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THE RELATIONSHIP BETWEEN PES PLANUS SEVERITY AND LOWER EXTREMITY FUNCTIONAL PERFORMANCE IN YOUNG ADULTS

ORIGINAL ARTICLE

ABSTRACT

Purpose: To examine the relationship between pes planus severity and lower extremity functional performance in young adults with pes planus.

Methods: Volunteers with asymptomatic flexible pes planus aged between 18-25 years were included, and 53 (32 Females) individuals with a mean age of 20.19±1.93 years were evaluated in this study. Navicular drop (ND) test was used to decide the presence and severity of pes planus. Balance and jump tests were used for assessing lower extremity functional performance. Balance performance was evaluated with the Y balance test and jump performance was evaluated with the single leg jump test (SLJ) using the Opto Jump system (Microgate, Bolzano, Italy).

Results: On the dominant side, a negative and weak correlation was found between ND values and balance results in anterior and posteromedial directions (p=0.014; r=-0.336, p=0.046; r=-0.276, respectively). On the non-dominant side, a negative and weak correlation was found between ND values and balance results in the anterior direction (p=0.040; r=-0.284). There was no correlation between ND values and SLJ heights in both extremities (p>0.05).

Conclusions: In young adults with asymptomatic flexible pes planus, insufficient dynamic balance performance was observed as the severity of pes planus increased, but the severity of pes planus did not affect vertical jump distance. This result suggests that interventions for pes planus severity may also have an effect on balance performance.

Key Words: Flat Foot, Physical Performance, Postural Balance

GENÇ YETİŞKİNLERDE PES PLANUS ŞİDDETİ İLE ALT EKSTREMİTE FONKSİYONEL PERFORMANSI ARASINDAKİ İLİŞKİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Pes planuslu genç erişkinlerde pes planus şiddeti ile alt ekstremite fonksiyonel performansı arasındaki ilişkiyi incelemektir.

Yöntem: Çalışmaya 18-25 yaş aralığında, asemptomatik esnek pes planusu olan gönüllüler dahil edildi. Çalışmamıza 20,19±1,93 yaş ortalamasına sahip 53 (32 Kadın) birey katıldı. Pes planus varlığını ve şiddetini belirlemek için naviküler düşme (ND) testi kullanıldı. Alt ekstremite fonksiyonel performansı için denge ve sıçrama testleri seçildi. Denge performansı Y balans denge testi ile, sıçrama performansı ise OptoJump sistemi kullanılarak tek ayak sıçrama testi (TAS) ile değerlendirildi.

Sonuçlar: Dominant tarafta ND değerleri ile anterior ve posteriomedial yönde denge sonuçları arasında negatif yönlü zayıf derecede bir korelasyon bulundu (sırasıyla p=0,014; r=-0,336, p=0,046; r=-0,276). Nondominant tarafta ise ND değerleri ile anterior yönde denge sonuçları arasında negatif yönde zayıf derecede bir ilişki bulundu (p=0,040; r=-0,284). Her iki ekstremitede de ND değerleri ile TAS yükseklikleri arasında anlamlı bir ilişkiye rastlanmadı (p>0,05).

Tartışma: Asemptomatik esnek pes planuslu genç erişkinlerde pes planus şiddeti arttıkça yetersiz dinamik denge performansı gözlendi, ancak pes planus şiddeti dikey sıçrama mesafesini etkilemedi. Bu sonuç pes planus şiddetine yönelik uygulamaların denge performansı üzerinde de etkili olabileceğini düşündürmektedir.

Anahtar Kelimeler: Düz Taban, Fiziksel Performans, Postural Denge

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INTRODUCTION

Pes Planus is a frequent foot deformity. This deformity is defined as the loss of height of the medial longitudinal arch (MLA) with forefoot abduction and hindfoot valgus while transferring body weight. (1, 2). The prevalence of pes planus in young adults is % 11.25 (3). The most important problem accompanying pes planus is inordinate pronation of the foot in standing and walking. Flattening of the MLA, increased foot pronation, and decreased plantar flexion muscle strength seen in pes planus cause increased plantar pressure on the medial side of the foot (4). This change in plantar pressure affects the person's functional performance by changing the alignment and loading in all body segments through the kinetic chain (5). Pes planus also causes excessive stress and compressive shear forces in the knee joint, and internal rotation in the hip joint due to impaired load transfer in the foot and ankle joints during walking (5-7).

Balance is a postural adaptation skill that keeps the center of gravity within the support surface during function or resting state (8). Especially when providing balance on one foot, the foot, which is the extreme segment of the lower extremity, forms the support surface. It is thought that biomechanical changes in the support surface may affect postural control, therefore changes in MLA may also affect balance performance (9). In the literature, there are studies showing that the support surface increases in individuals with pes planus, but this change in foot posture negatively affects postural stability and balance ability (4, 6, 10, 11).

Vertical jump height is an evaluation method used in many sports that gives information about lower extremity strength, neuromuscular fatigue and jump performance (12). A physiological process including the neuromuscular system and biomechanical conditions are effective in jumping performance (13). When individuals with pes planus and normal foot structure were compared during vertical jump, significant differences were found in plantar pressure and lower extremity kinematics in individuals with pes planus (14). Neuromuscular coordination is required during the vertical jump, involving the foot-ankle, knee, hip joints, and trunk muscles. In addition, it is known that the muscles around the foot and ankle are closely related to the thrust in the jump function. It has been shown that it affects foot plantar flexor and dorsiflexor muscles strength values and, accordingly, jump heights in individuals with pes planus (15). In addition, in a study conducted on gymnasts, it was found that the activation of the gastrocnemius medialis and soleus muscles during the vertical jump was lower in those with pes planus compared to the normal arch structure (13).

In many studies in the literature, the negative effects of pes planus on lower extremity physical performance have been reported. (4, 16, 17). However, revealing the effect of pes planus severity on performance in individuals with pes planus may guide in determining the risk factors of inadequate lower extremity performance in these individuals. In addition, knowing this relationship is important in terms of considering performance-oriented approaches in the evaluation and treatment of these individuals. We conducted our study with the assumption that lower extremity functional performance will decline with an increase in the amount of navicular drop (ND) in young adults with flexible asymptomatic pes planus. The aim of this study is to examine the relationship between pes planus severity and balance and jump performance.

METHODS

Participants and Design

This study is a cross-sectional study. This research was carried out in Alanya Alaaddin Keykubat University Vocational School of Health Services Department of Therapy and Rehabilitation to examine the relationship between pes planus severity and lower extremity functional performance in individuals with bilateral asymptomatic flexible pes planus between January 2020 and April 2021. The Clinical Research Ethics Committee of Alanya Alaaddin Keykubat University approved this study (10354421-2020/15-04). The study was accomplished in accordance with the Declaration of Helsinki. All individuals participating in the research were informed verbally and in writing about the purpose, scope and duration of the research. An "Informed Consent Form" was obtained from the individuals, indicating that they voluntarily agreed to participate in the study.

In the present study, volunteers with asymptomatic flexible pes planus aged 18-25 years, a body mass index (BMI) of 18.5-30 kg/m², ND values of 10 mm and above for both extremities, and a positive Jack's finger test (18) were included. Exclusion criteria were having symptoms such as pain and fatigue in the foot-ankle during activities of daily living, a neurological or orthopedic disease affecting the lower extremity, a history of trauma or surgery in the foot-ankle, and leg length discrepancy of more than 1 centimeter (cm), and being involved in any amateur or professional sports.

The demographic information and physical characteristics of the individuals (such as age, weight, height, gender) were recorded. The dominant leg was determined by questioning which leg the individuals used to kick the ball (19).

Within the scope of our study, 248 young adult individuals were evaluated for the presence of pes planus. It was determined that the amount of ND in 74 individuals was 10 mm or more on both feet and they had flexible pes planus according to Jack's finger lift test. Of these, 11 participants were excluded because they did not meet the other inclusion criteria, 6 participants had complaints of pain, and 4 participants did not want to participate in the study. Our study was completed with a total of 53 individuals, 21 men and 32 women (Figure 1).

Navicular Drop (ND) Test

The ND value is obtained by subtracting the navicular height measured by placing weight on the foot while standing, from the navicular height measured without weighting the foot while sitting (20, 21). These obtained values give information about the height of the MLA in the sagittal plane. If the amount of ND is 10 mm or more, it is considered pes planus (22). For the ND test in our study, the volunteers were seated with their hips and knees at 90°, and the ankle joint was placed in a subtalar neutral position. The navicular tubercle was identified and marked by palpating approximately 2.5 cm anterior-inferior to the medial malleolus (23). The height of the navicular tubercle relative to the ground was measured. The same measurement was made while standing with equal body weight transferred to both feet. Individuals with a differ-

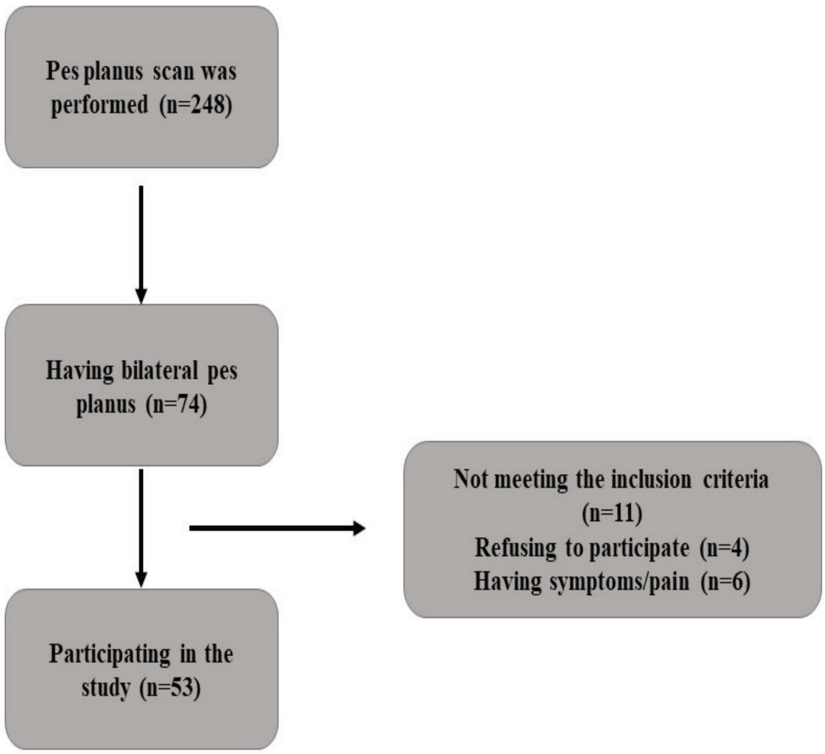

Figure 1. Flowchart of the study

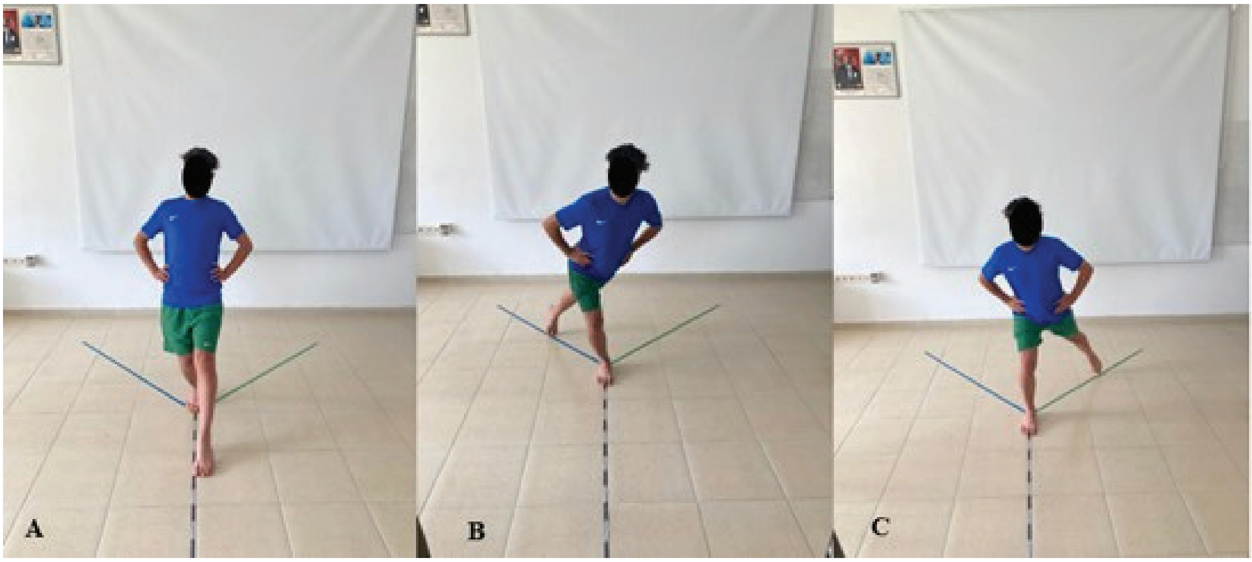

Figure 2. Y balance test (A- Anterior B- Posteromedial C-Posterolateral)

ence of 10 mm or more between the two measurements were accepted as pes planus. The test was repeated for both extremities.

Dynamic Balance Assessment

The Y-balance test was used to evaluate lower extremity dynamic balance performance in our study. This test is used to determine the level of motor control, assess the risk of injury, measure the development of sportive performance, and evaluate dynamic balance performance. The Y-balance test is a modified form of the Star Excursion Balance Test. The validity and reliability assessments of this test were performed by Plisky et al. (24). To perform the test, a Y-shaped mechanism was prepared on the ground. After fixing in the anterior direction using a tape measure on a hard surface, tape measures were placed at an angle of 135° in the posterolateral (pl) and posteromedial (pm) directions. Before the test was performed, how the test will be performed was explained and the participants performed the test at least 3 times. During the test, the volunteers were asked to touch as far as they could without transferring weight with their toes on tape meters in three directions with their hands on their waists, and the distance they reached was recorded in centimeters (cm) (Figure 2). The test was repeated if the subjects lost their balance, separated their hands from their waists, could not return to the starting point, and lifted their heel off the ground. The average of three successful reach distances in each direction was recorded for analysis. The test was repeated in this way for both extremities. The obtained value was normalized using lower extremity lengths. Lower extremity length was considered as the distance between the medial malleolus and the anterior superior spina iliaca. The following formula was used to determine the normalized reach distance. (24, 25).

Relative (normalized) reach (%) = Average reach distance / limb length X 100

Jumping Assessment

The vertical jump test on one leg was used to evaluate the jumping performance of the participants in our study. The jump heights of the participants were evaluated using the OptoJump System and software (Microgate, Bolzano, Italy). The validity and reliability study of this system was accomplished by Glatthorn et al. (26). The single leg vertical jump (SLJ) test was performed for both extremities with the use of Drift protocol included within testing procedures in the Optojump System. For the SLJ test, the participants were asked to jump on one leg in the starting position with their hands on the waist and knees stretched. According to the test protocol, the participants tried to jump as far as they could reach, with the legs stretched without pulling the knees up (Figure 3). Participants were verbally motivated to reach the maximum height in jumps. The SLJ test was repeated 5 times on both

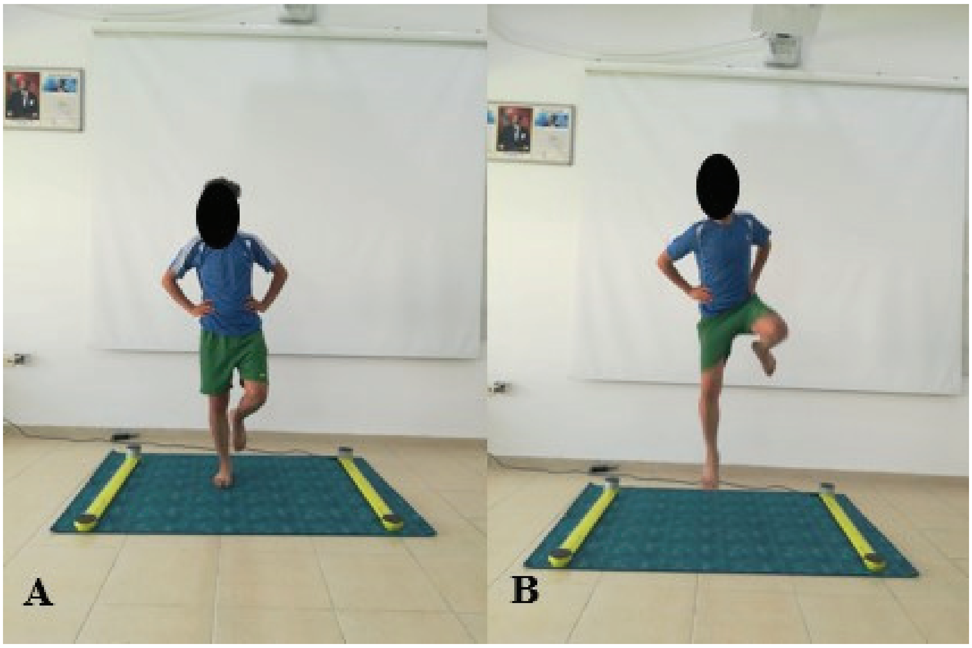

Figure 3. The single leg vertical jump test (A: Single leg vertical jump test starting position, B: Single leg vertical jump moment)

extremities for each participant. The tests were repeated in cases of excessive slump before jumping, involvement of the other foot in the jump, or separation of the hands from the waist. The highest jump height achieved in the SLJ test was recorded in cm (27).

Statistical Analysis

G* Power version 3.1.9.2 software (Heinrich-HeineUniversität Düsseldorf, Düsseldorf, Germany) was used to perform statistical power analysis. It has 0.4 effect size, 5% type I error margin and 85% statistical power conditions to evaluate the relationship between ND values and Y balance test values in 53 individuals with bilateral pes planus statistically (28, 29).

The "SPSS 21.0 for Windows" program was used for statistical analysis. Descriptive statistics are expressed as mean ± standard deviation for normally distributed numerical variables, and as median, minimum, maximum, percentile, and interquartile values for numerical variables that did not show normal distribution. The Shapiro-Wilks test was used for normality evaluation. The Spearman Correlation Analysis method was used to determine the statistical relationship between ND values and Y balance test and SLJ values. Any p value less than 0.05 was accepted as statistically significant. Correlations were interpreted as weak (0.1-0.39), moderate (0.4-0.69), or strong (0.7-0.99) (30).

RESULTS

The physical characteristics of the individuals participating in our study are given in Table 1. Forty-six of these individuals were right dominant. The descriptive statistics of the ND values, Y balance, and SLJ test values for both extremities of the par-

Table 1. Physical Characteristics of the Participants

N=53	X±SD	Min-Max
Age (years)	20.19±1.93	18-25
Height (m)	1.68±0.08	1.52-1.89
Weight (kg)	64.17±11.84	42-95
BMI (kg/m²)	22.48±2.48	18.56-28.68

N: Number of individuals participating in the study, BMI: Body mass index, X: Mean, SD: Standard deviation.

Table 2. Descriptive Statistics of the Measured Values

N=53	Median	Min-Max	Percentile	Interquartile value
ND (mm) (Dominant)	13	11-21	12/14	2
Anterior (%) (Dominant)	78.20	65.33-95.85	73.59/84.7	11.11
Posteromedial (%) (Dominant)	80.48	67.50-97.03	72.82/84.36	11.55
Posterolateral (%) (Dominant)	87.80	74.67-106.92	83.91/93.33	7.52
SLJ (cm) (Dominant)	8.80	2.70-15.80	6.45/10.60	4.20
ND (mm) (Nondominant)	13	10-21	11/15	4
Anterior (%) (Nondominant)	79.65	67.4-97	76.32/85.47	9.16
Posteromedial (%) (Nondominant)	78.75	68.19-95.35	74.91/83.91	9
Posterolateral (%) (Nondominant)	87.91	76.84-109.09	82.77/93.37	10.59
SLJ (cm) (Nondominant)	7.70	3.70-17.30	5.60/10.50	13.60

N: Number of individuals participating in the study, ND: Navicular drop value, SLJ: Single leg vertical jump.

ticipants in the study are shown in Table 2.

As a result of the statistical analysis, a weak negative correlation was detected between the ND value and the anterior direction of balance values in both extremities (dominant p=0.014; r=-0.336/ nondominant p=0.040; r=-0.284). While a weak negative correlation was detected between the ND values and the balance values in the posteromedial direction on the dominant side (p=0.046; r=-0.276), no statistically significant correlation was found between the ND values and the balance values in the posterolateral direction (p>0.05). It was found that there was no correlation between ND value and balance assessment in both the posteromedial and posterolateral directions on the nondominant side (p>0.05). There was no relationship between ND value and SLJ heights in both extremities (p>0.05) (Table-3).

DISCUSSION

In the present study, the relationship between the amount of ND and lower extremity functional performance including balance and jump parameters was assessed in young adults with pes planus, and it was determined that these individuals may show insufficient dynamic balance performance as the severity of pes planus increases. It was concluded that the vertical jump performance was not affected.

In our study, it was found that dynamic balance performance decreased with increasing ND value in individuals with flexible pes planus. There are

Table 3. Relationship Between ND Value and Balance, Jump Results

Dominant side	ND		Nondominant side	ND	
	r	p		r	p
Anterior	-0.336	0.014*	**Anterior**	-0.284	0.040*
Posteromedial	-0.276	0.046*	**Posteromedial**	-0.029	0.838
Posterolateral	-0.014	0.918	**Posterolateral**	-0.067	0.631
SLJ	-0.130	0.354	**SLJ**	-0.024	0.867

p<0.05 significant difference; p>0.05 no significant difference; Spearman Correlation test, ND: Navicular drop value, SLJ: Single leg vertical jump.

many studies in the literature examining the effect of balance in individuals with pes planus (4, 17, 31). Kızılcı and Erbahçeci found that the single leg standing time was negatively affected according to the pes planus severity (17). Dabholkar et al., in their study involving 60 individuals aged 18-25 years, found that the Y balance test scores of individuals with pes planus in all three aspects were lower than those with normal feet (31). Cote et al., in their study in 48 individuals, showed that there was a difference between the dynamic balance performances of individuals with and without pes planus (4). In our study, we think that the decrease in balance performance with the increase in the amount of ND, which indicates the severity of pes planus, may be due to reasons related to the level of structural disorders in the foot structure that occur in individuals with pes planus. As body weight is shifted onto the forefoot and toes, the intrinsic and extrinsic plantar flexors exert forces against ground reaction force as well as non-contractile structures such as the plantar fascia and other plantar ligaments to increase stiffness for forefoot stabilization. This counterforce may be insufficient to maintain foot stability in individuals with pes planus. Imbalance in load distribution that causes this insufficient counterforce, weakness in the muscles supporting the arch, weakness in the plantar fascia and ligaments may cause balance problem (17, 32).

Vertical jump height is an evaluation method used in many sports that gives information about lower extremity strength, neuromuscular fatigue, and jump performance (12). As a result of our study, it was observed that the MLA height did not affect the vertical jump height on one leg in individuals with asymptomatic flexible pes planus. In the study of Fu et al., in 20 male individuals, individuals with pes planus during vertical jump had greater plantar flexion and smaller external rotation in the ankle, and greater flexion, abduction movement, and smaller external rotation movement in the knee than those with a normal foot structure (14). Tudor et al. concluded that MLA structure does not affect vertical jump height in adolescent basketball players (33). Hu et al., in their study in 66 university students, concluded that the height of the MLA did not affect the vertical jump height of the two feet (34). Supporting these studies, Ho et al., in a study conducted in 26 male basketball players, found that athletes with low MLA showed a jumping performance similar to athletes with normal arch structure (35). David et al. reported that there was no relationship between ND value and vertical jump height in their study in 105 healthy volunteers aged 18-35 years (36). Contarlı and Çankaya also stated that the presence of pes planus did not affect vertical jump performance in gymnasts (13). Considering that the neuromuscular control and biomechanical alignment of the whole lower extremity are effective on jump performance (13, 37), the fact that the participants in our study were young and in the asymptomatic period of pes planus suggests that the severity of pes planus may not have affected jump performance yet.

In the literature, there are studies reporting the results of physical performance comparisons of individuals with pes planus and healthy individuals (4, 16, 17, 38) or examining the relationship between high MLA and performance (36, 39). However, as far as we know, there is no study examining the effect of the severity of pes planus on dynamic balance performance and vertical jump height in young adults with asymptomatic flexible pes planus. We think that the results of our study will make a significant contribution to the literature, as it is the first study to investigate the effects of pes planus severity on dynamic balance and vertical jump height in young adults with asymptomatic flexible pes planus.

Our study has several limitations. The fact that only asymptomatic individuals with flexible pes planus were evaluated in our study is a limitation. Another limitation is that the gender factor is not taken into account. We think that similar studies should be conducted in individuals with symptomatic pes planus and also considering the gender factor.

In conclusion, individuals with asymptomatic flexible pes planus may show insufficient balance performance with the increased severity of pes planus. We think that interventions to reduce the severity of pes planus in young adults with asymptomatic flexible pes planus may also improve balance performance and prevent other problems that may arise related to balance.

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