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The Effect of Sport Participation and Gender on Foot Posture and Function in American Football Players: A Cross-Sectional Study

Amerikan Futbolu Oyuncularında Spora Katılımın ve Cinsiyetin Ayak Postürü ve Fonksiyonu Üzerine Etkisi: Kesitsel Araştırma

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ABSTRACT Objective: The aim of this study was to compare foot posture and functionality in American football players according to gender and duration of participation in sport. **Material and Methods:** American football players between the ages of 18-28 (23.18±2.93 years) were included. The demographic features of participants were recorded as gender and duration of participation in sport. Foot posture and functionality were evaluated by using the Foot Posture Index (FPI) and the Foot Function Index (FFI). **Results:** The mean FPI score was 1.65±1.55 on the dominant side and 1.8±1.52 on the nondominant side. There was no significant difference between the FPI and the FFI scores of female and male American football players ($p>0.05$). When examined in terms of participation time in sports, FFI scores were found to be better in favor of those who have been playing for more than 5 years ($p<0.05$). **Conclusion:** The foot posture values of the athletes evaluated were within normal limits. The mean foot posture of the athletes was within normal ranges. The results of this study showed that there was no difference in foot posture and function in American football players according to gender, while the duration of participation in sports for 5 years or more affects foot function. The results of the study indicate that it is important to consider the duration of participation in sports and foot posture in the exercise planning for training or injury prevention.

Keywords: Foot; posture; exercise; football

ÖZET Amaç: Bu çalışmanın amacı, Amerikan futbolu oyuncuların spora katılım süresi ve cinsiyete göre ayak postürlerini ve ayak fonksiyonlarını karşılaştırmaktır. **Gereç ve Yöntemler:** Çalışmaya, 18-28 yaş arası (23,18±2,93 yıl) Amerikan futbolu oyuncuları dâhil edildi. Katılımcıların demografik özellikleri, cinsiyet ve spora katılım süresi kaydedildi. Ayak postürü ve fonksiyonelliği Ayak Postür İndeksi (APİ) ve Ayak Fonksiyon İndeksi (AFİ) kullanılarak değerlendirildi. **Bulgular:** APİ skoru ortalamalarının dominant tarafta 1,65±1,55, nondominant tarafta 1,8±1,52 olduğu belirlendi. Kadın ve erkek Amerikan futbolu oyuncularının APİ ve AFİ skorları arasında anlamlı bir fark bulunmadı ($p>0,05$). Spora katılım süresi açısından incelendiğinde, AFİ skorlarının 5 yıldan uzun süredir oynayanlar lehine daha iyi olduğu bulundu ($p<0,05$). **Sonuç:** Değerlendirilen sporcuların ayak postür değerleri normal sınırlar içindedir. Çalışmanın sonuçları, Amerikan futbolu oyuncularında cinsiyete göre ayak postürü ve fonksiyonelliğinde bir fark olmadığını, ancak spora 5 yıl ve daha uzun süre spor geçmişi olan sporcuların ayak fonksiyonunun daha iyi olduğunu göstermektedir. Çalışma sonuçları, antrenman veya yaralanma önleme amaçlı egzersiz planlamasında spora katılım süresinin ve ayak postürünün dikkate alınmasının önemli olduğunu göstermektedir.

Anahtar Kelimeler: Ayak; postür; egzersiz; futbol

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American football is a field-based team and contact sport that requires power, strength and speed. In team sports, the risk of injury increases as the number of players increases, and the highest number of injuries among university sports has been reported in American football.[1] Several studies have investigated proposed risk factors in athletic populations. These include demographic such as gender, age, and body mass index, foot posture, foot and ankle alignment, laxity, muscle strength, balance and proprioception, previous history of ankle sprain, and sport-related parameters. There is no convincing evidence on how significant or effective these parameters are. However, most studies agree on the importance of previous history injury, being overweight, joint laxity and gender.[2-4]

The addition of the risk of collision to sports activities such as jumping, running, and lateral cutting often significantly increases the risk of foot, ankle, and knee injuries in American football.[5] Furthermore, it is generally believed to be associated with impaired foot posture, pathomechanics, and functionality, and all these parameters may subsequently predispose the foot, ankle, and related structures to musculoskeletal injury.[6] So, in clinical practice, foot posture is frequently evaluated for injury prevention and management. Features related to the foot and ankle is a factor that can affect both the performance of the athletes and the biomechanics of injury. According to some research foot injury has been associated with several factors, such as increased age, female gender, and obesity. However, research into the overall foot posture, function and gender has been limited.[7]

Since foot and ankle injuries make up 15 to 20% of all game-related injuries in American football, it is especially essential to evaluate foot posture, function, and biomechanics in conditions that accurately mimic competitive-level activity. As well, foot function and duration of participation are associate with injury risks and mechanisms.[8] For this reason, it will be beneficial to focus on the foot in professional sports. This study was planned to investigate the effects of gender and duration of participation in sports on foot posture and functionality in American football players. The hypotheses of the study are as follows:

$H1_1$: There is a difference between the foot posture and foot function scores of male and female American football players.

$H1_2$: There is a difference between the foot posture and foot function scores of American football players with less than 5 years and more than 5 years.

MATERIAL AND METHODS

This study was carried out between October-November 2022 as a cross-sectional study. Total 40 American football players (18 female, 22 male) between the ages of 18-28 (mean age: 23.18±2.93 years) were participated in this study. Participants were informed about the study which was carried out with the approval of Baskent University Institutional Review Board and Ethics Committee (date: September 7, 2022, no: 22/158). Participants who agreed to participate in the study were asked to sign an informed consent form. This study was conducted, and data were analyzed according to the Declaration of Helsinki.

PARTICIPANTS

The inclusion criteria were being between the ages of 18-28, playing American football for at least 2 years and doing exercise regularly. The exclusion criteria were having a lower extremity injury in the last 6 month, having an operation about lower extremity in the last 2 years.

OUTCOME MEASUREMENTS

Descriptive characteristics of the participants were questioned. Foot posture and functionality were evaluated by using Foot Posture Index (FPI) and Foot Function Index (FFI).

Foot Function Index

A FFI was developed to measure the impact of foot pathology on function. The FFI is a self-administered index consisting of 23 items divided into 3 sub-scales defined as “pain, disability, and activity limitation”. Nine questions make up the pain subcategory, which assesses foot discomfort in various contexts, such as when wearing shoes or being barefoot. Nine questions in the disability subcategory gauge how challenging it is to carry out various functional activities owing to foot problems, such as how challenging it is

to climb stairs. The 5 elements that make up the activity limitation subcategory assess limitations in activities brought on by foot issues, such as spending the entire day in bed. Participants were asked to mark each question from 0 (no pain or difficulty) to 10 (worst pain imaginable or difficult enough to require help) on a Likert scale that best described their feet during the past week. Higher scores on the index indicate worse pain.[9]

Foot Posture Index

The FPI is a tool for measuring foot position. The FPI comprises of 6 verified, criterion-based observations of a person's forefoot and rear foot while they are standing comfortably. The rear foot was evaluated by palpating the head of the talus, observing the curves above and below the lateral malleoli, and determining how much the calcaneus was inverted or everted. The forefoot is observed by measuring the talonavicular joint bulging, the medial longitudinal arch's congruence, and the amount of forefoot abduction and adduction relative to the rear foot. Using a 5-point Likert-type scale, the FPI categorizes foot posture into 4 categories: normal (0 to +5), pronated (+6 to +9), severely pronated (10+), and supinated (-1 to -4) and highly supinated (-5 to -12).[10]

STATISTICAL ANALYSIS

A priori power analysis was conducted using G*Power Software (Heinrich-Heine-Universität, Düsseldorf) for sample size estimation, based on data from published study. The effect size of 0.86 for FFI that reported by Soohoo et al. was taken as reference.[11] With this effect size, α=0.05 significance and >0.80 power, the minimum total sample size required for analysis of the difference between 2 independent means is at least 38.

Data analysis was performed with the statistical package for the social sciences (SPSS Version 26 from IBM, United States) for all outcome measures. The normality of the distributions of the variables was tested using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro- Wilk tests). Within the scope of the study, Mann-Whitney U test was used for comparisons between independent groups formed according to gender and sports participation. $p<0.05$ was accepted as statistically significant.

RESULTS

Descriptive characteristics of the participants were given in Table 1. Eighteen of the participants were

TABLE 1: Descriptive data of the participants

	Minimum-maximum	X̄±SD
Age (year)	19-30	23.18±2.93
BMI (kg/m^2)	17.58-31.64	24.31±3.5
American football playing time (month)	4-144	48.55±39.76
Weekly training with crampons (hour)	1-5	2.6±0.84
Daily standing time (hour)	3-12	6.35±2.51

SD: Standard deviation; BMI: Body mass index

TABLE 2: Comparison of the foot posture and function scores according to gender

		Female		Male		Mann-Whitney U test	
		Minimum-maximum	X̄±SD	Minimum-maximum	X̄±SD	U	p value
FPI (dominant)		(-3)-5	1.83±1.86	(-1)-4	1.5±1.26	163.5	0.338
FPI (nondominant)		(-3)-5	1.83±1.82	(-1)-4	1.77±1.27	187.5	0.77
FFI (dominant)	Pain	0-20	3.5±6.91	0-13	3.73±4.43	158.5	0.233
	Disability	0-11	2.5±4.13	0-7	1.36±2.15	189	0.774
	Activity limitation	0-4	0.33±0.97	0-6	0.32±1.29	184	0.508
	Total score	0-32	6.33±11.45	0-19	5.41±6.61	169	0.388
FFI (nondominant)	Pain	0-20	3.56±7.04	0-10	3.23±3.74	158.5	0.233
	Disability	0-12	2.61±4.37	0-7	1.23±2.14	182	0.601
	Activity limitation	0-4	0.33±0.97	0-6	0.41±1.33	193.5	0.844
	Total score	0-35	6.5±11.86	0-17	4.86±5.63	170	0.404

SD: Standard deviation; FPI: Foot Posture Index; FFI: Foot Function Index

TABLE 3: Comparison of foot posture and function scores between groups with less than 5 years of participation and groups with 5 years or more of participation in sport

		Less than 5 years of participation (<60 months)		5 years or more of participation (≥60 months)		Mann-Whitney test	
		Minimum-maximum	X̄±SD	Minimum-maximum	X̄±SD	U	p value
FPI (dominant)		(-3)-4	1.5±1.68	0-5	1.83±1.38	188	0.781
FPI (nondominant)		(-3)-4	1.5±1.6	0-5	2.17±1.38	156.5	0.247
FFI (dominant)	Pain	0-20	6.18±6.39	0-7	0.5±1.69	77	**<0.000****
	Disability	0-12	3.36±3.73	0-1	0.06±0.24	86	**<0.000****
	Activity limitation	0-6	0.59±1.5	0-0	0	153	**0.033***
	Total score	0-32	10.14±10.22	0-7	0.56±1.76	66	**<0.000****
FFI (nondominant)	Pain	0-20	5.73±6.24	0-7	0.5±1.69	77.5	**<0.000****
	Disability	0-11	3.32±3.98	0-1	0.06±0.24	95.5	**0.001***
	Activity limitation	0-6	0.68±1.52	0-0	0	144	**0.018***
	Total score	0-35	9.73±10.23	0-7	0.56±1.76	66	**<0.000****

*p<0.05; **p<0.001. SD: Standard deviation; FPI: Foot Posture Index; FFI: Foot Function Index

female (45%) and 22 of the participants (55%) were male. 22-participant played American football for less than 5 years (55 %) and 18 participant played more than 5 years (45%). The FPI score of all participants was 1.65±1.55 for the dominant side and 1.8±1.52 for the nondominant side. The mean FFI score of all participants was 5.83±9.00 for the dominant side and 5.6±8.89 for the non-dominant side. It was found that the difference of the FPI and FFI scores in the gender groups was not statistically significant (p>0.05) (Table 2). There was no significant difference between the FPI scores of the participants who played American football for less than 5 years and for 5 or more years (p>0.05), but the difference between the FFI scores were statistically significant (p<0.05) (Table 3).

DISCUSSION

The aim of this study was to compare foot posture and functionality in American football players according to gender and duration of participation in sports. This study showed that gender and duration of participation in sports do not affect foot posture in American football players, but duration of participation in sports is effective in foot functionality. To the best of our knowledge, this study is one of the few studies examining foot posture and functionality in American football players according to gender and duration of participation in sports.

All sports as swimming, basketball and American football have specific technical movements. The technical movements consist continuously unidirectional movements, high repetition, and strong muscle forces are produced in the distal of lower extremities during, running, cutting, and tackling.[12] In this context according to Hsu et al. American football players may sustain several types of foot and ankle injuries because of contact and noncontact mechanisms.[12] Safar Cherati et al. stated that postural abnormalities are associated with foot and ankle injuries in professional football players.[13]

In previous epidemiologic studies, upper extremity actively used sports like basketball, badminton, and American football had usually foot and ankle injuries. So, the authors thought that it is important to identify foot posture impairment before the injury happens.[14,15] Carson et al. demonstrated that foot postures influence loading pattern of the foot and tend to injury in American football players.[16] In this study results, the foot postures of American football player had normal ranges (0 to +5) in dominant and nondominant side. Desai et al. showed that there was no difference between the foot postures of marathon runners, badminton players and football players, and

most of them had normal foot posture according to the foot posture index.[17] This situation can be useful for coaches and parents to prepare appropriate program for preventing injury in future. It is important to prevent the American football player from overloading and injuries so foot exercises should be included in training programs.

There are many studies in the literature investigating the effects of gender on foot posture.[18,19] There is no consensus about the results because those studies have usually examined the effects of different variables in different sport and age groups. Gender is an essential feature for foot posture. There are studies in the literature indicating that gender is not effective on foot posture in young adults while other studies are indicating that foot injuries that girls more likely than boys.[20,21] Therefore, in the literature gender related changes on foot postures are still controversial.[18,19] Consequently, gender of individuals can be effective on the foot postures.[22] Lin et al. reported that girls were 3 times more likely than boys to sustain anterior cruciate ligament injuries in high school athletes or competitions in the United States.[20] Wentz et al. also showed higher bone stress injuries different patterns between females and males in military and athletic populations.[21] Hsu et al. stated that injuries have a higher incidence in males more predisposed to hamstring strains and hip/groin injuries, and female to quadriceps strains and severe knee and ankle ligament injuries than in female football players.[12] The result of this study shows that there is no difference in FPI between male and female American football players. While this result can be explained by the similar effects of foot posture, it also shows that there is a need for studies comparing the effect of gender on foot posture in American football players. Research in the literature on the disparity in injury rates between women and men has focused on gender-based biological characteristics such as injury mechanism, anatomy, and hormones, and has not considered broader gender-based biomechanical influences.[23,24] Parsons et al. demonstrate that studies had failed to decrease injuries rate disparity between male and female players over 20 years.[25] Tan et al.'s study on the impact of gender following anterior cruciate ligament reconstruction found that rates of graft failure and rupture were the same for both sexes, and both genders were equally likely to experience anterior knee discomfort.[26] According to Ünlüer et al. reported that foot posture and gender had similar effects on balance in asymptomatic adults.[27] The researchers showed that the frequency of injuries during training and matches among male and female American football players, and foot functionality in the dominant and nondominant feet were similar, and the most diagnosed injury was lower extremity sprains. On the other hand, there is a limited number of studies about gender on foot functionality and there is no comparison of foot functionality between female and male American football players. There are some feasibility studies about effects of exercises on foot functionality.[28] Therefore, focusing on gender in this study of foot evaluation heightens awareness of possible influences, challenge us to think about gender, and inform more effective approaches to foot and ankle injury prevention.

American football players are more frequently injured in the lower extremities than the upper extremities, and the most seen location of the injury is the ankle.[12,29] According to research on injuries, 85% of injuries occurred in the lower extremities, and sprains, muscle stiffness, and ligament rips were the most common forms of injuries.[30] Lopezosa-Reca et al. compared foot postures between swimmers and footballers after about 9 years of practices.[31] They showed that FPI values obtained indicate that the swimmers had a more strongly pronated foot posture than the football players. Post et al. implemented that exceeding 8 month per year in a single sport was associated with overuse injury in youth sport and athletes.[32] In this study results there is similar values about FPI between sport practices more and less than 5 years. The foot functions of the athletes who played American football for less and more than 5 years were observed to be significantly different. The functionality of the dominant and nondominant feet in American football players is better in those who have played for more than 5 years. In other words, American football players' foot functionality, including pain, disability and activity limitation, improves as the duration of sport participation increases. The authors thought that the musculoskeletal structures of

foot and ankle adapted repetitive weight loading after sport practices over time. However, repetitive mechanical loading can stimulate metabolism and increase the strength of the ligaments with sufficient rest and recovery.[33]

A functional foot is a gripping and sensory organ that can balance body weight on a small surface, as well as transfer body weight.[12] American football players use their feet running, standing, walking, and directing the body. During standing, directing the body, or running more body weight is transferred to a foot than the other one. Long-term use of one foot more causes overload on one side of the body.[34] Muscle imbalances or asymmetries may occur over time duration of participation in sports after overloading. It is thought that this situation may adversely affect the functionality of the dominant and nondominant foot. However, since there are limited studies on American Football and its effects on dominant and nondominant posture and functionality in the literature.[29] Even though there are studies which shows frequency of injuries and American football players' foot posture, the effect of gender and duration of participation in sports on foot posture and functionality has not been investigated to our best knowledge.[12,29,30] As it is known, there is a risk of injury to the ankle and foot of the American football player.[12,35] So, there is a need for a more specific evaluation for evaluating foot postures and functionality and the authors thus try to show the effects of duration of participation in sports and gender difference on the foot posture and functionality in this study. Although this study results showed similar foot postures and functionalities between female and male American football players, the functionality of foot was different according to duration of participation in sports.

LIMITATIONS

This study has some limitations. Factors that may affect foot posture and foot functionality such as plantar sensations and previous injuries were not evaluated. This study was not a regression study with large sample size, so the authors interpreted the results of a cross-sectional study. In addition, the age of starting sports is also a factor that may affect foot posture and functionality. One of the important limitations of the current study is that the age of starting sports was not questioned.

CONCLUSION

The current study shows that gender and duration of participation in the sport do not affect the foot posture of American football players. On the other hand, while gender did not affect foot functionality, participation in sports for more than 5 years positively affected foot functionality. This leads us to the conclusion that the evaluation of the foot should be prioritized in sports branches where lower extremity function is important, such as American football, which was examined in our study. Evaluation of foot function and posture of the individual participating in sports during the duration of participation in sports will be beneficial both in terms of improving performance and preventing injuries. Furthermore, the evaluation of other parameters such as sensation of foot or plantar pressure distribution in addition to foot posture and functionality in future studies may contribute to our current knowledge.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Senay Çerezci Duygu, Tezel Yıldırım Şahan, Aslıcan Çağlar, Ayça Aytar, Aydan Aytar;* ***Design:*** *Senay Çerezci Duygu, Tezel Yıldırım Şahan, Aslıcan Çağlar;* ***Control/Supervision:*** *Ayça Aytar, Aydan Aytar;* ***Data Collection and/or Processing:*** *Burak Eser, İrem Saylam, Sedat Mert Keskin;* ***Analysis and/or Interpretation:*** *Senay Çerezci Duygu, Tezel Yıldırım Şahan, Burak Eser, İrem*

Saylam, Sedat Mert Keskin; ***Literature Review:*** *Senay Çerezci Duygu, Tezel Yıldırım Şahan, Aslıcan Çağlar;* ***Writing the Article:*** *Senay Çerezci Duygu, Tezel Yıldırım Şahan, Aslıcan Çağlar;* ***Critical Review:*** *Ayça Aytar, Aydan Aytar;* ***References and Fundings:*** *Ayça Aytar, Aydan Aytar;* ***Materials:*** *Ayça Aytar, Aydan Aytar, Burak Eser, İrem Saylam, Sedat Mert Keskin.*

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