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RESEARCH ARTICLE / ARAŞTIRMA MAKALESI

Investigation of foot function, pain, flexibility and muscular performance levels according to the degree of pes planus in patients with plantar fasciitis: a cross-sectional study

Plantar fasiitli hastalarda pes planus derecesine göre ayak fonksiyonu, ağrı, esneklik ve kas performansı düzeylerinin incelenmesi: kesitsel bir çalışma

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ABSTRACT

Objective: The aim of this study was to investigate how the degree of pes planus (PP) affects pain, flexibility, muscle performance, and foot functionality in individuals with plantar fasciitis (PF).

Material and Methods: The study included 58 individuals with PF. Participants were divided into three groups based on their PP degrees determined by the Feiss line test: '0' (no PP), '1' (Grade 1 PP) and '2' (Grade 2 PP). Pain intensity was assessed using the Visual Analog Scale (VAS), flexibility was evaluated using gastro-soleus and plantar fascia flexibility tests, muscle performance was measured using the Heel Rise test, and foot functionality was assessed through the Foot Function Index (FFI).

Results: No differences were found among the groups in terms of pain intensity, gastro-soleus flexibility, muscle performance, and foot functionality ($p>0.05$). A significant difference was observed in plantar fascia flexibility between groups '0' and '1', with greater flexibility in the group without PP compared to those with Grade 1 PP ($p=0.024$); groups '0'-'2' and '1'-'2' revealed similar results ($p=0.431$; $p=0.494$).

Conclusion: The degree of PP appears to have a limited impact on pain, gastro-soleus flexibility, muscle performance, and foot functionality in individuals with PF, although it may affect plantar fascia flexibility. Current evidence is insufficient to support treatment modifications based solely on PP degree. Future studies with larger samples and objective biomechanical assessments are needed to further clarify these relationships.

Keywords: Plantar fasciitis, pes planus, foot function, pain, flexibility

ÖZ

Amaç: Bu çalışmanın amacı, pes planus derecesinin (PP) plantar fasiitli (PF) bireylerde ağrı, esneklik, kas performansı ve ayak fonksiyonelliğini nasıl etkilediğini araştırmaktır.

Gereç ve Yöntem: Çalışmaya PF'li 58 birey dâhil edildi. Katılımcılar, Feiss çizgi testi ile belirlenen PP derecelerine göre üç gruba ayrıldı: '0' (PP yok), '1' (Grade 1 PP) ve '2' (Grade 2 PP). Ağrı şiddeti Visual Analog Skala (VAS) ile, esneklik gastro-soleus ve plantar fasya esneklik testleri ile, kas performansı Topuk Yükseltme Testi (Heel Rise Test) ile, ayak fonksiyonu Ayak Fonksiyon İndeksi (FFI) ile değerlendirildi.

Bulgular: Gruplar arasında ağrı şiddeti, gastro-soleus esnekliği, kas performansı ve ayak fonksiyonu parametrelerinde istatistiksel olarak anlamlı bir fark bulunmadı ($p>0.05$). Ancak grup '0' ile grup '1' arasında plantar fasya esnekliği açısından anlamlı bir fark vardı ve pes planusu

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olmayan grupta esneklik daha yüksekti (p=0.024). Grup '0'-'2' ve grup '1'-'2' karşılaştırmalarında ise benzer sonuçlar elde edildi (p=0.431; p=0.494).

Sonuç: PP derecesinin, PF'li bireylerde ağrı, gastro-soleus esnekliği, kas performansı ve ayak fonksiyonu üzerinde sınırlı etkide olduğu görünmektedir, ancak plantar fasya esnekliğini etkileyebilir. Kanıtlar, yalnızca PP derecesine dayanarak tedavi planlamasında değişiklik yapılmasını desteklememektedir. Daha geniş örneklemli ve objektif biyomekanik ölçümlerle desteklenecek çalışmalar, bu ilişkileri daha iyi anlamak için gereklidir.

Anahtar Sözcükler: Plantar fasit, pes planus, ayak fonksiyonu, ağrı, esneklik

INTRODUCTION

PF is a common foot condition affecting the plantar fascia, with multiple factors involved in its etiology (1,2). Repetitive strain leading to micro-tears at the insertion site of the plantar fascia due to chronic overload is considered effective in the pathogenesis of PF. It is more of a chronic degenerative process than an acute inflammatory one (3-6). PP, pes cavus, leg length discrepancy, tightness of the Achilles tendon, gastrocnemius, soleus and intrinsic foot muscles, or muscle weakness, obesity, inappropriate footwear use, prolonged standing, or walking required by certain jobs are listed as risk factors (2,4,7,8).

One of the risk factors for the development of PF is PP, defined as a reduction or complete loss in the height of the medial longitudinal arch (MLA). MLA is an important structure with shock absorption and flexibility capabilities in the foot (9-11). In individuals with PP, the collapse of the MLA and subsequent foot pronation increase stress on the plantar fascia, creating a risk factor for PF development (7). The prevalence of PP in the general population is approximately 25% (10). In individuals with PF, PP and weakness in gastrocnemius, soleus, and intrinsic foot muscles have been reported in 3.7% of cases (11).

While the natural anatomical structure of the foot is preserved in individuals without PP, the collapse of the foot arch in the presence of PP leads to increased pronation, creating constant and abnormal pulling forces on the plantar fascia. This situation reduces the plantar fascia's ability to relax, potentially causing a loss of flexibility. Additionally, PP causes body weight to concentrate more on the heel and forefoot. This creates extra stress on the plantar fascia, contributing to flexibility loss. Loss of flexibility can lead to micro traumas and fibrotic changes in the plantar fascia over time, further reducing plantar fascia flexibility (6). Therefore, early diagnosis and intervention can slow the progression of this condition.

The most characteristic symptom of PF is heel pain, especially after taking the first steps in the morning or following prolonged standing/walking activities. This pain can significantly restrict daily activities and negatively impact quality of life. Depending on the level of pain, various treatment methods may be recommended, including avoiding aggravating activities, performing stretching exercises, physical therapy, foot orthotics, night splints, and medication. If conservative procedures fail to alleviate pain, different injections may be considered (12). Due to the multifactorial nature of PF etiology, no single treatment method is standardized (4). Therefore, correct diagnosis, evaluation, and management of PF are crucial.

The aim of this study was to investigate how the degree of PP (no PP, Grade 1 PP, and Grade 2 PP) affects pain, flexibility, muscle performance, and foot functionality in individuals diagnosed with PF. The findings obtained could help determine treatment strategies according to the degree of PP in individuals with PF.

MATERIAL AND METHODS

Ethical statement

Permission was obtained from the Ethics Committee of Ankara Yıldırım Beyazıt University, Health Sciences Ethics Committee on January 16, 2024, with the number 01-531 for conducting the study. After obtaining ethical committee approval for the research, necessary permissions were acquired from the institution. The study was

conducted in accordance with the 2008 revision of the Helsinki Declaration.

Participants

Individuals who applied to the Sports Medicine Polyclinic, and who were diagnosed with PF by a sports medicine specialist were invited to participate if they met the inclusion criteria. Participants were informed about the study, and informed consent forms were signed. Lateral foot X-rays were taken of all participants. Participants were divided into three groups based on their PP degrees determined by the Feiss line test: '0' (no PP), '1' (Grade 1 PP), and '2' (Grade 2 PP).

Inclusion and exclusion criteria

Inclusion criteria were tenderness upon palpation of the heel, pain in the plantar region, presence of calcaneal spur on lateral foot radiographs, unilateral PF diagnosis, and voluntary participation. Individuals with a history of lower extremity surgery or trauma, diseases predisposing to heel pain (e.g., diabetes mellitus, myalgia), leg length discrepancy of 1.5 cm or more, Grade 3 PP, and a body mass index above 35 kg/m^2 were excluded from the study.

Sample size calculation

The sample size for the study was calculated using the G-Power 3.1.9.7 program. Three groups were formed according to the degree of PP, and the ANOVA (fixed effect, one-way) test in the G-Power program was used for comparisons among the groups. The power of the test was set at 90%, the error rate at 5%, and the effect size at 0.50 (medium). As a result of the calculations, the total sample size was found to be 54. Therefore, it was planned to conduct the study with at least 54 individuals with PF. However, due to recruitment limitations, the final group sizes were somewhat imbalanced (e.g., Groups 0 and 2 each with n=10). This imbalance may reduce statistical power and limit the reliability of between-group comparisons. Statistical analyses were interpreted with caution considering these limitations.

Data collection tools

Information on the dominant side and duration of complaints was recorded by asking the participants. Lower extremity dominance was determined by asking which leg they naturally used to kick a ball. Pain assessment was performed using a 10 cm visual analog scale (VAS). Foot function was evaluated using the Foot Function Index (FFI). This evaluation criterion, assesses pain, disability, and activity limitations in PF patients and is filled out by the patient, was used in its validated Turkish version (13).

Determination of pes planus degree

The pes planus degrees of the participants were determined using the Feiss Line test. Although the test is commonly used clinically to assess the medial longitudinal arch, evidence on its psychometric properties is mixed. A modified Feiss-based test (the Navicular Position Test) has demonstrated excellent intra- and inter-rater reliability (intra-rater ICC=0.94; inter-rater ICC=0.91) (14). Conversely, comparative studies of foot posture measures report variability across methods and emphasize limitations in Feiss Line reliability and radiographic validity (15,16). Therefore, to minimize measurement variability all Feiss Line assessments in the present study were performed by the same experienced physiotherapist.

Participants were asked to stand on a hard surface with their feet shoulder-width apart and distribute their weight equally on both feet. In a normal foot, an assessment was made over the Feiss line drawn between the navicular bone and the center of the metatarsophalangeal joint of the big toe. PP degrees were determined based on how far the scaphoid tubercle descended below the Feiss line. The tubercle descending one-third of the distance between the Feiss line and the ground was classified as Grade 1, two-thirds as Grade 2, and fully touching the ground as Grade 3 PP. Those with Grade 3 PP were not included in the study. Those remaining on the Feiss line were recorded as having no PP (Group 0) (17).

Flexibility tests

Tests were performed with patients sitting on a flat surface with their knees extended towards the wall. Each test was repeated three times, and the average of the three measurements was taken (18).

Gastrocnemius-soleus flexibility test: Participants were instructed to sit in a long sitting position with their knees extended, press their foot soles against the wall, then extend their arms forward and try to reach their toes. The distance between the longest toe and the wall was measured in this position (18).

Plantar fascia flexibility measurement: Participants extended their legs forward, leaned their feet against the wall, and placed their hands behind their backs to minimize hamstring tension as much as possible. Then, using dorsiflexion, they pulled their ankles towards themselves as much as possible. In this position, the distance between the wall and the tip of the big toe was evaluated (18).

Functional tests/heel rise test: Muscle performance was assessed using the Heel Rise test. Participants were asked to rise onto their tiptoes barefoot on a hard surface for one minute, and the number of times they rose onto their tiptoes within one minute was recorded (19).

Statistical Analysis

Data were analyzed using SPSS (Statistical Package for the Social Sciences) v23. Descriptive statistics (mean, standard deviation, median, minimum, maximum, frequency, and percentage) were calculated. The Shapiro-Wilk test was used to examine the normality of data, and Levene's test was used to assess homogeneity of variances. For qualitative variables, group comparisons were performed using the Fisher-Freeman-Halton exact chi-square test. For quantitative variables, one-way analysis of variance (ANOVA) was applied when the assumptions of normality and homogeneity were met. In cases where assumptions were violated, the non-parametric Kruskal-Wallis H test was used. When overall group differences were identified, Tukey's HSD or pairwise comparisons with Bonferroni correction were applied to control for multiple testing. Statistical significance was set at $p<0.05$ (20).

RESULTS

Fifty-eight PF patients were included in the study. General characteristics of the participants are summarized in Table 1. Of the participants, 67.2% were female, and 32.8% were male. The dominant side and the affected side were the right.

Table 1. General characteristics of participants

Variables	Levels	Frequency (%)
Gender	Female	39 (67.2)
	Male	19 (32.8)
Dominant side	Right	54 (93.1)
	Left	4 (6.9)
Affected side	Right	19 (32.8)
	Left	39 (67.2)
Groups (based on pes planus degree)	0	10 (17.2)
	1	38 (65.6)
	2	10 (17.2)

General characteristics of participants according to groups are summarized in Table 2. About 80% of group '0', 65.8% of group '1', and 60% of group '2' were female. There was no significant difference in gender distribution among the groups (p=0.607)

Table 2. General characteristics of participants according to groups

Variables	Groups	'0' (n=10)	'1' (n=38)	'2' (n=10)	p[a]
Gender	Female	8 (80.0)	25 (65.8)	6 (60.0)	0.607
	Male	2 (20.0)	13 (34.2)	4 (40.0)	
Dominant side	Right	10 (100.0)	36 (94.7)	8 (80.0)	0.263
	Left	0 (0.0)	2 (5.3)	2 (20.0)	
Affected side	Right	3 (30.0)	14 (36.8)	2 (20.0)	0.718
	Left	7 (70.0)	24 (63.2)	8 (80.0)	

Figures as n (%); [a]: Fisher-Freeman-Halton test

All participants in group '0', 94.7% in group '1', and 80% in group '2' had a dominant right side. There was no significant difference in the dominant side among the groups (p=0.263). About 70% of group '0', 63.2% of group '1', and 80% of group '2' had the left side affected.

There was no significant difference in the affected side among the groups (p=0.718). Information on participants' age, body weight, height, BMI (body mass index), and complaint durations is summarized in Table 3.

Table 3. Participants' age, body weight, height, BMI, and complaint durations

Variables	Mean ± SD	Median	Range [min-max]
Age (yrs)	45.5 ± 9.1	47.5	40.0 [20.0-60.0]
Body weight (kg)	79.2 ± 12.2	77.5	55.0 [56.0-111.0]
Height (cm)	167.2 ± 11.0	165	40.0 [150.0-190.0]
BMI (kg/m^2)	28.4 ± 3.8	28.5	20.9 [21.3-42.2]
Complaint duration (mo)	31.0 ± 43.6	12	179 [1-180]

SD: standard deviation; min: minimum; max: maximum; mo: months

Information on participants' age, body weight, height, BMI, and complaint durations according to groups is summarized in Table 4. No significant differences were found among the groups in terms of age, body weight, height, BMI, and complaint durations (p>0.05).

Table 4. Participants' age, body weight, height, BMI, and complaint duration according to groups

Variables/Groups	"0"	"1"	"2"	p
Age (yrs)	44.6 ± 9.9	45.3 ± 9.1	47.1 ± 9.1	0.817[a]
Body weight (kg)	72.8 ± 9.2	80.4 ± 12.9	80.9 ± 10.8	0.270[b]
Height (cm)	162.8 ± 11.1	168.3 ± 11.4	167.4 ± 9.2	0.314[b]
BMI (kg/m^2)	27.7 ± 4.4	28.3 ± 3.0	29.2 ± 5.6	0.679[a]
Complaint duration (mo)	44.3 ± 50.6	29.5 ± 43.4	22.6 ± 37.4	0.682[b]

Values are given as mean ± SD; mo: months; [a]: one-way ANOVA; [b]: Kruskal-Wallis H test

Information on participants' pain measurements according to groups is summarized in Table 5. No significant differences were found among the groups in terms of rest pain, activity pain, night pain, and gastrocnemius tightness (p>0.05). However, a significant difference was found in plantar fascia tightness among the three groups (p=0.027). A difference was noted in plantar fascia tightness between groups '0' and '1' (p=0.024); differences between groups '0'-'2' and '1'-'2' were not found to be significant (p=0.431; p=0.494).

Table 5. Information on participants' pain, flexibility, and muscle endurance according to groups

Measures/Groups	"0"	"1"	"2"	p
Resting pain	2.48 ± 3.24	2.36 ± 2.56	4.33 ± 3.20	0.206[b]
Activity pain	7.37 ± 2.48	7.52 ± 2.04	8.76 ± 1.19	0.195[b]
Night pain	3.38 ± 3.35	2.00 ± 3.09	1.57 ± 2.86	0.318[b]
Gastrocnemius tightness(cm)	9.37 ± 2.96	8.86 ± 2.12	8.94 ± 1.67	0.982[b]
Plantar fascia tightness(cm)	7.21 ± 1.72	5.86 ± 1.37	6.43 ± 1.14	0.027[a]
Heel rise test (reps/min)	25.6 ± 8.9	27.9 ± 13.6	32.9 ± 16.0	0.514[b]

Values are given as mean ± standard deviation; [a]: one-way ANOVA; [b]: Kruskal-Wallis H test

Information on participants' functional measurements according to groups is summarized in Table 6. No significant differences were found among the groups in terms of pain, disability, activity limitation, and total FFI(p>0.05).

Table 6. Information on participants' functional measurements according to groups

Measures/Groups	"0"	"1"	"2"	p[a]
Pain	52.6 ± 15.7	57.9 ± 26.3	71.3 ± 25.7	0.248
Disability	44.7 ± 21.7	58.4 ± 31.4	69.3 ± 26.3	0.217
Activity limitation	14.0 ± 6.3	14.9 ± 7.6	18.4 ± 10.3	0.501
Total FFI	109.4 ± 40.2	133.2 ± 62.2	162.9 ± 59.1	0.114

Values are given as mean ± SD; FFI: foot function index; [a]: Kruskal-Wallis H test result

DISCUSSION

In this study, we examined the effects of the degree of pes planus (PP) (no PP, Grade 1 PP, Grade 2 PP) on pain, flexibility, muscle performance, and foot functionality in individuals with plantar fasciitis (PF). Our findings revealed no significant differences among groups in terms of pain, gastro-soleus flexibility, muscle performance, or foot functionality. Plantar fascia flexibility was significantly lower in the group with Grade 1 PP compared with the group without PP, while other group comparisons were similar.

Biomechanical analyses indicate that PF is frequently associated with mechanical imbalances in the foot arch (6), and PP may contribute to altered foot mechanics (21). However, in our study, the presence and degree of PP did not affect pain intensity or foot functionality. Therefore, the current evidence does not support modifying treatment strategies solely based on PP degree in individuals with PF.

Although plantar fascia flexibility was lower in individuals with Grade 1 PP, this difference did not result in observable differences in pain or functionality among the groups, and its clinical significance remains unclear. Consequently, it is premature to suggest specific preventive or therapeutic interventions based on PP degree. Future studies with larger samples and objective biomechanical measurements are needed to clarify whether reduced plantar fascia flexibility has long-term implications.

PP primarily affects the plantar fascia and intrinsic foot muscles. While some studies suggest plantar flexor muscle strength may be lower in individuals with PP, gastro-soleus muscle performance and flexibility appear to be maintained (10,22-24). Consistently, our study presented no differences in gastro-soleus muscle performance or flexibility among the groups, indicating that PP degree does not substantially affect these muscles in individuals with PF.

Literature indicates that PP is only one factor in the multifactorial pathogenesis of PF (2). Our findings suggest that PP mainly affects plantar fascia flexibility, while other clinical measures are minimally affected. Given the limited significant results, further research is necessary before making clinical recommendations regarding treatment based on PP degree.

A strength of the study is the inclusion of functional assessments in PF patients using clinically meaningful measures. Additionally, similar demographic characteristics among groups enhance the reliability of the results.

One of the most important limitations of this study is the lack of long-term follow-up data. Long-term prospective studies are needed to understand whether the effects of PP on the plantar fascia become more pronounced over time. Another limitation is that the degree of pes planus was assessed using the Feiss line test, which, although commonly used clinically, is a subjective method with mixed evidence regarding its validity and reliability. The use of more advanced biomechanical tests such as gait analysis, plantar pressure measurement, or radiographic methods could provide more objective assessments.

Additionally, the final group sizes were somewhat imbalanced (e.g., Groups '0' and '2' each with n=10), and the relatively small sample size in each group may limit the robustness of parametric analyses. Although non-parametric tests were applied when assumptions were violated, statistical power remains restricted, which may affect the reliability of between-group comparisons. Finally, while a statistically significant difference was observed in plantar fascia flexibility between groups, the magnitude of this difference was small, and its clinical relevance may therefore be limited. Future studies with larger and more balanced samples, as well as objective biomechanical assessments, are warranted to clarify these relationships.

CONCLUSION

Plantar fascia flexibility may be reduced in individuals with plantar fasciitis (PF) and Grade 1 pes planus (PP), while pain, muscle performance, and foot functionality appear minimally affected by PP degree. Given the limited significant findings, current evidence does not support making specific treatment modifications based solely on PP degree. Further research with larger samples and objective biomechanical assessments is needed to clarify the potential long-term implications of PP on PF.

Ethics Committee Approval / Etik Komite Onayı

The approval for this study was obtained from Ankara Yıldırım Beyazıt University University Clinical Research Ethics Committee, Ankara, Türkiye (Decision no: 01-531, Date: 16/01/2024).

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

Consept: TK, BA; design: TK, BA; supervison: TK; materials: TK,HG; data collection and/or processing: TK,HG; analysis and interpreta-tion: AEY; literature review: TK,HG; writing manuscript: TK; critical reviews: BA. All authors contributed to the final version of themanuscript and discussed the results and contributed to the final manuscript.

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