Black Sea Journal of Health Science
doi: 10.19127/bshealthscience.1740052

Open Access Journal
e-ISSN: 2619 – 9041

Research Article
Volume 8 - Issue 6: 255-262 / November 2025

THE INVESTIGATION OF THE CORRELATION BETWEEN NAVICULAR DROP DEGREE AND STATIC BALANCE, FLEXIBILITY AND STRENGTH

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Abstract: The biomechanics of the human body is influenced by muscle strength and flexibility. Deformities in the foot arch can affect balance. Therefore, this study aimed to investigate the relationship between foot arch height and lower extremity muscle strength, flexibility, and static balance. The study included 80 individuals (56 females, 24 males) aged between 18 and 30 years. Navicular drop was assessed using the Navicular Drop Test. Static balance was evaluated with the single-leg stance test. Hip flexor and gastrocnemius flexibility were measured, and muscle strength was assessed using a hand-held dynamometer. Pes planus was observed in 27 left feet (25 moderate pronation, 2 severe pronation) and 23 right feet (20 moderate pronation, 3 severe pronation). Statistical analysis revealed no significant relationship between navicular drop degree and lower extremity muscle strength, flexibility, or static balance ($P>0.05$). A strong correlation was found between right and left navicular drop values ($P<0.05$). No significant association was found between hip flexor flexibility and strength, balance, or navicular drop ($P>0.05$). However, a positive correlation was identified between dorsiflexor muscle strength and static balance ($P<0.05$). To improve static balance, strengthening the dorsiflexor muscles of the foot is recommended. Additionally, if navicular drop is detected on one side, early evaluation of the opposite foot is advised for preventive rehabilitation planning.

Keywords: Flexibility, Navicular drop, Strength, Static balance

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Received: July 12, 2025
Accepted: October 01, 2025
Published: November 15, 2025
Cite as: Altuntaş Yılmaz N, Çiçek B, Venç KŞ, Duran Kılınç D. 2025. The investigation of the correlation between navicular drop degree and static balance, flexibility and strength. BSJ Health Sci, 8(6): 255-262.

1. Introduction

The foot plays a vital role in maintaining the body's postural control through its structural and sensory components (Menz et al., 2005). Both structural and functional changes in the foot can negatively affect balance and muscle function. Any disruption in the harmony between the components that constitute the foot's main structure may lead to postural deformities, excessive rearfoot pronation, and consequently to common conditions such as pes planus, patellofemoral pain syndrome, and plantar fasciitis (Tome et al., 2006). The navicular drop test is used to assess the flexibility of the medial longitudinal arch (MLA) and the amount of pronation of the foot. First described by Brody, this test allows for the evaluation of MLA height and the degree of foot pronation, and thus enables the classification of pes planus severity (Rathleff et al., 2012).

Pes planus is defined as a reduction or complete loss of MLA height. It is characterized by medial displacement of the head of the talus in relation to the navicular bone, leading to stretching of the tibialis posterior tendon. This tendon, which normally maintains an arch shape, loses its tension and structure, resulting in a collapse of the MLA (Benedetti et al., 2011). Pes planus is categorized as either physiological or pathological. Physiological pes planus may occur in the general population, is often asymptomatic, and can improve over time. Pathological pes planus, however, is associated with a rigid foot structure and can lead to disability, thus requiring treatment (Milenković et al., 2011).

To maintain upright posture, the nervous system integrates visual, auditory, and somatosensory input to generate appropriate muscular responses that control the center of gravity. This control is crucial for keeping the body's center of mass within the base of support, a process defined as balance (El-Shamy and Ghait, 2014). In achieving this balance, the hip, knee, and ankle must work in coordination. The ankle, functioning as a fixed point in the closed kinetic chain, can influence balance if any disruptions occur in the foot arch. Moreover, excessive supination or pronation affects the plantar contact surface, decreasing sensory input and leading to balance disturbances (McDonald et al., 2016). Muscles such as the quadriceps, gastrocnemius, and tibialis anterior, which are responsible for knee extension, ankle plantarflexion, and dorsiflexion respectively, collectively contribute to body posture, gait, and balance. In individuals with pes planus, the activity of lower limb muscles may differ from those with normal foot posture, possibly leading to alterations in muscle strength (Um et al., 2015).

Recent studies have also used ultrasound-based shear wave elastography to assess changes in muscle stiffness—especially in the tibialis posterior muscle—among individuals with flatfoot, further highlighting the biomechanical implications of this condition (Marouvo et al., 2023). Although previous studies have explored individual aspects of foot arch deformities—such as muscle strength, flexibility, or balance—few have simultaneously investigated their interrelationship in a young healthy population. This study addresses this gap by examining the correlation between navicular drop, lower extremity muscle strength, muscle flexibility, and static balance, providing a more comprehensive understanding of functional limitations associated with foot arch deformities.

Therefore, the aim of this study was to investigate the relationship between foot arch height and lower extremity muscle strength, muscle flexibility, and static balance, and to identify potential functional limitations associated with arch deformities in order to contribute to comprehensive evaluation and effective rehabilitation planning.

2. Materials and Methods

2.1. Research Design

This study is a descriptive research designed to investigate the relationship between navicular drop degree and lower extremity muscle strength, muscle flexibility, and static balance.

2.1.1. Sample

The study was conducted with undergraduate students enrolled in the Faculty of Health Sciences at Necmettin Erbakan University. The population of the study consisted of second- and third-year students from the Department of Physiotherapy and Rehabilitation, totaling 212 students. Sample size calculation was performed using G*Power software (Düsseldorf, Germany). Based on a power analysis with a 95% confidence level (1–α), 95% statistical power (1–β), and an effect size of d = 0.5, the required sample size was determined to be 78 participants (Kaneko and Sakuraba, 2013).

2.2. Data Collection Tools and Procedures

Data were collected in a laboratory setting between September and November 2023. The study initially began with 94 students enrolled in the Faculty of Health Sciences at Necmettin Erbakan University who provided informed consent. However, the study was completed with 80 participants due to the exclusion of 14 individuals who did not meet the inclusion criteria.

The inclusion criteria were: aged between 18 and 30 years, absence of any chronic diseases, no history of foot trauma or surgery, no neurological or systemic diseases, and not being pregnant. Participants with open wounds or excessive sensitivity in the foot area, as well as those who started but did not complete the study, were excluded. The evaluation process took approximately 30–40 minutes per participant.

Initially, participants underwent the Navicular Drop test to determine their navicular drop status. Subsequently, static balance was assessed separately for the right and left foot using the single-leg balance test. Measurements were recorded with both eyes open and eyes closed conditions. Muscle flexibility was evaluated using the Thomas test and the gastrocnemius-Lefteus flexibility test by measuring the distance between the foot and the wall or floor. Muscle strength was measured using a handheld dynamometer, and the values were recorded.

2.3. Navicular Drop Test

The Navicular Drop test was applied to determine the height of the medial longitudinal arch of the foot. The test was performed in two categories: with full weight bearing and without weight bearing. Participants were asked to be barefoot. First, with full weight bearing, the distance between the navicular tuberosity and the floor was measured in millimeters using a ruler. The same measurement was repeated in a seated position without weight bearing.

Finally, the navicular drop value was calculated by subtracting the non-weight bearing measurement from the full weight bearing measurement. In healthy individuals, the normal navicular drop value ranges between 6 and 9 millimeters, while values of 10 millimeters or greater are considered pathological (Silva et al., 2022; Karartı et al., 2018).

2.4. Single-Leg Balance Test

The single-leg standing test was used to assess static balance. During the test, participants stood on one foot with their legs shoulder-width apart, ensuring that the knees did not touch each other. This procedure was repeated for both the right and left foot. The test was conducted under two conditions: eyes open and eyes closed. If participants maintained their body position for the full 120 seconds, the test was terminated. For durations shorter than 120 seconds, the time was recorded until test termination. The test ended if the foot touched the ground, the knees touched each other, the participant hopped in any direction, or any part of the body touched a support surface (Çolak and Akıl, 2020).

2.5. Muscle Flexibility Assessment

Iliopsoas muscle flexibility assessment (Thomas Test) test is used to evaluate muscle contracture and spasticity related to the hip joint, specifically assessing the flexibility of hip flexors including the iliopsoas muscle group, gracilis, rectus femoris, and sartorius. Participants were placed in the prone position and the hip was flexed. The contralateral hip was checked; if it passively flexed, iliopsoas spasticity or contracture was recorded as positive. The height from the floor was measured (Güven et al., 2015).

Gastrocnemius muscle flexibility assessment test was performed bilaterally. Initially, participants stood facing a wall, and a distance of 1 meter was measured using a tape measure. Both feet were positioned at the 1-meter mark, shoulder-width apart. Participants placed their hands against the wall and were instructed to maintain this position. They flexed their elbows to bring their torso closer to the wall. The distance between the wall and the participant's clavicular notch was measured with a tape measure, and the centimeter value was recorded. During the test, it was important for participants to maintain foot contact with the ground and keep the torso in an upright position to ensure accuracy (Çolak and Akıl, 2020).

2.6. Muscle Strength Assessment

In this study, muscle strength of the lower extremity groups was evaluated using a handheld dynamometer in four directions of foot movement: dorsiflexion, plantarflexion, inversion, and eversion. Bilateral strength of the quadriceps femoris and hamstring muscles was also assessed. All measurements were performed according to the "make test" procedure, which involves the participant performing a maximal isometric contraction against a fixed dynamometer position (Karartı et al., 2018).

2.7. Measurement of Plantar Flexor and Dorsiflexor Muscle Strength

Plantar flexor and dorsiflexor muscle strength measurements were performed with patients in the supine position, lying in a long sitting position with knees extended. For the assessment of invertor and evertor muscle strength, patients were seated at the edge of the examination table with their feet unsupported and knees flexed.

For hamstring muscle strength evaluation, participants lay prone on a flat table and were instructed to flex their knee to a 90º angle; muscle strength was measured in this position. It was important that the participant did not support themselves against the table during this test.

For quadriceps assessment, participants were seated on a surface elevated enough so that their feet did not touch the ground. The hips and knees were positioned at 90º flexion in a sitting posture. The dynamometer was placed perpendicular to the leg, approximately 2–3 cm above the malleoli, and measurements were recorded in this position.

Before the test, each participant was verbally informed about the procedure, and verbal cues continued throughout the assessment. A single practice trial was performed prior to testing to teach the participant. Then, for each muscle group, maximal isometric contractions lasting 5 seconds were performed three times, with 10 seconds rest between repetitions. The average of the three values was recorded (Telci et al., 2011, Desmyttere et al., 2019).

2.8. Statistical Analysis

Statistical analysis of the collected data was performed using the Statistical Package for the Social Sciences (SPSS) software, version 21.0 for Windows (IBM SPSS Statistics for Windows, Version 21.0; Armonk, NY: IBM Corp). The normality of the data distribution was assessed using the Kolmogorov–Smirnov test. Descriptive statistics were presented as mean ± standard deviation for normally distributed numerical data, median (25th–75th percentile) for non-normally distributed numerical data, and frequency (%) for categorical data.

Depending on the normality of the data, Pearson or Spearman correlation tests were used to analyze relationships between variables. A P-value of less than 0.05 was considered statistically significant. Relationships between scales were examined using correlation analysis, with correlation coefficients reported as Pearson's correlation coefficients.

3. Results

A total of 80 young adults (56 females, 24 males) with a mean age of 20.78 ± 2.37 years (range: 18–32) participated in the study. Minimum, maximum, and mean ± standard deviation values for age, height, and weight of the participants were determined (Table 1). In this study, pes planus was identified in 27 left feet (25 moderate pronation, 2 severe pronation) and 23 right feet (20 moderate pronation, 3 severe pronation).

Statistical analysis showed no significant relationship between the navicular drop degree and lower extremity muscle strength, flexibility, and static balance ($P>0.05$). However, a strong significant correlation was observed between the navicular drop degrees of the right and left sides ($P<0.001$). Positive correlations were found among muscle strengths relative to each other ($P<0.05$) (Table 2).

No relationship was found between gastrocnemius-Lefteus muscle flexibility and navicular drop angle. However, a significant negative correlation was observed between gastrocnemius-Lefteus flexibility and quadriceps muscle strength. Flexibility of the hip flexors showed no significant correlation with any parameter, except a significant correlation between right and left sides ($P<0.05$) (Table 3). A strong positive correlation was found in static balance measurements with eyes open and closed on the same side ($P<0.001$) (Table 4). A positive correlation was also determined between dorsiflexor muscle strength and static balance ($P<0.05$) (Table 5).

Table 1. Minimum, maximum, and mean ± standard deviation values of age, height, weight, static balance with eyes open and closed, navicular drop distances, muscle strength, and flexibility of all participants.

Demographic/Parameter	Gender	n	Min.	Max.	Mean ± SD	Demographic/ Parameter	Gender	n	Min.	Max.	Mean ± SD
Age (years)	Female	56	18.00	32.00	20.67 ± 2.26	Muscle Strength (kg)					
	Male	24	19.00	32.00	21.04 ± 2.64		Female	56	6.76	34.80	6.76 ± 6.76
	Total	80	18.00	32.00	20.78 ± 2.37	DF Right	Male	24	11.10	32.30	21.50 ± 5.79
Height (m)	Female	56	1.53	1.74	1.63 ± 0.05		Total	80	6.76	34.80	19.43 ± 6.16
	Male	24	1.69	1.95	1.80 ± 0.06		Female	56	8.80	35.20	18.54 ± 6.30
	Total	80	1.53	1.95	1.68 ± 0.10	DF Left	Male	24	14.30	35.43	21.96 ± 5.12
Weight (kg)	Female	56	40.00	75.00	57.74 ± 8.40		Total	80	8.80	35.43	19.56 ± 6.14
	Male	24	55.00	120.00	76.04 ± 15.75		Female	56	10.30	44.13	22.69 ± 6.49
Static Balance	Total	80	40.00	120.00	63.23 ± 13.88	PF Right	Male	24	11.40	41.70	27.27 ± 7.11
	Female	56	6.00	120.00	92.91 ± 36.95		Total	80	10.30	44.13	24.07 ± 6.99
Right Open	Male	24	34.00	120.00	108.7 ± 26.54		Female	56	8.46	42.90	21.29 ± 6.17
	Total	80	6.00	120.00	97.66 ± 34.77	PF Left	Male	24	13.13	42.90	25.72 ± 7.22
	Female	56	2.00	115.00	29.55 ± 28.44		Total	80	8.46	42.90	22.62 ± 6.77
Right Closed	Male	24	2.00	120.00	42.00 ± 34.10		Female	56	5.26	19.90	11.12 ± 3.94
	Total	80	2.00	120.00	33.28 ± 30.57	Everter Right	Male	24	5.66	24.63	13.70 ± 4.72
	Female	56	5.00	120.00	94.53 ± 34.67		Total	80	5.26	24.63	11.89 ± 4.32
Left Open	Male	24	24.00	120.00	102.9 ± 32.65		Female	56	4.00	49.36	12.00 ± 6.32
	Total	80	5.00	120.00	97.06 ± 34.08	Everter Left	Male	24	6.03	25.50	13.62 ± 4.30
	Female	56	2.00	103.00	26.35 ± 27.00		Total	80	4.00	49.36	12.49 ± 5.81
Left Closed	Male	24	4.00	120.00	40.16 ± 37.58		Female	56	4.66	21.03	12.17 ± 3.79
	Total	80	2.00	120.00	30.50 ± 30.97	Inverter Right	Male	24	7.90	22.20	14.08 ± 3.69
Navicular Drop Distance - Right	Female	56	0	15.00	5.00 ± 3.43		Total	80	4.66	22.20	12.74 ± 3.84
	Male	24	0	10.00	4.75 ± 2.93		Female	56	3.50	18.03	10.70 ± 3.21
	Total	80	0	15.00	4.92 ± 3.27	Inverter Left	Male	24	5.40	18.63	13.40 ± 3.40
Navicular Drop Distance - Left	Female	56	0	14.00	4.89 ± 2.90		Total	80	3.50	18.63	11.51 ± 3.48
	Male	24	1.00	12.00	4.58 ± 2.65	Quadriceps Right	Female	56	15.80	65.76	33.86 ± 10.72
	Total	80	0	14.00	4.80 ± 2.81		Male	24	33.66	93.53	60.68 ± 16.55
Flexibility Tests							Total	80	15.80	93.53	41.91 ± 17.68
Gastrocnemius Length	Female	56	39.00	57.00	50.50 ± 4.05	Quadriceps Left	Female	56	10.30	63.10	31.51 ± 11.57
	Male	24	38.00	61.00	53.33 ± 6.23		Male	24	30.30	79.93	55.69 ± 13.86
	Total	80	38.00	61.00	51.35 ± 4.94		Total	80	10.30	79.93	38.76 ± 16.54
Iliopsoas Right	Female	56	5.00	19.00	9.01 ± 2.41	Hamstring Right	Female	56	9.23	34.06	19.41 ± 5.25
	Male	24	4.00	14.00	9.66 ± 2.55		Male	24	18.80	36.00	28.36 ± 4.60
	Total	80	4.00	19.00	9.21 ± 2.46		Total	80	9.23	36.00	22.09 ± 6.51
Iliopsoas Left	Female	56	5.00	20.00	9.00 ± 2.56	Hamstring Left	Female	56	7.56	33.33	18.60 ± 5.15
	Male	24	5.00	12.00	9.31 ± 2.09		Male	24	16.10	44.53	27.51 ± 5.61
	Total	80	5.00	20.00	9.21 ± 2.46		Total	80	7.56	44.53	21.27 ± 6.67

Min= minimum, Max= maximum, Mean= average, SD= standard deviation, DF= dorsiflexor, PF= plantarflexor, E= evertor, İ= invertor, Q= quadriceps, H= hamstring, Ilio= iliopsoas.

Tablo 2. Correlations between lower extremity muscle strength measurements

			DF		PF		Evers		Inver		Quad	
			Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
DF	Right	r	1.000	0.895**	0.537**	0.561	0.589	0.478	0.559	0.570	0.324	0.268
		P		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.017
	Left	r	0.895	1.000	0.500	0.549	0.573	0.537	0.587	0.580	0.251	0.250
		P	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.026
PF	Right	r	0.537	0.500	1.000	0.806	0.482	0.359	0.530	0.499	0.357	0.273
		P	0.000	0.000		0.000	0.000	0.001	0.000	0.000	0.001	0.015
	Left	r	0.561	0.549	0.806	1.000	0.557	0.434	0.581	0.581	0.242	0.131
		P	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.031	0.249
Evers	Right	r	0.589	0.573	0.482	0.557	1.000	0.668	0.599	0.845	0.255	0.276
		P	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.024	0.014
	Left	r	0.478	0.537	0.359	0.434	0.668	1.000	0.582	0.667	0.102	0.132
		P	0.000	0.000	0.001	0.000	0.000		0.000	0.000	0.371	0.248
Inver	Right	r	0.559	0.587	0.530	0.581	0.599	0.582	1.000	0.698	0.268	0.194
		P	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.017	0.086
	Left	r	0.570	0.580	0.499	0.581	0.845	0.667	0.698	1.000	0.175	0.197
		P	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.124	0.082
Quad	Right	r	0.324	0.251	0.357	0.242	0.255	0.102	0.268	0.175	1.000	0.809
		P	0.004	0.026	0.001	0.031	0.024	0.371	0.017	0.124		0.000
	Left	r	0.268	0.250	0.273	0.131	0.276	0.132	0.194	0.197	0.809	1.000
		P	0.017	0.026	0.015	0.249	0.014	0.248	0.086	0.082	0.000	

DF= dorsiflexor, PF= plantarflexor, Evers= evertor, Inver= invertor, Quad= quadriceps, r= correlation coefficient, P= significant value.

Table 3. Correlation between lower extremity flexibility and muscle strength

			Quadriceps Muscle Strength		Hip Flexor Flexibility	
			Right	Left	Right	Left
Gastrosoleus Flexibility		r	-0.226*	-0.301*		
		P	0.045	0.007		
Hip Flexor Flexibility	Right	r				0.905**
		P				0.000
	Left	r			0.905**	
		P			0.000	

**= correlation is significant at the 0.01 level (2-tailed), *= correlation is significant at the 0.05 level (2-tailed).

Table 4. Statistical analysis results of static balance data with eyes open and closed

		RFO	LFO	RFC	LFC
RFO	r	1.000	0.678	0.325	0.256
	P		0.000	0.003	0.023
RFC	r	0.325	0.279	1.000	0.596
	P	0.003	0.013		0.000
LFO	r	0.678	1.000	0.279	0.227
	P	0.000		0.013	0.044
LFC	r	0.256	0.227	0.596	1.000
	P	0.023	0.044	0.000	

RFO= static balance right foot eyes open, RFC= static balance right foot eyes closed, LFO= static balance left foot eyes open, LFC= static balance left foot eyes closed.

Table 5. The relationship between static balance and dorsiflexors

			Static Balance Eyes Open		Static Balance Eyes Closed	
			Right	Left	Right	Left
Dorsiflexor	Right	r	0.242*		0.241*	
		P	0.031		0.031	
	Left	r		0.279*		0.271*
		P		0.012		0.015

4. Discussion

This study investigated the relationship between navicular drop status and associated parameters such as static balance, lower extremity muscle flexibility, and muscle strength in young individuals. Among 80 young participants, moderate to severe pes planus was identified in 27 left feet and 23 right feet. No significant relationship was found between navicular drop degree and lower extremity muscle strength, flexibility, or static balance. However, a significant correlation between the right and left sides of navicular drop within the same individual was observed. A negative correlation between plantar flexor muscle flexibility and knee extensor strength was noted. Additionally, a significant positive relationship was found between dorsiflexor muscle strength and static balance. A significant correlation between the right and left sides of navicular drop within the same individual was observed, along with a negative correlation between plantar flexor muscle flexibility and knee extensor strength, and a positive association between dorsiflexor strength and static balance.

Previous studies reported that approximately one-quarter of individuals with pes planus exhibit gastrocnemius-Lefteus muscle tightness (Mosca, 2010). In contrast, Ünver et al. compared gastrocnemius-Lefteus and hamstring muscle tightness between pes planus patients and healthy individuals, finding similar values in both groups (Ünver et al., 2019). Consistent with these findings, our study did not find a significant relationship between gastrocnemius muscle flexibility and navicular drop angle, which is indicative of pes planus. Literature also reports that hip flexors may be shortened in individuals with pes planus. Alam et al. (2019) demonstrated that rehabilitation exercises focusing on iliopsoas stretching and tibialis posterior strengthening were beneficial for patients with pes planus. Contrary to this, our study found no correlation between iliopsoas muscle tightness and other parameters. This discrepancy may be due to the younger age of our participants, who may not yet have developed deformities.

Ransimala et al. (2020) investigated the relationship between hip abductor muscle strength and pes planus in university students. They reported statistically significant differences in hip abductor strength between males and females with and without pes planus. Another study found that high foot arches were not significantly associated with lower extremity muscle strength and that pes planus rarely caused injury (Lizis et al., 2020). Bakırhan et al. (2021) examined the effect of foot arch height on knee and ankle muscle strength in women aged 18–24 and found no significant differences in ankle muscle strength or pes planus severity. Similarly, our study evaluated hip and leg muscle strength and found no significant relationship between navicular drop degree and lower extremity muscle strength. Our study similarly did not find a significant relationship between navicular drop and hip or leg muscle strength, suggesting that young healthy individuals may compensate for arch deformities through neuromuscular adaptations.

It as been previously reported that feet with high arches exhibiting excessive supination or pronation fail to adequately adapt to the ground surface, thereby increasing the load on musculoskeletal structures during postural stability and balance maintenance (Alam et al., 2019; Şahin et al., 2022). In a 2019 study comparing individuals with pes planus and healthy university students, similar to our study, the navicular drop test was used to assess pes planus, and the Flamingo test was employed to evaluate static balance. The study included 21 female students (n=13 control, n=8 pes planus) and reported a significant difference in static balance between the groups, concluding that pes planus negatively affects individuals' static balance (David et al., 2020). However, the small sample size of this study was noted as a limitation. Contrary to these findings, our study did not observe a significant difference between navicular drop and static balance. Determining the relationship between static balance and navicular drop requires further studies with larger sample sizes.

Kızılcı and Erbahçeci (2016), conducted a study involving 100 male participants, half of whom had pes planus and the other half were healthy controls. They reported that the pes planus group demonstrated shorter balance retention times and greater postural sway, concluding that pes planus deformity negatively impacts physical fitness in males. Another study comparing pronation groups to healthy controls found that both dynamic and static balance, assessed via the Four Square Step Test with eyes open and closed, were worse in the pronation group, indicating the negative effects of pes planus on pain and body balance (Aktan and Kutlay, 2022). All participants were students from the Department of Physiotherapy and Rehabilitation, which limits the sample's ability to represent the general population (external validity). Additionally, these participants' body awareness and physical activity levels may differ from those of the general population. In contrast, our study did not find a significant relationship between navicular drop and static balance. However, we observed strong positive correlations between eyes-open and eyes-closed balance measures on the same side, and dorsiflexor strength was positively associated with static balance. The lack of significant impact of navicular drop on balance in our study may be attributed to the young age of participants, absence of severe structural deformities, and preserved neuromuscular control in this population.

In contrast to these studies, our statistical analyses found no relationship between navicular drop degree and static balance. However, a strong positive correlation was found between eyes-open and eyes-closed static balance measurements on the same side. Additionally, dorsiflexor muscle strength was positively associated with static balance. Given that this study was conducted in a young population, we believe that muscle weakness, foot arch deformities, joint alignment issues, or age-related problems that could affect static balance may not have yet manifested, which might explain the lack of impact on static balance.

Due to the relatively young mean age of the participants included in the study, the observed relationships are recommended to be interpreted specifically for this age group. Further research with larger sample sizes and broader age ranges is needed to generalize the findings.

5. Conclusion

In this study, no significant relationship was found between navicular drop degree and lower extremity muscle strength, flexibility, or static balance in young adults. However, a strong correlation between right and left navicular drop values and a positive association between dorsiflexor muscle strength and static balance were observed. These findings suggest the importance of dorsiflexor muscle strengthening to improve balance. Additionally, early assessment of the contralateral foot in cases of navicular drop may be beneficial for preventive rehabilitation. Further studies with larger and more diverse populations are needed to confirm these results.

Author Contributions

The percentages of the authors' contributions are presented below. All author reviewed and approved the final version of the manuscript.

	N.A.Y.	B.Ç.	K.Ş.V.	D.K.D.
C	40	20	20	20
D	100	-	-	-
S	100	-	-	-
DCP	10	30	30	30
DAI	70	10	10	10
L	25	25	25	25
W	25	25	25	25
CR	25	25	25	25
SR	25	25	25	25
PM	25	25	25	25
FA	25	25	25	25

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of interest

There is no conflict of interest.

Ethical Considerations

Ethical approval for this study was obtained from the Scientific Research Ethics Committee of the Faculty of Health Sciences at Necmettin Erbakan University (Approval date: April 17, 2023, protocol code: 2023/423). Necessary institutional permissions were also granted by the faculty administration. Written informed consent was obtained from all participants through a "Voluntary Informed Consent Form" before data collection.

Acknowledgments

We would like to thank all the students who participated in and supported the conduct of this research.

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