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Are the Levels of vitamin D and Those of Some Clinical Parameters in Athletes Diagnosed with Medial Tibial Stress Syndrome Different From Those in Healthy Athletes?

Medial Tibial Stres Sendromu Tanısı Olan Sporcuların D Vitamini Düzeyi ve Bazı Klinik Parametreleri Sağlıklı Sporculardan Farklı Mı?

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ABSTRACT

Objective: To determine the levels of some biomechanical factors and vitamin D in athletes diagnosed with medial tibial stress syndrome (MTSS) and in healthy athletes.

Materials and Methods: Athletes diagnosed with MTSS and healthy athletes were included in the study between April 2017 and March 2018. Physical characteristics, lower extremity length, results of the navicular drop test, shoe sizes, MTSS scores, and serum levels of 25-hydroxy vitamin D, calcium and phosphorus were examined

Results: Of the 33 patients (25 men and eight women), 26 were diagnosed with MTSS for the first time. The mean duration of symptoms was 2.0±2.5 months. MTSS score was 4.7±2.1 points. No significant difference was observed between the patient and control groups (n=25) in the age, height, duration of training, and the number of yearly and weekly training sessions ($p>0.05$). Athletes diagnosed with MTSS had significantly higher body weight and body mass index ($p<0.05$). Results revealed a significant difference in the lower extremity length between the group with MTSS (90.2±5.3 cm) and the control group (87.8±4.4 cm, p=0.02). Independent and paired group analysis displayed no right-left side difference ($p>0.05$). The levels of vitamin D were not different between the two groups (MTSS group; 21.9±9.9 ng/ml, control group; 22.8±9.0 ng/ml, $p>0.05$).

Conclusion: Some biomechanical factors may have greater impact than the levels of vitamin D on the development of MTSS. Although vitamin D levels of athletes diagnosed with MTSS did not differ from those of healthy athletes, they were below the normal range in both groups. Therefore, all athletes should maintain adequate vitamin D levels.

Keywords: Medial tibial stress syndrome, biomechanical factors, vitamin D

ÖZ

Amaç: Bu çalışmanın amacı, MTSS tanısı bulunan sporcular ile sağlıklı sporcuların bazı biyomekanik faktörlerini ve D vitamini düzeylerini analiz etmektir.

Gereç ve Yöntemler: Nisan 2017-Mart 2018 tarihleri arasında MTSS tanısı konulmuş sporcular ve spora katılım muayenesi için başvuran sağlıklı sporcular araştırmaya dahil edildi. Katılımcıların fiziksel verileri, muayeneler sırasında ölçülen 'Naviküler Çökme Testi' sonuçları, alt ekstremite uzunlukları, ayakkabı numaraları, MTSS skorları, serum 25-hidroksi D vitamini, kalsiyum ve fosfor düzeyleri incelenerek analiz edildi.

Bulgular: MTSS tanılı 33 hastanın (sekiz kadın, 25 erkek) 26'sına ilk kez bu tanı konulmuştu. Hastaların yakınmaları ortalama 2.0±2.5 aydır devam etmekteydi. Ortalama MTSS skorları 4.7±2.1 puandı. Kontrol grubu (n=25) ile kıyaslandığında;

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hastaların yaş, boy, cinsiyet, spor yılı, yıllık antrenman süresi, haftalık antrenman süresi farklı değildi (p>0.05). MTSS tanılı gruptaki bireylerin vücut ağırlığı ve vücut kütle indeksi anlamlı olarak daha yüksekti (p<0.05). Biyomekanik değerlendirmede ise sadece alt ekstremite uzunluğu açısından (MTSS grubu: 90.2±5.3 cm, kontrol grubu: 87.8±4.4 cm) gruplar arasında anlamlı fark saptandı (p=0.02). Biyokimyasal testlerde ise D vitamini (MTSS grubu: 21.9 ± 9.9 ng/ml, kontrol grubu: 22.8 ± 9 ng/ml) açısından gruplar arasında fark yoktu (p>0.05).

Sonuç: MTSS gelişimi için D vitamini düzeyinden ziyade biyomekanik faktörler daha etkili olabilir. MTSS tanısı alan sporcuların D vitamini düzeyi sağlıklı sporculardan farklılık göstermemekle birlikte her iki grupta da D vitamini seviyesi normal düzeyin altındadır. Bu sebeple tüm sporcuların yeterli D vitamin düzeyini koruması sağlanmalıdır.

Anahtar Sözcükler: Medial tibial stress sendromu, biyomekanik faktörler, D vitamini

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INTRODUCTION

Medial tibial stress syndrome (MTSS) is the most common leg injury triggered particularly by exercises that involve running and jumping (e.g., athletics, football, dance, and gymnastics), (1,2). MTSS, which particularly affects the distal posteromedial two-thirds of the tibia, is defined as pain induced by exercise and provoked by palpation (2,3). The incidence of MTSS is 13.6-20% in athletes and 7.2-35% in military personnel (4). MTSS is often diagnosed in sports medicine clinics. Potential risk factors for the development of MTSS are a high body mass index (BMI), bone geometry, gait kinematics, lower limb length discrepancy, amount of navicular drop, joint range of motion (ROM), and training history (4).

Although the etiology of MTSS has not been completely defined to date, the development of periostitis because of excessive strain applied to the tibia is thought to govern the development of MTSS (5,6). Results from a recent study on a wide spectrum of injuries due to tibial stress, including MTSS, periostitis, periosteal remodeling, and tibial stress reaction or fracture, indicate that MTSS could progress to tibial stress fracture (6). The regional bone density is low in athletes with MTSS (7), and bone density may persistently be low for up to nine years (8). Low bone mineral density (BMD) in patients with MTSS could be a precursor of stress fracture (6), which suggests that in addition to biomechanical factors, vitamin D levels, which play an important role in bone metabolism, could be different in these patients.

Vitamin D is synthesized in the skin after exposure to UV light, and is obtained from the diet, albeit in small amounts (9). A serum concentration of >30 ng/ml is the recommended level of vitamin D (10). Previous studies indicate that vitamin D deficiency in athletes has a negative effect on bone health, increases the risk of injuries to the musculoskeletal system, and is a predisposing factor for stress fractures (10,11). Vitamin D plays an important role in controlling inflammation, decreasing the risk of infection, and accelerating the recovery process in exercise-related injuries in the skeletal, muscular, cardiovascular, and immune systems (9,10).

To date, limited information is available on the optimal methods for the prevention and treatment of MTSS; thus, biomechanical factors and the level of vitamin D, which affects bone metabolism, are risk factors that play a role in the etiopathogenesis of MTSS.

The hypothesis of the present study is that the levels of vitamin D are low in athletes diagnosed with MTSS. It is aimed to retrospectively analyze physical characteristics, lower limb lengths, navicular drop test scores, shoe sizes, and vitamin D levels in healthy athletes and in athletes diagnosed with MTSS, and to determine the parameters that differ among these groups.

MATERIAL and METHODS

The records of patients that have applied to the Sports Medicine Clinic (geographic location, 38°E, 36°N) were retrospectively reviewed between April 2017 and March 2018. The study included patients aged 12-30 years, who had MTSS that had not been treated, and had complaints of pain in the medial tibia for the last month. The patients were not taking any vitamin D supplements, had no systemic disease, no history of ligament injury in the knee, lower extremity surgery or fracture, no neurological or vascular complications, and developmental factors. Patients were excluded if they had received physical therapy in the previous six months, had taken an analgesic within the previous month, were pregnant, were diagnosed with an inflammatory disease, or had lower back pain.

The control group included healthy athletes aged 12-30 years, who exercised regularly (1.5 h per session, three days a week), and trained in a similar manner to that of the patients, and presented for examination to participate in sports. Lower limb lengths were determined, the navicular drop test was performed, and biochemical blood tests (serum levels of 25-hydroxy (OH) vitamin D, calcium, and phosphorus) were run. None of the subjects in the control group were taking vitamin D supplements, and none of them had any history of MTSS diagnosis, surgery, ligament injury, or lower extremity fracture.

Physical data, duration of training, duration of complaints, recurrence of complaints, results of the navicular drop test, lower extremity lengths, shoe sizes, MTSS scores, and serum levels of 25-(OH) vitamin D, calcium, and phosphorus for each participant were obtained from digital archive records.

BMI

BMI was calculated using the method defined by the World Health Organization and was expressed as kg/m^2 (5).

MTSS Score

To determine the severity of MTSS, the scoring system developed by Winters et al. (2) was used. Patients were requested to score the following: limitations in sporting activities (0-3 points): pain while performing the sporting activities (0-3 points), pain while performing activities of daily living or usual work (0-2 points), and pain at rest (0-2 points). Patients with bilateral MTSS scored the above items considering the extremity with greater pain. The potential maximum total score was 10 points (2).

Navicular Drop Test

With the patient in a sitting position, the most prominent point of the navicular tuberosity was marked on the bare foot using a fine-point pen. Then, the patient was instructed to stand maintaining the subtalar neutral position. The distance between the floor and the navicular tuberosity was measured in mm in both the sitting and standing positions. The difference between the measurements was recorded as the amount of navicular drop (12).

Measurement of Lower Limb Length

Lower limb length was measured with the patient in a supine position, and the feet shoulder-width apart. The distance between the anterior superior iliac spine and the most prominent point of the ipsilateral medial malleolus was measured in cm and was recorded for both extremities. The difference between the distance in the left and right extremities was defined as the lower limb length discrepancy (13).

Blood Samples

Blood samples were taken from the antecubital vein, between 09:00-15:00h. The samples were centrifuged to separate the serum that was used to determine the levels of 25-(OH) vitamin D, calcium, and phosphorus. The levels of 25-(OH) vitamin D were measured using an immunoassay according to standardized laboratory procedures.

Ethics

Approval for the study was granted by the Ethics Committee of Sanko University (Decision No: 13, Dated: 19.04.2018).

Statistical Analysis

Data obtained in the study were analyzed using SPSS software ver 22 (SPSS, Chicago, IL, USA). Data conformity to normal distribution was assessed using the Shapiro-Wilk test. Descriptive statistics were expressed as mean ± standard deviation (SD), median, and percentage (%), as appropriate. To compare the normally and non-normally distributed variables, the independent t-test and the Mann-Whitney U-tests were used, respectively. The level of statistical significance was set at $p<0.05$.

RESULTS

A total of 33 patients, including 25 men and eight women, diagnosed with MTSS were evaluated. They had engaged regularly in athletics (n=17, 51%), football (n=9, 27%), and other sports (22%), including basketball (n=2), weightlifting (n=2), cycling (the same athlete who participated in athletics training, n=1), handball (n=1), and karate (n=1, with no direct trauma to the postero-medial tibial region). The monthly presentation were as follows (n; %): January (4; 12.1%), February (2; 6.1%), March (6; 18.2%), April (4; 12.1%), May (3; 9.1%), June (5; 15.2%), July (3; 9.1%), September (2; 6.1%), November (3; 9.1%), and December (1; 3.0%). Of the 33 MTSS patients, 26 (78%) were diagnosed for the first time. Extremities were affected bilaterally in 30 (90%) patients, and unilaterally in three (2 right side and 1 left side, 10%) patients. The mean duration of the complaints was 2.0 ± 2.5 months, and the mean MTSS score was 4.7 ± 2.1.

The control group included 19 men and six women engaged in athletics (n=15, 60%), basketball (n=3, 12%), and other sports activities (28%), including football (n=2), karate (n=2), cycling (n=1), tae-kwondo (n=1), and volleyball (n=1). Monthly presentation were as follows (n; %): January (5; 20%), February (1; 4%), March (4; 16%), May (1; 4%), June (3; 12%), July (1; 4%), August (1; 4%), September (3; 12%), October (1; 4%), November (3; 12%), and December (2; 8%). The timing of vitamin D analysis was free from any bias.

No significant differences were observed between the groups for age, gender, height, training years, annual duration of training, and the number of training sessions per week (p>0.05). Body weight and BMI of the patients in the MTSS group were significantly higher than those of the subjects in the control group (p=0.02 and p=0.01), (Table 1). Clinical and biomechanical evaluations revealed that lower extremity length was significantly greater in the athletes in the MTSS group than in the controls (p=0.02). No difference was observed between the independent and paired groups for right-left sides (p>0.05). No significant difference was observed in lower limb length discrepancy, shoe size, and the amount of navicular drop (p>0.05) between the two groups (Table 2).

Table 1. Physical data of the subjects

	MTSS group (n=33)	**Control group** (n=25)	**p**
Age (yr)	18.9 ± 3.7	18.0 ± 4.0	0.20
Height (cm)	173.4 ± 8.3	169.3 ± 9.5	0.10
Body weight (kg)	64.2 ± 12.5	56.1 ± 12.0	0.02*
Body mass index (kg/m^2)	21.2 ± 3.1	19.4 ± 2.7	0.01*
Training time (yr)	3.9 ± 3.5	4.2 ± 4.0	0.90
Yearly training sessions (mo/yr)	9.5 ± 2.2	9.7 ± 2.9	0.20
Weekly training sessions (hr/wk)	10.2 ± 4.3	11.7 ± 3.0	0.08

Figures as mean or median ± standard deviation, MTSS: medial tibial stress syndrome; *****: p<0.05

No significant difference was observed in the levels of 25-(OH) vitamin D and serum calcium (p>0.05) between the two groups. The serum phosphorus level was significantly lower in the MTSS group, as compared with than the control group (p=0.01), (Table3).

Table 2. Clinical and biomechanical data

	MTSS group (n=63)	Control group (n=50)	p
Shoe size	41.0 ± 2.1	40.3 ± 2.0	0.08
Navicular drop (mm)	5.8 ± 2.4	5.5 ± 2.5	0.40
Lower extremity length (cm)	90.2 ± 5.3	87.8 ± 4.4	0.02*
Right	90.2 ± 5.3	87.9 ± 4.5	0.10
Left	90.1 ± 5.4	87.7 ± 4.5	0.10
p (R-L)	0.96	0.87	
Lower extremity length discrepancy (cm)	0.1 ± 0.3	0.1 ± 0.2	0.20

Figures as mean or median ± standard deviation; MTSS: medial tibial stress syndrome, (R-L): differences between right and left (R-L) extremities; *: p<0.05.

Table 3. Results of biochemical tests

	MTSS group (n=33)	Control group (n=25)	p
Serum 25-(OH) vitamin D (ng/ml)	21.9 ± 9.9	22.8 ± 9.0	0.80
Serum calcium (mg/dl)	9.4 ± 0.4	9.4 ± 0.4	0.70
Serum phosphorus (mg/dl)	3.4 ± 0.5	3.9 ± 0.4	0.01*

Figures as mean or median ± standard deviation; MTSS: medial tibial stress syndrome; *: p<0.05.

DISCUSSION

Present data revealed that body weight, BMI, and lower limb length were significantly higher in patients with MTSS compared with subjects in the control group. Although vitamin D levels were lower in the patient group, the difference was not statistically significant.

Many studies have investigated the factors governing the development of MTSS. Results of a meta-analysis pointed that individuals with high BMI are at risk of MTSS development (4). Madeley et al. reported a BMI of 23.5 kg/m^2 in patients with MTSS and 22.8 kg/m^2 in a control group (14), Moen et al. reported these rates to be 23.8 kg/m^2 and 22.5 kg/m^2, respectively (15), and Yagi et al. reported BMI of 20.5 kg/m^2 and 19.4 kg/m^2 in men and 19.3 kg/m^2 and 18.4 kg/m^2 in women in the two groups, respectively (16). Although whether the increase in body weight originates from an increase in the rate of fat or muscle tissue has not been determined thus far, BMI is an important factor that governs the development of periosteal activation hyperstimulated by the effect of repeated bending and twisting on the tibia (4). Present data indicate that body weight and BMI, even within normal limits, are high in patients with MTSS.

Gender is not only a demographic characteristic, but also an important parameter that predicts predisposition for injuries. Yates et al. proved a relationship between the female gender and development of MTSS. A previous study revealed that approximately twice the number of female military personnel than male military personnel were diagnosed with MTSS (17). The rate of injury is greater in women than in men training together at the same level of fitness (18). The higher tendency of women to bone stress injuries could be the result of the relatively smaller body structure and gender-based differences in running kinematics and the presence of “female athlete triad” conditions (19-21). The prevalence and incidence rates were not calculated in this study, and thus, the risk rate was not determined according to gender, which is a limitation of the study. However, the diagnosis of MTSS was made in both genders.

Community-based studies have thoroughly investigated the impact of the type of training on the incidence of MTSS. Stress injuries such as MTSS are more frequent in athletes who train more often each week and in those with a shorter history of exercise (20). While present results indicated no statistically significant differences between the groups in terms of sport participation duration and weekly/yearly training times, these durations were shorter in the MTSS patients. The duration of training is an important risk factor, as a shorter period of participation in sport does not provide sufficient compatibility of the bones to the greater stresses that are associated with high-intensity activities (20). The similarity in training details indicates that other factors are responsible for the development of MTSS.

The side affected by the symptoms and the frequency of the recurrence of the complaints are important factors in MTSS (20). Symptoms were present in bilaterally in 29 of 30 patients in a study by Madely (14) and in all 11 patients in a study by Yüksel et al. (22). Results obtained in the present study revealed the bilateral presence of symptoms in the extremities of 90% of the patients. Hubbard et al reported that 87% patients with MTSS and 16% athletes in the control group had a positive history of MTSS (23). Presently a history of recurrence in 22% patients was seen, whereas the individuals in the control group had no history of MTSS. Thus, the number of athletes with a history of MTSS diagnosis in the present study was lower than that reported in previous studies. Bilateral involvement and high recurrence rates may reflect a strong association between MTSS and anatomic and some biomechanical factors such as lower limb length.

Pronation during running has a protective function of absorbing the impact force applied to the bones. The amount of navicular drop is a clinical finding of the response to pronation, which shows the static and dynamic state of the foot. A negative correlation exists between navicular drop and pronation, as both are part of rearfoot eversion. However, during running, the height of the arch and navicular drop are related not to rearfoot eversion, but to tibial internal rotation. Individuals with increased navicular drop do not have sufficient tibial internal rotation and this may predispose them to MTSS (4).

A meta-analysis documented that patients with MTSS had a collapse of >0.54-1.84 mm. Bandholm et al. determined navicular drop as 7.7 mm in a group diagnosed with MTSS and as 5.0 mm in the control group (24). A study by Bennett et al. revealed a navicular drop of 6.8 and 3.6 mm in MTSS and control groups, respectively (25). A study by Hubbard et al. indicated that these figures were 8.6 and 7.8 mm (23); Rathleff et al. obtained figures of 7.1 and 5.4 mm (26). Raissi et al. reported these values as 6.1 and 5.1 mm (27), and Yagi et al. reached figures of 4.9 and 4.5 mm in men and 4.9 and 4.2 mm in women, respectively (16). The differences in the figures of navicular drop observed in previous studies may be attributed to the differences in methods of measurement. Although the difference in the value of navicular drop between the groups was not statistically significant in all studies, it was higher in patients with MTSS, compared with subjects in the control groups (4). Present results are consistent with previously obtained ones, in that the navicular drop is greater in patients with MTSS.

A previous study indicates that the amount of navicular drop should not be independently evaluated, but should be normalized to the length of the foot (28). Pisky et al. evaluated navicular drop and foot length and revealed that neither of the parameters constituted a risk for MTSS (12). Data about shoe size was evaluated an indicator of foot length presently, and while no statistically significant difference in shoe size between the groups was observed, patients with MTSS had larger shoe size. However, data obtained using the present method of evaluation are not sufficient to normalize the amount of navicular drop to the foot length.

Leg length is a significant parameter in lower extremity biomechanics (29). A study performed in military personnel displayed that a difference of more than 5 mm between the two extremities increases the risk of stress fracture in the longer leg by 73% (30). Furthermore, the risk of stress fracture is higher in the shorter extremity with a difference between right and left sides of 1.3 mm (31). In addition, the longer and shorter extremities are at a risk of developing overuse injuries (29). Although present results showed no statistically significant difference in the lower extremity length discrepancy between the groups, lower extremity length was longer in patients with MTSS. This could be related to the change in the capacity of the extremity to absorb vertical force/impact transmission according to length. No differences between the independent group and paired group tests for the right-left sides were observed.

The development of MTSS is associated with several anatomic and biomechanical factors. However, the pathogenesis of this syndrome has not been completely understood thus far (21). The effect of the level of vitamin D on the pathogenesis of MTSS has not been clarified to date. Several studies have determined the role of vitamin D and established the benefits of this vitamin for athletes. Vitamin D plays an important role in bone health. Deficiency of vitamin D affects the musculoskeletal system, increases the risk of injury, or prolongs the recovery period (32).

A previous study showed that the risk of stress fracture in subjects with a 25-(OH) vitamin D level of 20 ng/ml was twice that in patients with a 25-(OH) level of 40 ng/ml (33). Kim et al. examined the relationship between bone stress injuries and vitamin D levels in long-distance runners and found no difference in vitamin D level between those who had experienced stress injuries and those who had not. However, a 10-unit increase in the vitamin D level decreased the loss period formed as a result of injury by 17% (34). The results of a study by Grieshober et al. revealed no relationship between vitamin D level and fracture risk in professional basketball players; moreover, these players experienced vitamin D deficiency (9).

While osteoclastic activity is completed in 2-3 weeks in bone remodelling, osteoblastic activity can last for three months (5). During the development of MTSS, long-term stress on the bone, repeated osteoclastic stimulation, and a decrease in the osteoblastic activity can have negative effects on the remodelling process of bone tissue (5). Thus, MTSS patients with long-term symptoms have reported low local bone mineral density scores (35). Furthermore, no difference was observed in patients with a mean symptom duration of five weeks, when compared with a control group (5).

The effect of vitamin D in MTSS, which is affected to a great degree by bone metabolism, is not known thus far. To the best of our knowledge, no studies to date have evaluated vitamin D levels in patients with MTSS. Present results showed that vitamin D levels were not different between the two groups. Therefore, anatomic and biomechanical factors may have a greater impact on the development of MTSS.

Vitamin D levels play an important role in the proliferation of the bones and muscles and in healing. In addition, vitamin D has positive effects on tendon to bone healing. Vitamin D plays a role in tendon to bone healing processes by increasing bone mineral density and skeletal muscle strength. Vitamin D may have positive effects in the treatment of in MTSS. The role of vitamin D in the development of MTSS should to determined, and further studies should be performed to determine the effects of vitamin D supplementation in patients with MTSS (36).

The limitations of the present study are that it was a single-center, retrospective study; the number of patients was low, symptom durations were short, and the effect of gender was not evaluated. In addition, advanced techniques for the analysis of biomechanical parameters were not used, and the measurements taken during clinical examination were not analyzed.

CONCLUSION

The pathogenesis of MTSS involves many intrinsic and extrinsic factors. The present study revealed differences in bodyweight, BMI, and lower extremity length between the two groups. The vitamin D level of all the athletes was below the normal level. Thus, further studies are required to completely understand the effect of vitamin D on the development of MTSS.

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