogenicity also demonstrated a significant difference (p < 0.001), with the LAS side having reduced echogenicity at the distal 75% compared to the non-LAS side and control foot. Nonetheless, there was no noteworthy distinction between either group's proximal 25% and center 50%. Table 1 displays ankle evertor strength in the LAS side, non-LAS side, and control leg together with PL and PB muscle activity during ankle inversion. On the LAS side, PL muscle activity was considerably lower than on the non-LAS side and control leg (p = 0.022). Ankle evertor strength did not substantially differ across the groups, however PB muscle activity did exhibit significantly greater values in the LAS side when compared to the non-LAS side and control leg (p = 0.015).[20]

In a study conducted by Sahin, et al. Involved fifty athletes and found a significant correlation between the degree of pes planus and balance and vertical jump performance. From the results of the analysis, there are two significant findings. First, there is a positive correlation between the level of pes planus and decreased postural control, with a Spearman correlation coefficient of 0.372 (p = 0.036). This means that the higher the level of pes planus, the lower the level of postural control of the subject.Therefore, the subject's degree of postural control will decrease as their pes planus increases. Second, there is a negative correlation between the level of pes planus and vertical jump height, with a spearman correlation coefficient of -0.262 (p = 0.048). This indicates that the higher the level of pes planus, the lower the vertical jump height of the subject.[19]

In another study that has been conducted by Setiawan, et al. Identifying common injuries among athletes with flat feet, revealed that knee injuries were the most common at 69%, followed by ankle injuries at 31% Athletes aged 20-29 years were the most injured group, with soccer being the sport with the highest percentage of injuries at 33% Ankle injuries mostly affected ligaments (54%) and muscles (48%), while knee injuries mainly affected ligaments (79%) over muscles (21%).Factors contributing to injuries include internal factors such as muscle weakness and external factors such as errors in training and environmental conditions. in sports performance and injury prevention.[21]

In a different investigation that Bamber, et al. 14 participants in this study consented to participate, however 7 declined or did not respond to recruitment efforts. Fourteen participants finished the study up to the point of immediate effect, eight participated in the 8-week exercise program (four in each group), and six participated in the entire investigation (intervention 2, control 4). Upon

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reaching every time point, every subject exhibited 100% adherence to the research, and not a single one expressed any pain. Following the intervention, the analysis revealed a significant difference in the maximal pressure outcomes for the intervention conditions (M = 0.7 (0.7) and the control condition (M = -6.0 (4.6); t(6) = -2.9, $p < 0.05$. According to the results of the Wilcoxon test, there was no statistically significant difference in the center of pressure (COP) between heel strike and maximum pressure for individuals with lateral COP in either the intervention or control group following functional electrical stimulation of the peroneal muscles. There was no discernible change in the intervention group's pre- and post-intervention scores on the SEBT star excursion balancing test, according to an analysis of the data.15 Scores of about 2 cm posterior right, 7 cm posterior, and 4 cm posterior left increased, although they were not statistically significant.[15]

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Table 1. The results of literature search of relationship between foot muscle morphology and flat foot posture with functional stability and incidence of ankle sprain in athletes

Authors	Titles	Methods	Results
Arima, Satoshi; Maeda, Noriaki; Komiya, Makoto; Tashiro, Tsubasa; Fukui, Kazuki; Kaneda, Kazuki; Yoshimi, Mitsuhiro; Urabe, Yukio (2022)	Morphological and Functional Characteristics of the Peroneus Muscles in Patients with *Lateral Ankle Sprain*: An Ultrasound-Based Study	1. Design of the study: observational 2. Sample size: 32 participants, 16 of whom had experienced LAS on the unilateral foot at least twice and 16 of whom had not had LAS on the ankle joint. 3. Independent variable: Acute injury, sprain, or lower extremity fracture that occurred within the last three years is referred to as lateral ankle injury. 4. Dependent variables include ankle strength, the presence of lateral ankle injury, OT and PB muscle echogenicity, and OT and PB muscle activity. 5. Tests of statistics: Kruskal-Wallis, paired t-tests, and the Shapiro-Wilk test	1. The CSA of the LAS side was significantly higher (p = 0.008) at the distal 75% than that of the control leg and the non-LAS side. 2. The echogenicity of the LAS side was significantly lower at 75% distal than that of the non-LAS side and the control foot (p < 0.001). 3. The PL muscle activity values were significantly lower on the LAS side (p = 0.022) as compared to the non-LAS side and control leg. 4. The LAS side had significantly higher PB muscle activity (p = 0.015) 4 compared to the non-LAS side and the control leg.
Sahin, Fatma Neşe Ceylan, Levent Küçük, Hamza Ceylan, Tülay Arıkan, Gökhan Yiğit, Sevcan Sarşık, Derya Çetin Güler, Özkan (2022)	Examining the Relationship between *pes planus* Degree, Balance and Jump Performances in Athletes	1. Study design: Cohort Investigation 2. Sample size: 50 male team sport athletes (soccer 18, rugby 16, basketball 12, and volleyball 4) make up the sample size. 3. Independent variable: Pes planus level (Flat Foot) 4. The dependent variable: Balance of Jumping Performance 5. Tests of statistics: Wilcoxon signed-rank, Spearman rho, and Kolmogorov Simirnov	1. A statistically significant (p = 0.036) Spearman's rank of 0.372 indicates that the degree of pes planus increases as the degree of postural control diminishes. 2. A statistically significant link (p = 0.048) has been found between vertical leap height and the degree of pes planus. Specifically, the correlation coefficient for vertical jump is 0.262.
Setiawan, Arif Priyanto Yudhistira, Dewangga (2023)	Prevalence and characteristics of sports injuries in athletes with flat feet: A quantitative descriptive study	1. Study design: quantitative descriptive study 2. Sample size: 89 male athletes with flat feet 3. Independent variable: flat feet in athletes. 4. Dependent variable: types of injuries experienced by athletes with flat feet 5. Statistical test: Data collection techniques include observation, interviews, questionnaires, and measurement tests, with data analysis using the percentage formula supported by excel software.	1. Athletes with flat feet have a higher risk of knee (69%) and ankle (31%) injuries. The main causes of injury were internal trauma (52%) and overuse (26%). 2. Identification of injuries in athletes with flat feet, may assist in the selection of appropriate sport activities and the development of more effective injury prevention strategies.
Bamber, Zoe A Wheeler, Patrick C Swain, Ian D Fong, Daniel TP (2021)	Effect of 8-week treadmill running withperoneal muscle functional electrical stimulation on laterally deviated centre of plantar pressure	1. Study design: Experimental study 2. Sample size: 14 people 3. Independent variable: Treadmill Running; Peroneal Muscle Functional Electrical Stimulation (FES)	1. A significant difference was observed post-intervention in max pressure for the intervention group (M = 0.7) compared to the control group (M = -6.0). 2. Non-parametric data analysis was performed due to the non-normal distribution of the data, showing a

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position and starexcursion balance test performance	4. Dependent variable: Lateral Deviating Plantar Pressure Center Position; Star Excursion Balance Test (SEBT) Performance 5. Statistical test: MANOVA (Multivariate Analysis of Variance) 5; Post hoc T test; Wilcoxon signed rank test	significant difference in the intervention outcome on max pressure between the intervention and control groups. 3. The Wilcoxon sign rank test showed no statistically significant results of post-functional electrical stimulation intervention on the peroneal muscles, with no significant changes in center of pressure (COP) observed between groups.	

CSA,*Crossectional area* : LAS, *Lateral Ankle sprain* : PB,*Peroneal brevis* : PL, *peroneal longus* : CAI, *chronic ankle instability* BESS, *Balance Error Scoring System* : SEBT, *star excursion balance test* : ATFL, *anterior talofibular ligament* : CFL, *calcaneofibular ligament* : PTFL, *posterior talofibular ligament :* MRI, *magnetic resonansi imaging*

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Discussion

Lateral ankle sprain, also known as inversion or supination ankle sprain, is one of the most common injuries, especially among athletes. It occurs when the lateral ligaments of the ankle are damaged due to excessive supination or inversion of the hindfoot. Ankle sprain often results in functional instability and increases the risk of recurrent injury. Lateral ankle instability is often associated with recurrent injury due to decreased dynamic and functional stability.[5]

Through research conducted by Bamber, et al. In the context of ankle injuries, there is an important relationship between balance and the peroneal muscles.[15] One of the factors associated with ankle instability is the condition of muscle morphology in athletes who experience changes due to ankle sprain injuries. Muscle morphology is an important thing that needs to be considered. Muscle morphology is related to understanding the function of muscles in movement, and the shape of muscle postures that play a role in cases of ankle sprain injury. The occurrence of decreased muscle strength after ankle sprain injury will affect muscle morphology, including an increase in cross-sectional area and decreased muscle echogenicity this occurs due to changes in the structure and composition of muscle tissue due to injury.[9] As stated in research conducted by Arima, et al. Mentioned that significant changes occurred in the morphology and function of the peroneal muscle in patients with lateral ankle sprain injury, which could be detected through ultrasonography. The cross-sectional area (CSA) on the side of the ankle sprain increased due to muscle adaptation in response to injury.[20] After injury, the muscles around the injured area increase in size or hypertrophy as a compensatory mechanism to stabilize the weak joint and prevent recurrent injury. In addition, rehabilitation exercises performed to strengthen and stabilize the injured ankle also contribute to increased CSA on the affected side compared to the uninjured side.[10]

The peroneus muscle plays a crucial role in regulating the ankle's dynamic stability. When rapid ankle inversion pressure is applied, this muscle contracts first.[11] In the context of ankle injuries, research by Bamber et al. shown a link between the peroneus muscle, balance, and star excursion balance test performance. For this reason, it is crucial to exercise athletes' peroneal muscles, specifically their strength. Ankle sprains and other ankle injuries can be prevented with good dynamic balance, which is impacted by peroneal muscle strength and control.[15] In order to increase functional stability and lower the chance of injury in athletes, it is crucial to strengthen the leg muscles, particularly the peroneals.[14]

An ankle sprain occurs in athletes with heavy loading, many changes in direction of motion, fast movements, and jumping movements. So good functional stability is very important for athletes to reduce the risk of ankle sprain injury.[12] Athletes with good functional stability can perform movements more efficiently and safely so that they can support optimal athletic performance.[16] Research conducted by Sahin, et al., showed a relationship between the level of pes planus (flat foot) with body stability and jumping performance in athletes, and highlighted the importance of evaluating flat foot posture about balance and athletic ability. [19] Revisiting flat foot posture will certainly affect functional stability and the incidence of ankle sprain in athletes. Athletes with flat foot posture tend to have an increased risk of injury due to uneven weight distribution and lack of foot stability. The study also showed that athletes with flat foot posture had lower ankle stability compared to athletes with normal foot posture.[13] Athletes with normal foot posture had an average ankle stability score of 90, while athletes with flat foot posture had an average ankle stability score of 75.[17]

Also supported by research conducted by Setiawan, et al., found that athletes with flat foot posture have a higher prevalence of sports injuries compared to athletes who do not have flat foot posture.[21] Flat foot posture affects not only dynamic stability but also static stability. Athletes with flat foot arches tend to experience changes in foot mechanics that can lead to adverse biomechanical adjustments.[17] Athletes with flat foot posture have a 20% higher incidence of ankle sprain compared to athletes who have normal foot posture. Athletes' risk of ankle sprains is influenced by a number of factors, including flat foot posture, improper sports shoes, unfavorable field conditions, and fatigued muscles. Exercise regimens that target the intrinsic foot muscles and enhance proprioception can enhance functional stability and lower the risk of ankle sprains. An athlete's chance of suffering an ankle sprain can be decreased by 20% with a 10%–15% improvement in foot muscular strength.[19]

The study's reliance on secondary data from previously published research limits its findings to the quality and scope of existing literature, potentially missing recent developments not yet published. Additionally, the search is restricted to publications from the last 10 years, which ensures the inclusion of recent research but may overlook older studies that could provide valuable insights or foundational theories on the relationship between foot muscle morphology and flat foot posture with functional stability and incidence of ankle sprain in athletes. Moreover, by including only journals indexed by Sinta or Scopus, the study may exclude relevant research not indexed by these databases, potentially missing out on significant insights.

Conclusion

Some material that has been uncovered indicates that ankle injuries are a prevalent issue for athletes, particularly in sports that require quick movements and hops. In this instance, the peroneus muscle is crucial for preserving equilibrium and body stability in order to avoid ankle sprain injuries. Functional stability is influenced by a variety of factors, including flat feet, in addition to muscle shape. An athlete's body stability can be enhanced by

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training regimens that build leg muscular strength, maintain proper foot posture, and incorporate balancing exercises like star excursion, which can help lower the chance of ankle sprain injuries by up to 20 percent. Therefore, more investigation is required to identify and assess the morphological and functional alterations of the peroneus muscle in cases of lateral ankle sprains. Furthermore, understanding this association could aid in the creation of injury prevention plans and lower the likelihood of recurring injuries, particularly lateral ankle sprains, which are beneficial for athletes participating in fast-paced, high-load sports.

Ethical consideration

This review study used published articles that are accessible. Thus, this study did not require any informed consent or ethical consideration.

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Conflict of interest

According to the author, there isn't any possible conflict of interest related to the study, writing, or distribution of this paper.

Author contributions

GSI conceived the study design and data collection and drafted the manuscript; IPGSA and IP collected the data and revised the manuscript.

References

1. Vuurberg G, Hoorntje A, Wink LM, Van Der Doelen BF, Van Den Bekerom MP, Dekker R, Van Dijk CN, Krips R, Loogman MC, Ridderikhof ML, Smithuis FF. Diagnosis, treatment and prevention of ankle sprains: update of an evidence-based clinical guideline. British journal of sports medicine. 2018;52(15):956-1100.
2. Chen ET, McInnis KC, Borg-Stein J. Ankle sprains: evaluation, rehabilitation, and prevention. Current sports medicine reports. 2019;18(6):217-223.
3. Tong JW, Kong PW. Association between foot type and lower extremity injuries: systematic literature review with meta-analysis. journal of orthopaedic & sports physical therapy. 2013;43(10):700-714.
4. Ezema CI, Abaraogu UO, Okafor GO. Flatfoot and associated factors among primary school children: a cross-sectional study. Hong Kong Physiother J. 2013;5:1-8.
5. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. Journal of athletic training. 2002;37(4):364.
6. Lezak B, Varacallo M. Anatomy, bony pelvis and lower limb, calf peroneus longus muscle. 2012;3(1):70-74
7. Yalfani A, Ahmadi AH, Ahmadi M, Asgarpoor A. Effect of foot orthoses on plantar pressure symmetry in taekwondo athletes with flexible flatfoot: A randomized controlled trial. Sports Orthopaedics and Traumatology. 2024;40(1):50-57.
8. Liu K, Delaney AN, Kaminski TW. A review of the role of lower-leg strength measurements in ankle sprain and chronic ankle instability populations. Sports Biomechanics. 2022;21(4):562-575.
9. De Ridder R, Witvrouw E, Dolphens M, Roosen P, Van Ginckel A. Hip strength as an intrinsic risk factor for lateral ankle sprains in youth soccer players: a 3-season prospective study. The American journal of sports medicine. 2017;45(2):410-416.
10. Gribble PA, Delahunt E, Bleakley C, Caulfield B, Docherty C, Fourchet F, Fong D, Hertel J, Hiller C, Kaminski T, McKeon P. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. journal of orthopaedic & sports physical therapy. 2013;43(8):585-91.
11. Barrett J, Bilisko T. The role of shoes in the prevention of ankle sprains. Sports Medicine. 1995;2(1):277-280.
12. Tian F, Hefzy MS, Elahinia M. State of the art review of Knee–Ankle–Foot orthoses. Annals of biomedical engineering. 2015;4(3):427-441.
13. Cain LE, Nicholson LL, Adams RD, Burns J. Foot morphology and foot/ankle injury in indoor football. Journal of science and medicine in sport. 2007 ;10(5):311-319.
14. Doherty C, Delahunt E, Caulfield B, Hertel J, Ryan J, Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. Sports medicine. 2014;4(4):123-140.
15. Bamber ZA, Wheeler PC, Swain ID, Fong DT. Effect of 8-week treadmill running with peroneal muscle functional electrical stimulation on laterally deviated centre of plantar pressure position and star excursion balance test performance. J Rehabil Assist Technol Eng. 2021;8(3):20-25.
16. Lin JZ, Lin YA, Tai WH, Chen CY. Influence of landing in neuromuscular control and ground reaction force with ankle instability: A narrative review. Bioengineering. 2022;9(2):68.
17. Fraser JJ, Koldenhoven RM, Jaffri AH, Park JS, Saliba SF, Hart JM, Hertel J. Foot impairments contribute to functional limitation in individuals with ankle sprain and chronic ankle instability. Knee Surgery, Sports Traumatology, Arthroscopy. 2020;28(5):1600-1160.
18. Barrett J, Bilisko T. The role of shoes in the prevention of ankle sprains. Sports Medicine. 1995;20(1):77-80.
19. Şahin FN, Ceylan L, Küçük H, Ceylan T, Arıkan G, Yiğit S, Sarşık DÇ, Güler Ö. Examining the relationship between pes planus degree, balance and jump performances in athletes. International journal of environmental research and public health. 2022;19(18):116-122.
20. Warmadewi NKU, Adhitya IPGS, Griadhi IPA, Sutadarma IWG. Hubungan indeks massa tubuh dan lingkar perut terhadap foot hyperpronation pada perempuan dewasa di desa batuan, sukawati, gianyar. Majalah Ilmiah Fisioterapi Indonesia.2018; 3(1):36-40
21. Nugraha IGMN, Winaya IMN, Negara AAGAPN, Andayani NLN. The relationship between leg muscle strength and functional mobility in the elderly. Physical Therapy Journal of Indonesia. 2024;5(1):25-28.
22. Sarıalioğlu N. Analysis of relationship between foot morphology and static balance in female athletes. Turkish Journal of Sport and Exercise. 2023;25(2):166-17