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Factors Affecting Static and Dynamic Balance in Individuals with Pes Planus: A 45 Case Clinical Study

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ABSTRACT

Pes planus is one of the most common biomechanical disorders of the lower extremities caused by different intrinsic and extrinsic factors and negatively affects activities of daily living from mild to severe. Balance-based domestic or international studies give limited data on the diagnosis of flatfoot. For this reason, we aimed to give the view of the static and dynamic balance states of individuals with pes planus in our clinic. Twenty-two patients diagnosed with pes planus of deformity grade 2 and above according to the Feiss line and 23 volunteers without pes planus were included in the study. All participants were evaluated for static (30TST and single leg stance tests) and dynamic [Berg balance scale (BBS), Tinetti balance & gait test and timed up & go (TUG) tests] balance. The distribution among the groups evaluated with nonparametric tests was significant in terms of both static {[$\chi_{group*tandem}(1)=17.107$, $p=0.000$], [$\chi(1)_{group*single\_leg}=13.442$, $p=0.000$]} and dynamic [($U_{group*berg}=60$, $p=0.000$), ($U_{group*tinetti}=30$, $p=0.000$), ($U_{group*timed\_up\&go}=7.5$, $p=0.000$)] tests. In all static balance and dynamic tests, the time to stay in balance was found to be lower in the pes planus group, as expected. Apart from this, when the relationship between demographic and clinical data, balance tests and groups was evaluated, no statistically significant relationship was found ($p>0.05$). Accordingly, static and dynamic balance tests were effective in evaluating flat feet, while factors such as obesity and gender did not affect the degree of disease.

Keyword: Pes Planus, Static Balance, Dynamic Balance, Tandem, Berg

Introduction

Pes planus (with some common names, flatfoot, planovalgus, calcaneo-valgus, and fallen arches) is a foot condition that is characterized by partial or complete deformation of the medial longitudinal arch that occurs after skeletal development, which is common in the adult population and can occur in a wide range of symptoms from mild to severe and limit activities of daily living (1). According to Mann and Holmes (2), the most common cause of flatfoot disease, the etiology of which can be divided into *extrinsic* (trauma, corticosteroid injections, obesity, diabetes mellitus and hypertension) and *intrinsic* (congenital flatfoot, posterior tibial tendon hypovascularity, tight gastrocnemius-soleus complex and matrix metalloproteinase - MMP polymorphism), is obesity, trauma, and posterior tibial tendon insufficiency (60%) that develops after corticosteroid injection (3). Various factors affecting the foot, which has this complex structure, under static and dynamic conditions, cause the development of flatfoot (4). The mechanical balance of the foot, which deteriorates with the development of flatfoot, changes the localization and severity of stresses, especially on the lower extremity articulars and lumbar vertebrae. It has been reported that angular deviations in the lower extremity affect the biomechanics of the foot, and static deformations occur in the foot (5). It has been reported that malalignment due to flatfoot negatively affects foot function and physical performance (6,7). In a local study conducted with male adults, it was reported that the balance period was higher in individuals without flatfoot than in individuals with flatfoot. In another study, it was stated that as the degree of flatffot increases, the time for individuals to stay in balance decreases (8). Considering these reviews and studies, it can be said that flatfoot and the accompanying foot deformity are important problems affecting both physical activity and daily living activities and balance. Therefore, holistic evaluation of balance in individuals with pes planus is very important in terms of applying treatment approaches for it. The aim of the study is to show the reflections of the

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relationship between vital values and static or balance tests in pes planus patients and individuals who do not have this disease in our clinic. In this way, it will be evaluated whether the commonly used evaluation methods are relevent in terms of our clinical experience.

Materials and Methods

Participants and Study Design: The present study was approved by the local ethics committee at the meeting numbered 10840098-604.01.01-E.63688, decision number 1027. The participants were informed about the study verbally and written, and their consent was obtained by signing the Informed Voluntary Consent Form. In total, 45 participants were included in the study. According to the determined GPower parameters (t test; means: Wilcoxon-Mann-Whitney test; one tails; parent distribution: normal), values with a critical t (or Z) value above 1.65 should be considered significant. In addition, it was decided to recruit a minimum of 176 participants so that the actual power value of the study would be 0.951. However, since the number of people who applied to our clinic and included in the study was limited to 45, data with a t (or Z) value above 2.19 and a p value below 0.016 were considered significant. In this way, the determined actual power (0.951) was kept constant. There were two groups. These were control and assesment groups. The assesment group consisted of patients with pes planus. Patients diagnosed with pes planus according to the feiss line and healthy volunteers who were demographically matched with these patients and who did not have a history of lower extremity injury, chronic lower extremity pain, or lower extremity surgery in the last 6 months were included in the study. Patients with visual pathology that may affect the central nervous system or balance, vestibular system pathology, deformity in the waist, hip or knee joints, and a history of lower extremity amputation or surgery were excluded from the study. The control group consisted of age-, education-, gender-matched healthy controls. Figure 1 shows how the participants were recruited into the study and the processes after which the data were evaluated.

Clinical Evaluation: Within the scope of the study, 30-second Tandem stance test without support (30TST) and single leg stance tests were applied to the participants for the evaluation of static balance. Berg balance scale (BBS), Tinetti balance & gait test and timed up & go (TUG) tests were used for dynamic balance assessment. Tandem stance test, which is also a 10-second version, is applied by asking him to walk on a defined line from heel to toe fashion. In a comfortable base of support, the participant is asked to walk for 30 seconds with eyes open and arms by the side of the trunk. Unassisted walking for less than 30 seconds is considered unsuccessful (9). In the standing on one leg test, the participant was asked to stand on one leg for 30 seconds while the knee was in 90° flexion. Five measurements were made with the stopwatch and the average time was recorded. The test was repeated for both sides. The test was terminated if the individual's upper foot touched the ground, excessive swinging, or jumping with the grounded foot. For the one-leg standing test, values below 30 seconds indicate impaired balance (10).

The Berg balance test, standardized by Şahin et al. (11), is a 14-item assessment tool that measures balance and fall risk. It is a 4 likert scale with options from 0 (cannot) to 4 (independent and safe). The maximum score a participant can get is 56. The Tinetti balance & gait test, validated by Ağırcan (12), is a 16-item assessment tool with a score from 0 to 2, including 9 items of balance and 7 items of walking. The total score that the participants can get is 32 (13). Timed Up and Go test, a point was marked 3 m from the chair where the participant was sitting. The participant was asked to get up from the chair, walk 3 m, come back and sit on the chair again, and the completion time of the test was measured. Times of fourteen seconds or more were considered as a high risk of falling (14).

Statistical Analysis: SPSS (Statistical Package for the Social Sciences) 24.0 program was used for statistical analysis. Whether the data conformed to the normal distribution was evaluated with the Kolmogorov-Smirnov test. The analysis of the data that did not fit the normal distribution was carried out with non-parametric tests. Descriptive statistics were given using frequency, median and inquartile range values. The associations between numerical variables (age, height, weight, BMI, Berg Balance Scale – total score, Tinetti Stance & Gait Test – overall score, Timed Up & Go – seconds) and the groups was evaluated with the Mann-Whitney U test. The distribution of ordinal variables among themselves was analyzed using the Chi-Square/Fisher tests, which were deemed appropriate. Spearman correlation test was used to evaluate the relationship between numerical variables. p values less than 0.05 was considered significant.

Results

In the data study of our clinic, which included 45 people, the mean age of the participants was 38.77±4.79 (min=30; max=45), the average height was 171.17±6.85 (min=158; max=185) cm, and the average weight was 80.55±9.92 (min=65; max=96) kg. In addition, the mean BMI of the participants was 27.56±3.71 kg/m² and the mean education duration was 13.40±5.39 (min=5; max=19) years. The additional demographic and clinical data of our clinic are presented in Table 1.

Static and dynamic test scores evaluated by Mann-Whitney U test and Chi-Square/Fisher test were significant among study groups as expected. As seen in Figure 2, Tinetti Balance & Gait Test overall score (U=60, p=0.000) and Berg Balance Scale total score (U=30, p=0.000) were significantly lower in pes planus patients, while Timed Up & Go durations were significantly higher in the control group (U=7.5, p=0.000). Similarly, the results of Tandem Stance Test [$\chi(1)$=17.107, p=0.000] and Single Leg Stance Test [$\chi(1)$=13.442, p=0.000] are statistically significant.

Table 2 shows the vital value differences between the flatfoot patients and the control group in our clinic. According to the Mann-Whitney U test results, there was no difference between the groups in terms of age (U=211, p=0.337), weight (U=237, p=0.715) and BMI ratio (U=208, p=0.311). Only the difference between the heights of the participants was found to have a significant difference at the trend level (U=178, p=0.089). Accordingly, it can be said that patients with flatfoot (median=170 cm) are shorter in stature than controls (median=175 cm).

When we evaluated the relationship between vital variables and static and dynamic tests using the Kruskal-Wallis test, no significant difference was found between ordinal BMI and education levels and Tinetti Balance & Gait Test overall score [$\chi^2_{BMI*Tinetti}(1)$=0.083, p=0.773] [$\chi^2_{Education*Tinetti}(2)$=3.705, p=0.157], Berg Balance Scale total score [$\chi^2_{BMI*Berg}(1)$=0.725, p=0.395] [$\chi^2_{Education*Berg}(2)$=1.255, p=0.534], or Timed Up & Go durations [$\chi^2_{BMI*Timed}(1)$=0.291, p=0.590] [$\chi^2_{Education*Timed}(2)$=2.687, p=0.261]. In addition, when the connection between vital values and dynamic tests was evaluated with Spearman correlation test, no statistically significant result was encountered (p>0.05) (Table 3).

We divided pes planus patients according to their grade and evaluated them according to their vital value and static test results. Accordingly, no significant relationship was found between the degree of disease and age (U=51, p=0.914), height (U=38.5, p=0.317), weight (U=47, p=0.694), BMI ratio (U=44, p=0.547), Berg Balance Scale (U=48.5, p=0.773), Tinetti Balance & Gait Test overall score (U=36, p=0.234), and Timed Up & Go durations (U=42, p=0.450) (Table 4). When the distribution between flatfoot grades and static tests [Tandem Stance Test {[$\chi(1)$=0.028, p=0.867] and Single Leg Stance Test [$\chi(1)$=0.028, p=0.867]} was evaluated with the Chi-Square test, no significant distribution was observed.

Discussion

Pes planus is a multidirectional deformity that occurs primarily with the collapse of the medial longitudinal arch and reduction of hindfoot eversion. It is seen that pes planus affects other segments of the body along with these problems that occur in the feet, causing postural disorders, problems in the musculoskeletal system, and balance problems in individuals (15).

In a study similar to our study in terms of sample size (16), in which different balance tests were used, the balance differences between pes planus patients and control groups were evaluated. Similar to ours, in this study, clinical features such as weight, height and BMI did not differ. Comparing the balance scores of the groups, it was determined that the time to stay in balance was higher in individuals without pes planus. When the relationship between the degree of pes planus and balance is examined, it has been determined that as the degree of pes planus increases, the time for individuals to stay in balance decreases. In individuals with pes planus, the collapse of the medial arch in the foot and the inequality in load distribution, together with the inadequacy of contraction, biomechanical disorders such as weaker muscles, tendons, and ligaments supporting the arch, and pain cause a feeling of tension, getting tired quickly, and deterioration of balance and coordination. These reasons negatively affect the time to stay in balance of individuals with pes planus (17).

According to the results of a study by Soni et al. similar to ours in terms of the number of patients, patients with flat feet have significantly lower mean scores in both static and dynamic balance tests (18). In the study, which also included demographic data, it was observed that different balance components were not affected by factors such as age, gender and BMI. In a health group study evaluating different types of 4-week

Table 1: Demographic & Clinical Features of Participants

			N	%
Study Groups	Control	45	23	51.1
	Assesment		22	48.9
Gender	Female		21	46.7
	Male		24	53.3
BMI	Normal		17	37.8
	Overweight		17	37.8
	Obese		11	24.4
Education	Elementary		11	24.4
	Middle		6	13.3
	High		28	62.2
Pes Planus Degree	Moderate (2nd)	22	15	68.1
	Severe (3rd)		7	31.9

Table 2: Relationship of Nonparametric Static Test Values Between Groups

	Groups	Median	Inquartile Range	Z	p
Age (years)	Control	40	9	-0.959	0.337
	Assessment	40	8		
Height (cm)	Control	175	6	-1.703	0.089
	Assessment	170	10		
Weight (kg)	Control	80	13	-0.365	0.715
	Assessment	85	18.5		
BMI (kg/m2)	Control	26.17	5.29	-1.012	0.311
	Assessment	27.77	8.84		

Table 3: Correlation Between Vital Values and Dynamic Tests

		Berg Balance Scale (total)	Tinetti Stance & Gait Test (overall)	Timed Up & Go (sec)
Age (years)	Correlation Coefficient	0.163	0.115	0.100
	Sig. (2-tailed)	0.286	0.454	0.514
Height (cm)	Correlation Coefficient	0.240	0.063	-0.233
	Sig. (2-tailed)	0.112	0.683	0.124
Weight (kg)	Correlation Coefficient	-0.019	0.007	-0.030
	Sig. (2-tailed)	0.902	0.965	0.845
BMI (kg/m2)	Correlation Coefficient	-0.103	-0.026	0.106
	Sig. (2-tailed)	0.501	0.867	0.489

exercises developed for the medial longitudinal arc (MLA), it was seen that MLA exercises were not beneficial in the evaluation of static balance. On the contrary, it was observed that dynamic balance components decreased positively after exercise (19). Although the tests we applied in our study did not reveal a significant difference between the balance components, the more significant scores obtained from the dynamic tests (Berg and Tinetti) can be used as an important assessment measure in flatfoot discomfort in which MLA is effective.

Table 4: Relationship of Pes Planus Grades and Vital and Static Test Values

	Pes Planus Degree	Median	Inquartile Range	Z	p
Age (years)	Moderate	36	8	-0.108	0.914
	Severe	40	15		
Height (cm)	Moderate	170	10	-1.000	0.317
	Severe	168	5		
Weight (kg)	Moderate	85	18	-0.394	0.694
	Severe	90	25		
BMI (kg/m2)	Moderate	27.76	5.82	-0.603	0.547
	Severe	29.41	10.03		
Berg Balance Scale (total)	Moderate	44	6	-0.289	0.773
	Severe	48	12		
Tinetti Stance & Gait Test (overall)	Moderate	26	6	-1.191	0.234
	Severe	28	6		
Timed Up & Go (sec)	Moderate	14	3	-0.756	0.450
	Severe	14	3		

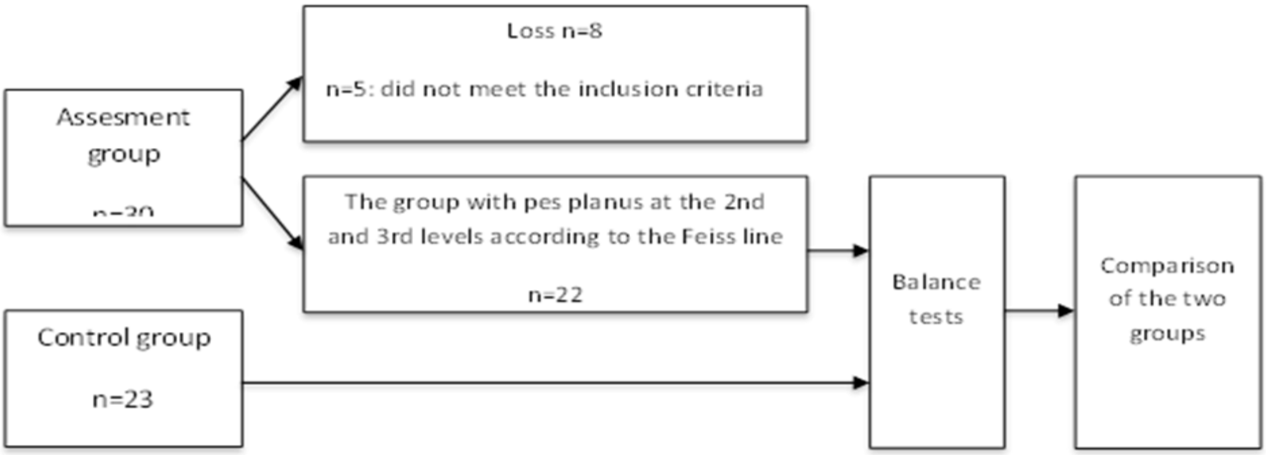

Fig.1. The Flow Chart of the Study

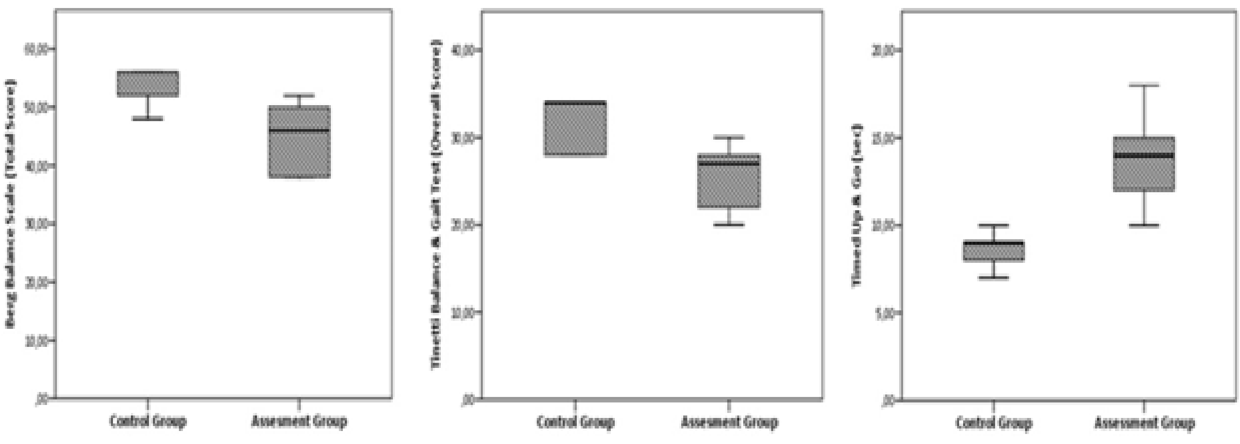

Figure 2. Results of Dynamic Balance Score of the Groups

In this study, the static balance status of the participants with pes planus and the dynamic balance status of the participants with pes planus were compared with the participants without pes planus. In all static balance tests, the time to stay in balance was lower in the group with pes planus. Berg and Tinetti's balance scores from dynamic balance tests were lower in the group with pes planus. In the Timed Up and Go test scores, the time to complete the test was longer in the pes planus group than in the control group. Considering these findings, it can be said that pes planus deformity affects both static and dynamic balance scores negatively. Evaluating the deteriorated static and dynamic balance and determining the appropriate treatment practices to improve the balance will help to increase the competence of individuals in physical activity and daily life activities.

In flatfoot (pes planus) disease, it is beneficial to establish muscle strategies with the help of a somatosensory input of joint mobilization or a fixed support in foot posture. For this reason, it can be expected that patients with flat feet will have low scores in dynamic balance tests that need to be done without support and include different functional tasks, or in static balance tests that are determined without using any equipment or according to ground reaction force. However, our research did not show any difference in these two balance test types. In addition, the lower p value obtained from the Tinetti Balance & Gait test, which is one of the most comprehensive measures of dynamic balance, will be illuminating for further studies in the evaluation of patients with flat feet.

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