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Research Article / Araştırma Makalesi

The impact of decreased tibial torsion angle on ankle sprain in football

Futbolda lateral ayak bileği burkulmalarında tibial torsiyon açısının etkisi

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ABSTRACT

Objective: Ankle sprains are one of the most common sports-related injuries. Among them, lateral ankle sprains (LAS) predominantly occur as inversion-type injuries. As a result of LAS, athletes are required to stay away from training/competitions for a certain period, which leads to a decline in their athletic performance. While the injury mechanisms for inversion-type injuries have been elucidated, it is imperative to investigate anatomical risk factors associated with these injuries.

Material and Methods: This study aimed to examine the influence of tibial torsion angle (TTA) in lateral ankle sprains. In the study, the TTA of 67 male football players was recorded during pre-season evaluations. Among these players, 23 experienced LAS, while 44 did not.

Results: A statistically significant difference in TTA was observed between players who suffered LAS during the season and those who did not ($p<0.05$). The findings indicate that individuals with lower TTA are more likely to experience LAS. In addition, a cutoff value analysis revealed that football players with right TTA<11° and left TTA<10° are at an increased risk of injury.

Conclusion: In conclusion, the tibial torsion angle should be included as a risk factor in pre-season assessments for lateral ankle sprains, and athletes with low TTA should be integrated into injury prevention programs targeting LAS.

Keywords: *Sports injuries, football, lateral ankle sprains, tibial torsion angle*

ÖZ

Amaç: Ayak bileği burkulmaları en sık görülen spor yaralanmalarından biridir. Bu tip yaralanmalar sıklıkla inversiyon tipinde görülen lateral ayak bileği burkulmalarıdır (LAB). LAB sonucu sporcular belirli bir süre antrenman ve/veya yarışmadan uzak kalmakta, bu durum sporcuların performansının düşmesine neden olmaktadır. İnversiyon tip yaralanmaların mekanizması ortaya konulmuş olmasına rağmen, anatomik risk faktörlerinin araştırılması gerekmektedir.

Gereç ve Yöntem: Bu çalışmada lateral ayak bileği burkulmalarında tibial torsiyon açısının (TTA) etkisi incelendi. Toplam 67 erkek futbolcunun TTA değerleri sezon başı değerlendirmelerde kayıt altına alındı. Futbolcuların 23'ü LAB tipi yaralanma yaşarken 44'ü bunu yaşamadı.

Bulgular: Sezon içinde yaralanan ve yaralanmayan sporcuların TTA'ları arasında istatistiksel olarak anlamlı fark saptandı ($p<0.05$). Elde edilen bulgulara göre TTA'sı düşük sporcuların LAB yaşama olasılığı artmaktadır. Bununla birlikte, yaralanma 'cut-off' değerlerinin belirlendiği çalışmada sağ tibial torsiyon açısı 11° ve sol tibial torsiyon açısı 10° altında kalan futbolcuların yaralanma riskinin arttığı belirlendi.

Sonuç: Tibial torsiyon açısının lateral ayak bileği burkulmasında bir risk faktörü olarak sezon başı değerlendirmelerinde yer alması ve düşük TTA'sı olan sporcuların LAB yönünden yaralanma önleme programlarına alınması gerektiği düşünülmektedir.

Anahtar Sözcükler: *Spor yaralanması, futbol, lateral ayak bileği burkulmaları, tibial torsiyon açısı*

INTRODUCTION

Ankle sprains, although predominantly of the inversion type, are characterized by the excessive stretching or tearing of ligaments located in the lateral aspect of the ankle (1-3). Approximately three-quarters of all ankle sprains occur as inversion-type injuries, with approximately 73% reported as anterior talofibular ligament injuries (1-4). These injuries are most commonly observed in sports that involve a significant amount of jumping and running, such as football, basketball, and volleyball (2,4-8). The high incidence rate of acute ankle sprains is partly attributed to the increased risk of re-injury following an initial ankle sprain (4). Ankle sprains, which affect approximately 1.7 billion individuals worldwide (9), are reported in two million people annually in the United States alone (10). Lateral ankle sprains, occurring at a rate of 1 in 10,000 individuals per day, represent the most common sports-related injury (11).

Several factors contribute to the susceptibility to lateral ankle sprains, including foot inversion, increased body mass, accelerated concentric force of the plantar flexors of the ankle, decreased proprioceptive perception of ankle inversion, and delayed reaction time of the peroneus brevis tendon (12). While many studies have suggested that ankle

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inversion, internal rotation, and plantar flexion play roles in the mechanism of lateral ankle sprains, recent research has highlighted the importance of ankle dorsiflexion in this mechanism (13). However, there is limited body of literature addressing the relationship between joint position and ankle anatomy in the context of ankle sprains. Further studies are needed to investigate the association between joint position, foot anatomy, and ankle sprains (14,15).

In ankle sprains, it is well recognized that numerous factors come into play, including anatomical structure of the foot, environmental conditions, and stresses inherent to the specific sport (particularly those requiring high skill levels and involving complex movements) (14-16). However, the exact influence of anatomical risk factors on ankle sprains has not been fully clarified in existing literature. Reducing tibial torsional load has been suggested as a potential means to decrease running-related injuries in athletes, highlighting its place in injury prevention programs. Nevertheless, there persists a gap in knowledge regarding this subject (17).

Balance and proprioception are among the most significant risk factors for ankle injuries (1,18). The impact of changes in the Tibial Torsion Angle (TTA) on balance and proprioception has been identified (17). While it has been noted that in external tibial torsion, the foot adapts better to sprain stress compared to a neutral foot angle (19), and that changes in TTA might increase biomechanical stress in athletes, leading to ankle injuries (18), the effect of a decrease in tibial torsion angle on ankle sprains has not been fully studied. Individuals engaged in different sports may experience alterations in their TTA due to the specific demands of their sport or the exercise regimens they follow (17). For instance, biomechanically, basketball players, who frequently engage in jumping activities, require inversion during both the take-off and landing phases. Consequently, ankle sprains are common among basketball players (20). Therefore, investigations into tibial torsion (TT) and ankle sprains should be sport-specific, as this approach would allow for a more objective assessment of how TTA changes in response to the stress imposed by a particular sport. According to literature, a decrease in TT angle is associated with an increased pronation, while an increase in angle leads to a supination problem. A decreased TT angle makes it easier for the foot to invert due to the shifting of the load towards the lateral side of the foot.

The purpose of this study is to determine the impact of the TTA on the risk of ankle sprains in football players. Additionally, determining the sport-specific cut-off value for TTA is of significant importance in both understanding its impact on ankle sprains and in the development of injury prevention programs tailored to each sport. The tested hypotheses of the present study were as follows: changes in TTA in professional football players may increase the incidence of lateral ankle sprains. We believe that this study will contribute to the literature on the subject and assist in future research endeavors related to this topic.

MATERIAL and METHODS

Participants

The study involved professional football players with a minimum of five years of experience in the Turkish Super League (Table 1). Over the course of five seasons, ankle injuries of 67 different football players were documented. TTA measurements of football players were taken and lateral ankle sprains within a season were tracked. The evaluation revealed that five of the football players frequently experienced lateral ankle sprains during their football careers. The independent variable of our study is the Tibial Torsion Angle, and the dependent variable is ankle sprains. It has been planned as an observational cohort study. Players who had been diagnosed with ankle sprains by the club sports physician and who had missed a minimum of three days of training due to the injury were included in the study. The severity of injuries was recorded using MRI imaging. None of the players had any foot deformities. Ethical approval for the study was obtained from the Selçuk University, Ethics Committee (25 May 2021, No. 2021/797). Each participant was provided with information about study procedures and asked to sign the informed consent form. Furthermore, written permission was obtained from the football club to utilize the data for scientific research.

Table 1. Physical characteristics of the participants

	LAS Injury		
Parameters	**Yes** (n=23)	**No** (n=44)	**t value**
Age (yr)	25.2±4.1	25.7±4.1	-0.729
Weight (kg)	78.3±4.9	78.9±3.9	-0.672
Height (m)	1.81±0.07	1.82±0.06	-1.317
BMI (kg/m²)	23.9±2.0	23.7±2.0	0.681

BMI: Body mass index

Data Collection

TTA measurements were taken and recorded for the athletes at the beginning of the season. TTA was determined by measuring the transmalleolar angle. This was performed with the athletes lying face down, knees flexed at 90°. The midpoints of the medial and lateral malleoli were connected to create a line under the heel. The angle between this line and a line drawn perpendicular to it and intersecting with the femur line provided the transmalleolar angle (21). Although the gold standard method for measuring Tibial Torsion Angle is CT (Computed Tomography), studies have shown a significantly good correlation and reliability bet–

ween goniometric measurement and CT-assisted measurement of tibial torsion (22). Goniometric measurement has been preferred as it is a reliable and cost-effective tool for determining tibial torsion, and also because it lacks the radiation exposure present in CT.

Statistical Analysis

The normality of angle distributions for each group was assessed using the Shapiro-Wilk test. An independent t-test was employed to compare normally distributed right and left tibial torsion angles between independent groups. The Receiver Operating Characteristic (ROC) analysis was used to determine the threshold value for binary classification of right and left angles (presence/absence of injury). Cut-off values determined based on the highest Youden index and the area under the ROC curve (AUC) values are presented in Table 3. The level of statistical significance was set at $p<0.05$. Statistical calculations were performed using JAMOVI v1.2.27.

RESULTS

It was found that the football players' age, weight, height, and body mass indices were similar among the groups with and without injuries ($p>0.05$) (Table 1). The right and left TTA measurements were similar ($p>0.05$) As seen in Table 2, the right and left TTA values of players who experienced ankle sprains were significantly lower than those of the players who did not experience injuries ($z=29.847$, $z=19.431$, $p<0.05$, respectively).

Table 2. Comparison of Tibial Torsion Angles

	LAS Injury			
Angle	**Yes** (n=23)	**No** (n=44)	**z value**	**p value**
Right tibial torsion(°)	7.2±2.6	16.1±4.2	29.847	0.001
Left tibial torsion (°)	7.7±2.9	16.3±4.3	19.431	0.001

ROC analysis is a valuable analytical method that contributes significantly to clinical decision-making processes when dealing with situations where the diagnostic process is time-consuming, expensive, requiring specialized equipment and personnel. It provides a means to determine appropriate cut-off values for readily available, cost-effective, and easily obtainable markers in a short time (23). Scores obtained through Linear Discriminant Analysis, Quadratic Discriminant Analysis and Logistic Discriminant Analysis were separately subjected to parametric and non-parametric ROC curve methods. The area under the ROC curve (AUC), optimum cut-off points, sensitivity, specificity, and Youden index values were determined. The cut-off values were determined considering the condition where the Youden index was maximized, which represents the optimum cut-off point based on the selection of sensitivity and specificity (24). As the AUC value approaches 1, the excellence of the model increases. For right TTA, an 0.97 AUC value was obtained, and based on a 0.82 Youden index, a cut-off value of 11° was determined. Similarly, for left TTA, an 0.96 AUC value was obtained, and based on a 0.75 Youden index, a cut-off value of 10° was established (Table 3).

Table 3. TTA and cut-off values based on injury status

	AUC	Z	p	SE	95% CI	Sensitivity	Specificity	Cut-off	YI
RTT	0.97	29.847	<0.001	0.016	0.897-0.997	95.7	86.4	≤11	0.820
LTT	0.96	19.431	<0.001	0.023	0.874-0.991	87.0	88.6	≤10	0.756

RTT: right tibial torsion, LTT: left tibial torsion; SE: standard error, CI: confidence interval, YI: Youden index. Cut-off and AUC values obtained from the ROC analysis. Threshold points determined based on the highest YI value.

It is widely accepted that as the area under the ROC curve approaches 1, the diagnostic accuracy increases. The optimal positive likelihood ratio threshold value is the one that provides the point closest to the upper-left corner on the curve. Upon examination of the ROC graph, a sensitivity of 95.7% and specificity of 86.4% were identified as the values closest to the upper-left corner for right TTA. For left TTA, a sensitivity of 87.0% and specificity of 88.6% were determined as the values closest to the upper-left corner. In the ROC curve, an area value of 100% corresponds to a diagnostic power of 1. The convergence of the curve to 100% sensitivity in the upper-left corner for both right and left TTA indicates that the findings obtained, in conjunction with the threshold value, have a strong diagnostic value (Figure 1).

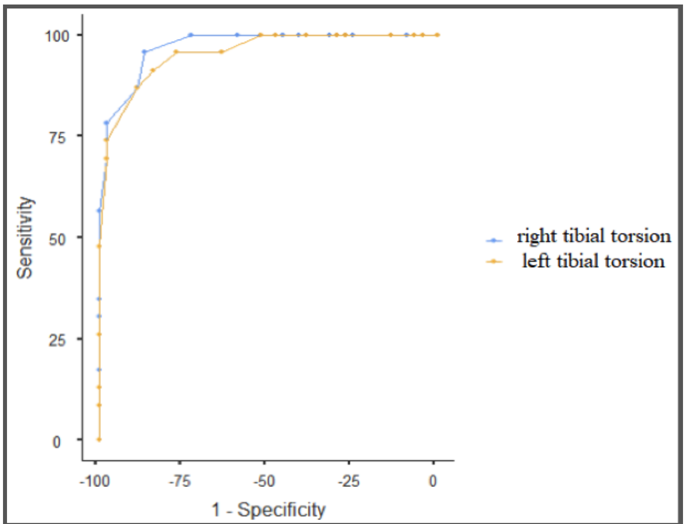

Figure 1. Roc curve

DISCUSSION

In our study involving professional football players, the similarity found between the right and left TTA is consistent with the literature. Previous studies have not found a significant difference between extremities in TTA measurements (25). In adult men, TTA measurements have yielded results ranging from 19.0±4.8 to 41.0±8.8 degrees (22). In our study, we obtained 16.1±7.2 and 16.3±7.7 TTA. The difference between our results and the literature may be due to the fact that the study in the literature was conducted on sedentary male groups. Furthermore, studying TTA measurements in individuals with developed deformations will also result in differences (22). Our study exclusively includes professional male football players. The difference emerging in the literature due to sports activities (17) and population differences (25) significantly influences TTA. Joint anatomy is recognized as an intrinsic risk factor for injury (26). However, there is a dearth of literature regarding anatomical influences on ankle sprains. Therefore, there is a need for further research on this topic (14). Identifying ankle injury risk factors is crucial for the development of prevention programs and minimizingthe incidence of injuries (15,27).

In the study, it was observed that football players who experienced lateral ankle sprains (LAS) had similar age, weight, height and BMI with those who did not experience LAS. However, a significant difference in tibial torsion angles (TTA) was identified between athletes with and without LAS. Athletes who experienced this type of injury had lower TTA values, and a relationship was established between the decrease in TTA angle and the risk of injury. Cut-off values were determined between athletes' injuries and TTA based on the ROC analysis results. It was found that a reduction in right tibial torsion angle <11° and left tibial torsion angle <10° increased the risk of injury. No previous study in the literature has reported cut-off values for TTA in ankle sprains or identified the specific values that pose a risk. Furthermore, there are very few studies that illustrate the relationship between TTA and LAS (16).

In a study comparing the running biomechanics of female athletes with ankle instability and those without sprains, it was reported that foot inversion increased significantly in women with ankle instability severe enough to cause concern (28). A cadaver study that involved modeling the ligaments and bones of the ankle, and the mechanism of lateral ankle injury reported that the primary effect during injury should be considered as the internal rotation of the foot. Macintyre and Joy (29) also included the impact of TTA on ankle injuries among dancers in their list of intrinsic injury risks. These findings align with our study, as an increased tendency toward internal rotation along with changes in TTA was observed.Changes in TTA have been noted to cause alterations in pressure within the ankle joint (30). McCarthy and colleagues suggested that internal tibial torsion could lead to syndesmotic injuries (31). The decrease in TTA we observed is consistent with the idea that internal tibial torsion could result in lower extremity alignment disorders significant enough to cause injuries, likely due to pressure changes on the ankle joint, leading to an increased risk of ankle sprains.

One study which investigated the anatomical risk factors for lateral ankle injuries in adolescent athletes reported that TTA did not influence ankle sprains (16). The mean age of the players in this study was 14.5 ± 3.0 years, and TTA's values of football, basketball, volleyball and handball players were compared in their study. As ankle kinematics varied within each sports branch, ankle injury mechanisms also differed. Therefore, it was reported that establishing a relationship between TTA and ankle sprains based solely on mean values across sports may not yield accurate results. While Saki et al. reported that TTA had no effect on ankle sprains, it is intriguing that non-injured athletes had lower mean values of 8.8 ± 5.5°, compared with 7.4 ± 5.0° in injured athletes. TTA completes its development at the age of 18. However, since this study focused on athletes aged 14-16, different results may have been obtained. In the same study, a relationship was identified between navicular drop and ankle sprains (16). According to literature, a decrease in tibial torsion angle leads to an issue of overpronation (32,33). The development of navicular drop due to overpronation aligns with our perspective that it may be associated with TTA.

Limitations of the Study

In this study, in order to control some of the factors contributing to ankle sprains, the research group consisted of players competing in the same team and under the same field conditions. Therefore, external stress and ground reaction effects were considered to be similar and stable. The influence of age was standardized as the research group consisted of young adult players. The impact of health and technical staff on ankle sprains was assumed to be similar, and since all players were elite athletes, they were subjected to the same protection and prevention programs. These factors collectively enhanced the observability of the effect of tibial torsion in a soccer team. Therefore, a healthy sedentary group was not included in the study. Among our limitations is the fact that general joint laxity tests were not conducted, and the relationship between TTA and the severity of injuries was not examined.

CONCLUSION

The findings obtained from our study, which followed professional football players for a period of five years, indicated that a decrease in tibial torsion angle is associated with an increased incidence of ankle sprain-type injuries. In football, a sport that frequently involves running and directional changes, tibial torsion angle should be considered as a risk factor in preventing ankle injuries. We believe that our study contributes to the literature by highlighting the importance of TTA in terms of lower extremity alignment, and indicating the likelihood of LAS when TTA falls below certain values in football players. Including players with TTA values <11° for the right foot and <10° for the left foot in ankle injury prevention programs is expected to reduce the incidence of such injuries and emphasize the importance of considering TTA as a criterion in pre-season assessments.

Ethics Committee Approval / Etik Komite Onayı

The approval for this study was obtained from Selçuk University, Faculty of Health Sciences Ethics Committee for Non-Interventional Clinical Investigations, Ankara, Turkey (Decision no:2021/09, Date: 25/05/2021).

Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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Author Contributions / Yazar Katkıları

The tasks of Conceptualization, Methodology, Investigation, Formal Analysis, and Writing - Original Draft were all carried out by the corresponding author, Ahmet Bayrak.

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