



Investigation of Risk Factors for History of Medial Tibial Stress Syndrome in Referees

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ABSTRACT

Purpose: The aim of this study was to investigate potential risk factors associated with a history of medial tibial stress syndrome (MTSS) in football referees.

Methods: A total of 39 referees participated in this cross-sectional study. Based on the definition criteria for MTSS reported in the literature, participants were divided into two groups: those with a history of MTSS (n=14) and those without (n=25). All assessments were conducted in a blinded manner, with examiners unaware of group allocation. The navicular drop test, Craig's test, and heel elevation endurance test were administered to evaluate lower extremity function. Hip internal and external rotation, knee flexion, and ankle dorsiflexion and plantarflexion ROM were measured using a standard goniometer. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). Additionally, participants were asked about their athletic history and the comfort of the footwear they used during training and competition. Perceived running condition was evaluated using the Visual Analog Scale (VAS).

Results: MTSS history was determined in 14 of the referees participating in the study. Statistically significant differences were found between groups regarding height length ($p = 0.006$), condition ($p = 0.045$), left knee flexion angle ($p = 0.007$) and right knee flexion angle ($p = 0.046$). According to the regression analysis result, MTSS history (right) and left knee flexion angle were found to be significantly related ($p = 0.015$). There was no significant difference or relationship between other variables ($p > 0.05$).

Conclusion: According to our results, individuals with a history of MTSS had significantly greater height, while their running condition and knee flexion angle were significantly lower compared to those without a history of MTSS. These variables showed statistically significant differences between the two groups.

Keywords: Medial Tibial Stress Syndrome, Risk Factors, Injury

INTRODUCTION

Medial tibial stress syndrome (MTSS) is one of the most common sport-related lower extremity injuries (1). Clinically, tenderness along the posteromedial border of the tibia is considered a hallmark feature of MTSS, and this tenderness is thought to arise as a result of repetitive loading and chronic muscular fatigue (2,3). The literature frequently investigates the risk factors for MTSS in runners, with reported incidence rates ranging from 4% to 20% (2-4). However, despite its high prevalence, there is no consensus on the underlying etiology. Female gender, high navicular drop, increased body weight, and a history of previous running injuries have frequently been proposed as potential risk factors (5,6). Therefore, identifying risk factors is crucial for the development of preventive programs aimed at reducing the occurrence of MTSS.

In football, matches are governed by referees, who are responsible for enforcing the rules of the game (7). Research has demonstrated a positive relationship between the physical performance levels of referees and their decision-making accuracy (8). As a result, referees need to maintain a high level of physical performance to keep up with the pace of the game and position themselves correctly to monitor the players and assess whether they are adhering to the rules (9,10). Studies on the physical workload of referees during matches have shown that referees in the English Premier League run an average of 9.5 km per match (11), Italian referees run approximately 11.5 km (12), and Spanish referees cover an average of 10 km, with 2.7 km of this at high speed (13). These data suggest that referees experience physical stresses similar to those of runners.

Although several studies have investigated the risk factors for MTSS among athletes in various disciplines, including football, volleyball, athletics, cheerleading, and physical education students (14-16), no studies have specifically examined referees. Therefore, the primary aim of our study is to identify referees in the amateur football league with a history of MTSS, based on the established diagnostic criteria. Our secondary aim is to examine factors that may influence the development of MTSS by comparing referees with and without a history of the condition.

METHODS

The study was conducted in accordance with the most recent revision of the Declaration of Helsinki and was approved by the Pamukkale University Non-Interventional Clinical Research Ethics Committee at the board meeting numbered 24.10.2019/18 (Protocol No: 60116787-020/75827). Written informed consent was obtained from all participants.

Participants

A total of 39 amateur football league referees who volunteered to participate were included in the study. The mean age of the participants was 22.92 ± 2.50 years. Participants were divided into two groups based on the presence or absence of a history of Medial Tibial Stress Syndrome (MTSS), as assessed by an experienced sports physiotherapist. Referees with a history of MTSS formed the study group (MTSS group, $n = 14$), while referees without a history of MTSS constituted the control group ($n = 25$). According to the literature, MTSS is characterized by diffuse pain along the posteromedial border of the tibia, which increases with activity (17). In this study, individuals who met two-thirds of these criteria were considered to have a history of MTSS. Participants with any of the following conditions were excluded from the study: lower extremity stress fractures, compartment syndrome, a history of trauma within the past year, lower extremity surgery, knee pathology, lower leg paresthesia, low back pain, or hip and knee pain.

Navicular Drop Test

The navicular drop test is a clinical assessment used to evaluate the flexibility and functional status of the foot arch. To perform the test, the subtalar joint is initially positioned in a neutral position, where the ankle is aligned in its natural stance without any inward or outward rotation. The test begins with the participant standing in a quiet tandem stance, with one foot placed directly in front of the other, and no load applied to the foot. During this posture, the distance between the navicular ridge and the floor is measured in millimeters using a goniometer. Subsequently, the participant is instructed to transfer their body weight onto the measured foot, and the distance between the navicular

ridge and the floor is re-measured. The difference between the initial and subsequent measurements is recorded as the navicular drop. This difference reflects the flexibility of the medial foot arch and the degree of arch collapse. The navicular drop provides an indication of the structural changes in the foot and the arch's mobility (18-19).

Craig Test

The Craig test is a clinical assessment used to evaluate the angle of femoral anteversion. This test helps to identify femoral anteversion or retroversion by measuring the rotational angle of the hip joint and the femoral position. During the test, the participant lies in a prone position with the hip extended. The side to be tested is placed in 90° flexion, and passive hip rotation is applied. The examiner palpates the greater trochanter to identify its most prominent position during this motion. Once the most prominent position of the greater trochanter is determined, the angle between the tibia and the vertical plane is measured using a goniometer. The resulting angle indicates the degree of femoral anteversion. According to the literature, an angle between 8-15 degrees is considered normal, an angle less than 8 degrees indicates retroversion, and an angle greater than 15 degrees indicates anteversion (20).

Heel Raise Endurance Test

The test was administered to evaluate the flexibility of the foot and the capacity for plantar flexion. Initially, a rope was placed horizontally anterior to the pectoral muscles, and a second rope was set between two posts, positioned to touch the dorsum of the foot when the participant performed maximum plantar flexion. The participants were instructed to achieve maximum plantar flexion to make contact with the rope. The test was terminated when the participants either leaned forward and touched the rope at chest level or when the dorsum of the foot failed to make contact with the rope. The test was repeated three times for both lower limbs. For each repetition, the time from the moment the participant made maximum plantar flexion and touched the rope until the end of the test was recorded in seconds. This process allows for the assessment of foot flexibility (21).

Range Of Motion- ROM

The active ROM of participants was recorded in degrees using a goniometer; the movements assessed included hip internal rotation, hip external rotation, knee flexion, ankle plantar flexion, and ankle dorsiflexion. For hip rotation measurements, participants were placed in the prone position with the knees flexed to 90°, and both internal and external rotation angles were measured in this alignment. Knee flexion was also measured in the prone position by instructing participants to actively flex the knee to its end range. For ankle ROM, participants lay supine with the knees fully extended; plantar flexion and dorsiflexion angles were then recorded. All measurements were performed in accordance with standardized procedures described in the literature, and participants were asked to actively move each joint to its maximal range without external assistance (22).

Running Condition

A visual analog scale (VAS) was employed to assess running condition. The scale consisted of a 10 cm horizontal line, with "0" indicating "no running condition" and "10" representing "perfect running condition." Referees were instructed to mark the point on the line that best represented their current running condition. The distance from the "0" point to the referee's mark was measured in centimeters and recorded as the running condition score (23).

Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI) was administered to referees through face-to-face interviews to assess their sleep quality. The PSQI is a widely used self-report questionnaire designed to evaluate sleep quality and disturbances over a one-month interval. It comprises 19 items that generate seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component is scored on a scale from 0 to 3, with higher scores indicating greater dysfunction. The sum of these component scores yields a global PSQI score ranging from 0 to 21; a global score greater than 5 suggests

poor sleep quality. The PSQI has demonstrated good reliability and validity across diverse populations and is commonly used in both clinical and research settings to identify sleep-related issues (24).

Statistics

The G*Power 3.1.9.7 program was used to determine the statistical power analysis of the study. While the effect size of our study was $d=0.84$, it had 69% power in the 95% confidence interval. SPSS 22 package program was used for statistical analysis. Continuous variables are presented as mean \pm standard deviation, and categorical variables are presented as frequencies and percentages. The Shapiro-Wilk test was used to assess the normal distribution of the examined variables. For the comparison of independent groups, the Independent Samples T-Test was applied to data that met the assumptions of parametric tests, while the Mann-Whitney U test was used for data that did not meet the parametric test assumptions. Regression analysis was conducted to investigate the risk factors for MTSS in the referees. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1. Demographic Features of the Participants

| Variables | Control (n=25) X \pm SD | MTSS (n=14) X \pm SD | p | |
|--------------------------|------------------------------|---------------------------|----------------|----------|
| Age(year) | 23.00 \pm 2.83 | 22.64 \pm 1.82 | 0.606 | T=0.520 |
| Height (m) | 1.78 \pm 0.05 | 1.82 \pm 0.05 | 0.006** | T=-2.907 |
| Weight (kg) | 71.24 \pm 9.03 | 73.00 \pm 8.17 | 0.550 | T=-0.603 |
| BMI (kg/m ²) | 22.57 \pm 2.42 | 22.00 \pm 2.31 | 0.484 | T=0.706 |

X: Mean, SD: Standard deviation, BMI: Body Mass Index, MTSS: Medial Tibial Stress Syndrome, p <0.05 was considered significant.

When comparing the evaluation results between the referees with a history of MTSS and the control group, significant differences were found in height ($p = 0.006$), running condition ($p = 0.045$), left knee flexion angle ($p = 0.007$), and right knee flexion angle ($p = 0.046$) in favor of the study group. No significant differences were observed between the groups for other variables ($p > 0.05$). Demographic information of the referees participating in the study is presented in Table 1. The differences between the study and control groups are shown in Table 2.

According to the results of the regression analysis, a significant relationship was found between a history of MTSS (right) and the left knee flexion angle ($p = 0.015$). No significant relationships were identified between other variables ($p > 0.05$). The results of the regression analysis are presented in Table 3.

Table 2. Differences Between Referees With and Without MTSS History

| Variables | Control (n=25) | MTSS (n=14) | p | |
|---------------------------------|----------------|--------------|----------------|----------|
| | X ± SD | X ± SD | | |
| Running Condition (cm) | 6.64 ±1.37 | 5.49±2.08 | 0.045** | T=2.079 |
| Endurance (right)(second) | 66.64±27.41 | 54.79±32.65 | 0.093 | Z=-1.699 |
| Endurance (left)(second) | 52.84±14.81 | 54.00±24.67 | 0.633 | Z=-0.498 |
| Navicular drop test (right)(cm) | 0.71±0.35 | 0.61±0.34 | 0.289 | Z=-1.102 |
| Navicular drop test (left)(cm) | 0.64±0.32 | 0.54±0.27 | 0.228 | Z=-1.254 |
| Hip internal (right)(degree) | 30.96±7.64 | 30.50±7.10 | 0.854 | T=0.185 |
| Hip internal (left)(degree) | 28.60±6.62 | 27.21±8.42 | 0.573 | T=0.568 |
| Hip external (right)(degree) | 26.60±7.93 | 22.21±7.52 | 0.076 | Z=-1.793 |
| Hip external (left)(degree) | 26.76±9.15 | 23.21±5.13 | 0.191 | T=1.332 |
| Knee flexion (right)(degree) | 130.84±6.61 | 126.43±10.45 | 0.046** | Z=-1.992 |
| Knee flexion (left)(degree) | 128.16±5.78 | 126.64±9.11 | 0.007** | T=-2.870 |
| Dorsiflexion (right)(degree) | 14.44±4.87 | 14.36±3.08 | 0.955 | T=0.057 |
| Dorsiflexion (left)(degree) | 14.32±3.70 | 14.93±4.34 | 0.784 | Z=-0.279 |
| Plantar flexion (right)(degree) | 29.52±10.09 | 29.78±8.14 | 0.553 | Z=-0.602 |
| Plantar flexion (left)(degree) | 31.32±8.60 | 29.64±7.07 | 0.538 | T=0.621 |
| PUKİ (total score) | 6.48±3.28 | 7.14±2.35 | 0.392 | Z=-0.872 |

X: Mean, SD: Standard deviation, BMI: Body Mass Index, MTSS: Medial Tibial Stress Syndrome, p <0.05 was considered significant.

Table 3. Regression Analysis Result

| MTSS (right) | p | O.R. | %95 C.I. | |
|---------------------|--------------|-------|-------------|-------------|
| | | | Lower Limit | Upper Limit |
| Knee Flexion (Left) | 0.015 | 0.063 | 1.030 | 1.320 |

MTSS: Medial Tibial Stress Syndrome; O.R. = Odds Ratio; C.I.= Confidence Interval; p <0.05 was considered significant.

DISCUSSION

In this study, it was found that referees with a history of MTSS had significantly lower levels of physical fitness and knee flexion ROM, while their height was greater. Additionally, the results of the regression analysis indicated that a decrease in knee flexion ROM of the asymptomatic leg may be an influential risk factor in the development of MTSS.

MTSS is a significant injury type observed in runners, with incidence rates ranging between 13.2% and 17.3% (2). In our study, however, the incidence of MTSS among referees was found to be 34%. Studies in the literature have utilized clinical assessment or self-assessment methods for the diagnosis of MTSS (2,16). Blienkendaal et al. (2018) investigated the incidence and risk factors of MTSS in first-year physical education students, a population previously unexplored, similar to our study. In their study (n=81), the MTSS score questionnaire, a self-assessment method, was used, and the MTSS incidence rate was found to be 20% (16). In our study, although MTSS history was determined by self-assessment, a higher incidence rate (34%) was found in referees compared to physical education students. However, the small sample size indicates the need for larger-scale studies on referees. In Blienkendaal et al.'s study, younger age and higher body mass index were associated with an increased risk of MTSS development. However, height, body weight, hip internal and external rotation ROM, and navicular drop were not found to be significant risk factors (16). In our study, no significant differences were found between the two groups with and without a history of MTSS regarding age, body mass index, body weight, hip internal and external rotation ROM, or navicular drop. However, height was found to be significantly higher in the group with a history of MTSS. The use of groups with different performance levels in studies may account for the differences in these results.

Yagi et al. (2013) investigated the relationship between hip internal and external rotation ROM and MTSS, finding that only hip internal rotation was associated with MTSS in males. However, no association was found between hip external rotation and MTSS. The study did not specify whether ROM was measured actively or passively, which complicates the interpretation of the results (14). Moen et al. (2009) observed that individuals with MTSS had significantly higher hip external rotation compared to the control group (25). In four different studies examining the effect of ankle ROM on MTSS, involving a total of 886 participants, no significant relationship was found between ankle dorsiflexion and MTSS (2,4,14-15). There are varying results in the literature regarding the relationship between ROM and MTSS. However, in our study, no significant difference was found in hip and ankle ROM values between groups with and without MTSS history. Moreover, regression analysis did not reveal a significant relationship between these parameters and MTSS history. In our study, a lower knee flexion angle in referees with a history of MTSS is consistent with findings in the literature regarding running biomechanics. Specifically, reduced knee flexion can decrease shock absorption during running, leading to increased tibial stress (26). Additionally, biomechanical changes such as increased pelvic drop and increased hip internal rotation during running have been suggested to increase pronation at the subtalar joint, creating rotational load on the tibia and facilitating MTSS development (27). In our study, a significant difference in knee flexion angle was found between the MTSS group and the control group. Furthermore, according to regression analysis, the knee flexion angle of the asymptomatic leg may be a contributing factor for MTSS risk.

According to studies conducted on runners, increased pelvic drop leads to a medial shift of the body's center of mass, causing knee valgus and subtalar joint pronation. High hip internal rotation values also contribute to excessive foot pronation. During the stance phase of running, high pelvic drop, high hip internal rotation, and low knee flexion values predispose runners to MTSS (5). In our study, a significantly lower knee flexion angle was found in referees with a history of MTSS, which may be related to running biomechanics. Additionally, the literature suggests that strong navicular drop may be responsible for MTSS (5, 28). However, no significant difference in navicular drop was found between the two groups in our study. This may be due to the participants' young age and normal body mass index, indicating that their foot arches may not yet have undergone deformation. Literature suggests that an increase in body mass index may contribute to MTSS history (29), as higher body weight relative to height creates higher mechanical load on the tibia during weight-bearing activities (16). On the other hand, in our study, there was no significant difference in body weight between the groups. Reinking et al. (2017) identified height as a low-risk factor for MTSS

(6). Similarly, in our study, the group with a history of MTSS had significantly greater height. An increase in femur length may increase the force arm, thereby increasing the load on the tibia.

Madeley et al. (2007) compared isotonic plantar flexor endurance between symptomatic athletes with MTSS and a control group, finding that athletes with MTSS performed significantly fewer heel raises than the control group. The researchers suggested that prolonged pain complaints may reduce activity levels, leading to a decrease in plantar flexor endurance (30). Therefore, athletes with low plantar flexor endurance may be at risk of developing MTSS due to chronic overuse. However, in our study, no significant difference in lower extremity endurance was found between the groups with and without MTSS. Additionally, there is no other study examining the relationship between plantar flexor endurance and MTSS. More research is needed to draw definitive conclusions on this matter.

Recent studies have shown that running-induced fatigue significantly alters lower limb biomechanics in all three planes, particularly affecting kinetic parameters. After fatigue, increases in ankle dorsiflexion ROM, frontal plane knee motion, and changes in joint moments and powers at the ankle, knee, and hip have been observed. These biomechanical alterations may impair joint stability, disrupt normal load distribution, and increase the risk of lower extremity injuries (31, 32). In our study, the group with a history of MTSS demonstrated significantly lower running conditioning compared to the control group. Poor running conditioning may accelerate the onset of fatigue, leading to early biomechanical changes that compromise shock absorption and increase mechanical stress on the tibia. These findings suggest that enhancing running conditioning could be critical for maintaining optimal biomechanics during prolonged activities and for reducing the risk of developing MTSS. Improving physical endurance may therefore play a protective role by minimizing fatigue-related biomechanical deviations and excessive loading on the lower limbs during running.

Additionally, based on a study showing a relationship between lower extremity injuries and sleep quality in recreational runners, we also assessed sleep quality in our study. The referenced study found an association between poor sleep quality and a history of lower extremity injuries (33). However, no study examining the relationship between MTSS and sleep quality was found. In our study, there was no significant difference in sleep quality between the groups with and without MTSS history.

The lack of isolated reporting of the symptomatic leg in this study may make the interpretation more difficult; however, the individual-level assessment offers a more holistic approach. The unequal group sizes represent a limitation of the study. Nevertheless, this study holds unique significance as the only one examining MTSS risk factors in referees. Future studies with larger sample sizes in similar populations could further validate the findings in a more comprehensive manner and contribute to the existing literature.

CONCLUSIONS

These findings reinforce the notion that referees represent a high-risk group for MTSS. Moreover, factors such as increased height, reduced knee flexion angle, and suboptimal running condition appear to significantly contribute to the risk of developing the condition. These variations may serve as predisposing factors for MTSS in referees. Given the essential and active role of referees in football, it is crucial that future research investigates strategies for preventing MTSS, specifically addressing these identified risk factors. Additionally, the lower knee flexion angle observed in the asymptomatic leg suggests that it could serve as a predisposing factor for the pathology. It is, therefore, important to implement preventive measures for individuals, particularly those of greater height, with a focus on enhancing their conditioning and increasing knee flexion angle.

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