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ORIGINAL ARTICLE

Impact of Foot Problems on Physical Activity, Balance, and Musculoskeletal Pain

Ayak Sorunlarının Fiziksel Aktivite, Denge ve Kas-İskelet Ağrısı Üzerindeki Etkisi

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ABSTRACT

Background/Aims: Foot problems are common in society and can frequently occur during daily life activities. This study aims to investigate common foot problems among healthy young adults and to determine the effects of these problems on physical activity, balance, and musculoskeletal pain.
Methods: Demographic data were recorded. Physical activity levels were evaluated using the International Physical Activity Questionnaire short form (IPAQ). Musculoskeletal disorders were assessed using the Extended Nordic Musculoskeletal Questionnaire (NMQ-E). The Foot Function Index (FFI) was utilized for foot function assessment. Balance was assessed using the Single Leg Standing Test. The navicular drop test was conducted for pes planus evaluation, and hallux valgus was assessed using the Manchester Scale and goniometric assessment.
Results: Data from 480 participants were analyzed (hallux valgus: 81, pes planus: 204, control: 195). A comparison of balance, FFI, and IPAQ scores revealed that the balance time of participants with pes planus decreased significantly compared to the control group ($p<0.05$). Significant differences in body pain were found among the groups for the lower back, hip/thigh, and ankle areas ($p<0.05$). No significant differences were observed among other sub-parameters ($p>0.05$). In the lower back region, pain was reported by 29 individuals in the hallux valgus group, 163 in the pes planus group, and 13 in the control group ($p<0.05$).
Conclusions: Foot deformities can negatively impact an individual's foot functionality and balance, leading to pain in various body regions.

Keywords: Balance, Hallux valgus, Pes planus, Physical activity, Pain

ÖZ

Giriş/Amaç: Ayak problemleri toplumda yaygındır ve günlük yaşam aktiviteleri sırasında sıkça ortaya çıkabilir. Bu çalışma, sağlıklı genç yetişkinler arasında yaygın ayak problemlerini araştırmayı ve bu problemlerin fiziksel aktivite, denge ve kas iskelet sistemi ağrısı üzerindeki etkilerini belirlemeyi amaçlamaktadır.
Yöntemler: Katılımcıların demografik verileri kaydedildi. Fiziksel aktivite düzeyleri Uluslararası Fiziksel Aktivite Anketi (IPAQ) kısa formu ile değerlendirildi. Kas-iskelet sistemi rahatsızlıkları Genişletilmiş Nordic Kas-İskelet Anketi (NMQ-E) ile değerlendirildi.. Ayak fonksiyonu değerlendirmesi için Ayak Fonksiyon İndeksi (FFI) kullanıldı. Denge, Tek Ayak Üzerinde Durma Testi ile değerlendirildi. Pes planus değerlendirmesi için naviküler düşme testi yapıldı, halluks valgus ise Manchester Skalası ve gonyometrik ölçümle değerlendirildi.
Bulgular: Toplam 480 katılımcının verileri analiz edildi (halluks valgus:81, pes planus:204, kontrol:195). Denge, FFI ve IPAQ skorlarının karşılaştırılmasında pes planus olan katılımcıların denge süresinin kontrol grubuna göre anlamlı ölçüde azaldığı görüldü ($p<0.05$). Alt sırt, kalça/üst bacak ve ayak bileği bölgelerindeki vücut ağrısı açısından gruplar arasında anlamlı farklar bulundu ($p<0.05$). Diğer alt parametrelerde anlamlı bir fark gözlenmedi. ($p>0.05$). Alt sırt bölgesinde halluks valgus grubunda 29 kişi, pes planus grubunda 163 kişi ve kontrol grubunda 13 kişi ağrı bildirdi ($p<0.05$).
Tartışma: Ayak deformiteleri, ayakların fonksiyonelliği ve durumu olumsuz olabilir. Ayrıca deformite varlığı çeşitli vücut bölgelerinde ağrıya yol açabilir.

Anahtar Kelimeler: Ağrı, denge, Fiziksel aktivite, Halluks valgus, Pes planus

Introduction

The foot carries body weight, lowers the gravity line on a narrow support surface, provides stability, and absorbs shocks during daily activities such as walking and running. Genetic structure, trauma, muscle weakness, ligament laxity, fall of the talar head, paralysis, high heels, and inappropriate shoe choices can cause many foot problems by disrupting foot structure and function (1).

Foot problems are common in society and can occur commonly during our daily living activities. Foot varus and valgus deformities, pes planus, pes cavus, and hallux valgus are among the most common foot problems (2). It has been stated that approximately 70-80% of the people in developed countries have several types of foot problems and complain of foot pain, and in a field study, foot pain or feeling of stiffness ranges from 18-63% (3, 4). Deformities caused by foot problems lead to loss of labor force, decreased quality of life, depression, and deterioration of mental health in young individuals (5).

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The foot, together with the ankle, knee, and hip joints, forms the lower limb kinematic chain that adjusts the body balance in an upright posture. Any change in the integrity of body biomechanics can negatively affect all body segments starting from the foot. Deformities in the arch height, flexibility, or strength of the foot impair its function and standing balance. Deformities, muscle weakness, decreased motor or sensory control, balance problems, as well as gait cycles can negatively affect the gait cycle and cause gait disturbance (6).

Physical activity (PA) levels have decreased significantly among young people, especially adolescents. Inadequate PA and sedentary behaviors are among the major lifestyle problems seen in young people in recent years (7). In a study examining the relationship between body composition, PA profile and the occurrence of knee and foot posture changes in young healthy adults, it was reported that PA level was negatively associated with knee and foot deformities (8).

Although it is known that foot problems lead to pain, balance problems, falls, physical inactivity, and difficulty walking in older ages, there are very few comprehensive studies on the youth period when the foot develops rapidly and is prone to deformity development (9, 10). This study aimed to investigate common foot problems among healthy young people studying in health departments and to determine the effects of these problems on PA, balance, and musculoskeletal pain.

Material and Method

This study is a case-control investigation conducted between October and December 2023. The research protocol received approval from the local ethics committee of Selcuk University Medical School Non-Interventional Clinical Researches Ethics Committee (approval number: 2023/483). The study adhered to the principles outlined in the Declaration of Helsinki and the guidelines of the International Council for Harmonization of Good Clinical Practice. The study included voluntary individuals aged between 18-30 years old.

In this study, the inclusion criteria were as follows: Healthy young adults between the ages of 18 and 35 were included. Participants were required to have no systemic diseases or chronic health conditions and no serious health problems that could limit PA. Individuals diagnosed with hallux valgus or pes planus were included, as well as those without any foot deformities who served as the control group. Additionally, all participants were required to provide informed consent and voluntarily agree to participate in the study. Only those who could independently perform daily activities and had no restrictions on PA were selected.

Exclusion criteria were based on participants' medical histories and health conditions. Individuals with serious orthopedic or neurological disorders that could significantly affect balance or walking ability, such as stroke or multiple sclerosis, were excluded. Similarly, participants with inflammatory or autoimmune diseases, such as rheumatoid arthritis or lupus, as well as those who were pregnant, were not included in the study. Participants who had experienced trauma or undergone surgery on the lower extremities within the past six months were also excluded. Those receiving active treatment or physical therapy for hallux valgus or pes planus deformities were not eligible for participation. Additionally, individuals with cognitive or psychiatric disorders that would prevent them from fully understanding or participating in the study were excluded.

In this study, individuals with concurrent diagnoses of both pes planus and hallux valgus were also excluded to ensure clearer differentiation between the two deformities and their respective impacts. This exclusion criterion was implemented to avoid potential confounding effects that might arise from the coexistence of these two conditions.

The demographic characteristics, PA levels, and musculoskeletal pain of all participants were assessed using a standardized form. Demographic data such as age (years), height (cm), weight (kg), body mass index (kg/m2) were recorded. Additionally, the patient was questioned whether she had any other foot problems. PA level was evaluated using the International Physical Activity Questionnaire short form (IPAQ) (11), and musculoskeletal disorders were assessed using the Extended Nordic Musculoskeletal Questionnaire (NMQ-E) (12). The Foot Function Index (FFI) (5) was used for foot function assessment. Balance assessment was performed using the single-leg standing test. The navicular drop test was conducted for pes planus evaluation. Hallux valgus was assessed using the Manchester Scale and goniometric assessment.

The Foot Function Index (FFI)

The Foot Function Index (FFI) was used to assess the foot function of the volunteers. Turkish adaptation was done by Yalıman et al (5). The FFI measures foot pain that affects a person's daily activities. Participants are asked to most accurately describe the condition of their feet over the past week and rate each question from 0 (no pain or difficulty at all) to 10 (most severe pain or too difficult to do). Participants are asked to read all the questions and mark their chosen number with an X. If right and left foot complaints are different, they are asked to write a score in separate boxes.

FFI is a 23-item scale with 3 subscales: pain, disability, and activity limitation. The pain subscale contains 9 items and measures the level of foot pain in various situations. The disability subscale contains 9 items and determines how much difficulty the person has during functional activities due to foot problems. The activity limitation subscale contains 5 items and assesses activity limitations caused by foot problems.

The Expanded Nordic Musculoskeletal Questionnaire (NMQ-E)

The Expanded Nordic Musculoskeletal Questionnaire (NMQ-E), developed by Dawson et al. (12), was used to assess musculoskeletal disorders. The NMQ-E is a self-administered questionnaire that provides reliable information on the onset, prevalence, and outcome of musculoskeletal pain in nine body regions (neck, shoulders, back, elbows, wrists/hands, lower back, hips/thighs, knees, ankles/feet). The questionnaire is a scale used to examine musculoskeletal pain and related conditions in workers and/or the general population. The NMQ-E asks yes/no questions about the presence or absence of pain, soreness, or discomfort in nine body parts at any time, in the last 12 months, in the last four weeks, and on the day of the assessment.

The International Physical Activity Questionnaire Short Form (IPAQ)

To determine the level of PA, the IPAQ, which was developed by Craig et al. (11), and the Turkish validity and reliability study conducted by Sağlam et al. were used. (13) This form can be self-administered and consists of seven questions related to activities performed in the "last seven days" to assess the level of PA. The questionnaire provides information on time spent sitting, walking, moderately vigorous activities, and vigorous activities. A score is obtained by multiplying minutes, days, and metabolic equivalent values. The Metabolic Equivalent of Task (MET) calculations of the participants were computed as follows (14);

Vigorous Activity: Number of Days × Minutes per day × 8

Moderate Activity: Number of Days × Minutes per day × 4

Walking: Number of Days × Minutes per day × 3.3

Total PA: Vigorous Activity + Moderate Activity + Walking

Balance Assessment

Single Leg Stance Assessment

During the single-leg stance test, the person is asked to stand on one leg for thirty seconds, focusing his/her eyes on a fixed point on the wall in front of him/her and keeping his/her balance. The test is performed on the right and left foot separately for eyes open and eyes closed. Each test is repeated three times and the average of the standing times of the individuals in each trial is taken and recorded. Standing times on the right and left foot are measured with a stopwatch. The test is terminated when the foot is lowered to the ground, the foot moves, or the eyes are closed during the test (15).

Assessment for Pes Planus

The arch of the foot is evaluated in both sitting and standing conditions. Feiss line (16) was used to assess arch height. It was checked whether the medial malleolus, navicular tubercle, and the head of the first metatarsal were on the same line. For the navicular drop test (17), the distance between the navicular tubercle and the ground was measured in the sitting position with no load on the foot and then the navicular-ground distance was measured bilaterally in millimeters in the bipedal standing position. The difference between loaded and unloaded conditions was considered normal if 5-9 mm, pronation if 10 mm or more, and supination if 4 mm or less.

Assessment for Hallux Valgus

Hallux valgus angle measurement is performed in three repetitions using a goniometer. The hallux valgus angle is the angle between the longitudinal plane of the proximal phalanx bone of the thumb and the longitudinal plane of the first metatarsal bone. Normal limits are usually between 5° and 15°. Angulations below 0° are considered hallux varus or adducts (18).

The Manchester Scale

The Manchester Scale, developed by Garrow (19) was used to determine the degree of hallux valgus deformity. In this scale, hallux valgus deformity is assessed with a clinical tool including photographs of the foot and classified into 4 levels: none-1, mild-2, moderate-3, severe-4. According to the scale;

• At the none-1 level, the first phalanx has a normal appearance,

• At the mild-2 level, there is minimal medial translation of the first metatarsal bone and lateral translation of the first phalanx,

• At the moderate-3 level, the translation of the first metatarsal bone is increased and the bony prominence of the distal end of the first metatarsal bone is prominent, and the first phalanx is translated under the second phalanx,

• At the severe-4 level, ossification at the distal end of the first metatarsal bone is completely prominent and the first phalanx is completely translated under the second phalanx.

The Turkish validity and reliability study of the scale was conducted in 2016 (20). According to the evaluation of the scale, those at the level of none-1 are included in the group without hallux valgus, and those with a value of 2 and above are included in the hallux valgus group.

Table 1. Demographic data of the participants

		Hallux Valgus (n=81)	Pes Planus (n=204)	Controls (n=195)	x^2	p
		(Group 1)	(Group 2)	(Group 3)		
		X±SD	X±SD	X±SD		
Age (years)		21.78±6.66	21.16±5.92	21.17±5.76	0.349	0.706
Height (cm)		165.64±8.55	165.04±8.13	166.66±8.46	1.903	0.150
Body Weight (kg)		59.63±12.06	60.56±13.71	63.10±13.89	2.617	0.074
BMI (kg/m²)		21.64±3.42	22.11±4.19	22.63±4.10	1.888	0.153
		n (%)	n (%)	n (%)		
Gender	**Female**	69 (85.19)	169 (82.84)	153 (78.46)	2.167	0.339
	Male	12 (14.81)	35 (17.16)	42 (21.54)		
Dominant Hand	**Right**	71 (87.65)	182 (89.22)	176 (90.26)	3.731	0.734
	Left	10 (12.35)	22 (10.78)	19 (9.74)		
Smoking	**Yes**	20 (24.69)	40 (19.61)	47 (24.1)	1.487	0.476
	No	61 (75.31)	164 (80.39)	148 (75.9)		

n: Number of participants, X: Mean, SD: Standard deviation, p <0,05

Statistical analysis

Statistical analysis of the study was performed using the Statistical Package for Social Sciences program for Windows, Version 22.0 (IBM, SPSS Statistics IBM Corp., Armonk, New York, USA). The normality distribution of continuous variables was examined using histogram plots, skewness and kurtosis coefficients, Shapiro-Wilk test, coefficient of variance analysis, and normal Q-Q plots without trend. The chi-square test was used to compare categorical variables. For intergroup comparisons of continuous variables, one-way ANOVA (Analysis of Variance) was used when the assumption of bivariate normal distribution was met, otherwise, the Kruskal-Wallis test was used. An overall p-value below 0.05 was considered statistically significant.

Results

The study included 81 participants with hallux valgus, 204 with pes planus, and 195 in the control group. The mean age of the participants was 21.78 ± 6.66 years in Group 1, 21.16 ± 5.92 years in Group 2, and 21.17 ± 5.76 years in Group 3. There were no statistically significant differences among the groups in terms of participants' ages (p=0.706), heights (p=0.150), weights (p=0.074), and other demographic variables (BMI (p=0.153), dominant hand (p=0.734), smoking (p=0.476)). In the hallux valgus group, there were 69 females and 12 males, in the pes planus group, there were 169 females and 35 males, and in the control group, there were 153 females and 42 males. The demographic information of the participants is summarized in Table 1.

When balance, FFI, and IPAQ scores were compared, it was concluded that the balance time of pes planus patients statistically significantly decreased compared to the control group. However, the balance time in

the group with hallux valgus statistically significantly increased compared to the control group. Significant differences were also found between the groups in FFI subheadings. The pain was significantly higher in pes planus and hallux valgus patients compared to the control group. However, the groups showed similar results in the IPAQ total score and other sub-parameters except for IPAQ severity and sitting (Table 2).

When comparing participants' body pains, significant differences were found in the groups for the lower back, hip/thigh, and ankle areas. There were no significant differences among the other sub-parameters. In the lower back region, there were 29 individuals with pain in the hallux valgus group, 163 in the pes planus group, and 13 in the control group. In the hip/thigh region, there were 15 individuals with pain in the hallux valgus group, 63 in the pes planus group, and 35 in the control

Table 2. Comparison of participants' balance, foot function, and physical activity scores

	Hallux Valgus (Group 1) X±SD	Pes planus (Group 2) X±SD	Controls (Group 3) X±SD	F, x^2	p	Groups
SLSA						
Right Eyes Open	23.14±9.99	18.81±10.36	22.45±9.61	8.778	<0.001	1.2 2.3
Left Eyes Open	22.83±9.96	19.73±10.57	21.62±9.85	3.263	0.039	1.2
Right Eyes Closed	8.68±6.88	6.67±5.40	7.82±6.60	3.585	0.028	1.2
Left Eyes Closed	8.04±6.00	5.750±5.24	7.59±6.33	6.903	0.001	1.2 2.3
FFI						
Pain Right	11.51±12.80	12.68±13.19	9.14±9.12	4.892	0.028	2.3
Pain Left	11.3±12.52	12.16±12.43	9.47±9.13	6.41	0.002	2.3
Disability Right	10.23±12.26	10.67±10.99	9.08±9.33	8.404	<0.001	1.3 2.3
Disability Left	10.19±12.43	10.44±11.36	9.29±9.18	15.727	<0.001	1.3 2.3
Activity Limitation Right	2.08±3.71	2.32±3.49	1.74±3.56	5.85	0.003	2.3
Activity Limitation Left	1.93±3.37	2.19±3.34	1.89±3.58	20.386	<0.001	1.3 2.3
Total Right	23.76±26.11	25.79±25.45	19.96±18.80	10.653	<0.001	1.3 2.3
Total Left	23.7±26.57	24.86±24.92	20.67±18.85	22.269	<0.001	1.3 2.3
IPAQ						
Vigorous	1349.14±5524.87	240.86±1160.25	893.54±3967.21	3.49	0.031	1.2
Moderate	643.70±1941.12	347.31±1157.97	395.84±1309.01	1.38	0.253	-
Walking	1698.69±2272.64	2074.47±2934.72	1885.76±2582.76	0.619	0.539	-
Sitting	316.30±411.23	230±212.16	312.67±357.01	4.142	0.016	2.3
Total	4007.83±7340.74	2892.65±4199.31	3487.81±5870.07	1.326	0.266	-

FFI: Foot Function Index, IPAQ: International Physical Activity Questionnaire, SLSA: Single Leg Stance Assessment, SD: Standart deviation, X: Mean

group. The comparison of participants' body pains is shown in Table 3.

Table 3. Body pain regions of participants according to groups

		Hallux Valgus (n=81) (Group 1)		Pes Planus (n=204) (Group 2)		Controls (n=195) (Group 3)		x^2	P
		n	%	n	%	n	%		
Neck	Yes	43	53.09	121	59.31	123	63.08	7.581	0.108
	No	38	46.91	83	40.69	72	36.92		
Shoulder	Yes	29	35.8	87	42.65	87	44.62	7.104	0.131
	No	52	64.2	117	57.35	108	55.38		
Upper Back	Yes	27	33.33	84	41.18	68	34.87	2.348	0.309
	No	54	66.67	120	58.82	127	65.13		
Elbows	Yes	2	2.47	11	5.39	16	8.21	3.581	0.167
	No	79	97.53	193	94.61	179	91.79		
Wrists Hands	Yes	13	16.05	46	22.55	39	20	1.543	0.462
	No	68	83.95	158	77.45	156	80		
Waist	Yes	29	35.8	163	79.9	13	6.67	252.975	<0.001
	No	52	64.2	41	20.1	182	93.33		
Hip Thighs	Yes	15	18.52	63	30.89	35	17.95	30.103	<0.001
	No	66	81.48	141	69.11	160	82.05		
Knee	Yes	43	53.09	81	39.71	87	44.62	4.271	0.118
	No	38	46.91	123	60.29	108	55.38		
Ankles	Yes	45	55.56	89	43.63	68	34.87	55.967	<0.001
	No	36	44.44	115	56.37	127	65.13		

n: Number of participants, x^2: Chi square test, $p < 0.05$

Discussion

When comparing groups, differences were observed in the open and closed-eye balance comparisons, with individuals in the pes planus group having the worst balance. Similarly, differences were found in the FFI comparison among groups, indicating poorer foot function in the pes planus group. In the comparison of PA (except sitting), it was concluded that groups had similar characteristics. Regarding the evaluation of body pains among groups, it was noted that participants in the pes planus group experienced more pain in the lower back, hip/thigh, and ankle regions.

Foot deformities can lead to differences in joint mobility and contact with the ground surface, which in turn can affect balance (21). In a study conducted on individuals with and without pes planus, it was observed that individuals with pes planus experienced an average decrease of 10% in balance duration with eyes open and a 20% decrease with eyes closed compared to those without pes planus (22). Studies on balance in individuals with Hallux valgus are controversial. In a study conducted by Taş et al., no change in balance parameters was observed between individuals with and without hallux valgus (23). However, Hurn et al. concluded that individuals with mild to moderate hallux valgus did not experience balance changes, whereas those with severe deformities experienced balance loss (20). In our study, it was observed that individuals with hallux valgus had better balance compared to the control group. The lack of consensus in the literature may be due to studies being conducted on different populations (20, 23). We also believe that the decrease in balance in the pes planus group may be due to the biomechanics of the foot intrinsic muscles and foot proprioception being affected by pes planus (20). The increase in balance duration in the hallux valgus group may be attributed to the population being young, having a low BMI, and exhibiting mild to moderate hallux valgus.

The impairment of foot function due to foot deformities is an inevitable consequence. In a study, it was indicated that as the severity of hallux valgus increases, foot functions are negatively affected (24). Talu et al. compared functionality with FFI scores in individuals with Hallux valgus in their study and found the highest

score in pain and the lowest score in activity limitation (25). In our study, similar to the literature, we also found the highest score in the pain subcategory of the FFI while the lowest score was observed in activity limitation. Similarly, individuals with pes planus also experience a negative impact on foot function (26). In a study conducted by Dikici et al., foot function was evaluated using the FFI. It was concluded that the FFI subparameters and total score were high in the pes planus group (27). In this study, we also observed that the FFI total score and subcategory scores of individuals with pes planus were higher compared to the control group. Additionally, similar to hallux valgus, it was found that the highest impairment was in the pain subcategory in the pes planus group. We believe that the impairment of functionality in both the hallux valgus and pes planus groups is due to disrupted foot biomechanics, which leads to pain and reduced functionality.

The pain caused by foot deformities and the resulting impairment in foot function can negatively affect individuals' physical activities. It has been noted in the literature that individuals with pes planus may struggle with activities such as prolonged standing and walking (28). In another study, it was found that individuals with pes planus experience negative effects on physical fitness parameters, with a decrease in stair climbing speed observed among individuals with pes planus (29). In this study, it was concluded that the total PA score showed similar characteristics among the groups. We believe that this may be due to the inclusion of individuals with mild to moderate hallux valgus complaints in the study and the fact that the study was conducted on young adults, who are one of the populations with the highest PA levels.

Foot deformities can lead to instability, which may result in pain not only in the foot but also in areas beyond the foot, such as the ankle, knee, or lower back. In a study, it was reported that individuals with unilateral pes planus deformity experienced pain in the thoracic region, while those with bilateral pes planus deformities had complaints of pain in the thoracolumbar and lumbar regions (30). Some researchers have also suggested that pes planus can lead to pain in the heel, knee, hip, and back (31). In another study, it was concluded that pes planus increases pelvic inclination, leading to the development of lower back pain (32). In our study, we also concluded that participants with pes planus experienced pain in the lower back, hips, and feet. The presence of pain in the lower back and hips may be attributed to changes in weight distribution and stabilization due to limitations in foot physical function and the development of pain.

This study has several limitations. Firstly, balance was not evaluated using computer-assisted devices. Similarly, foot functionality was assessed only through surveys, and specific clinical evaluation parameters were not utilized. Additionally, our study only included young adults. There is a need for studies that include populations from different age groups.

In conclusion, foot deformities can negatively affect an individual's foot functionality and balance, and may lead to pain in various parts of the body beyond the foot. Our study conducted on young adults has enabled us to conclude that these effects can be observed even in the early stages. We believe that addressing foot deformities in the early stages is crucial to preventing these effects and associated secondary complications in older age groups.

Ethics Committee Approval

Ethical approval for this study was obtained from the Selcuk University Medical School Non-Interventional Clinical Research Ethics Committee (approval number: 2023/483). All authors declared that they follow the rules of Research and Publication Ethics.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Authors' Contributions

All authors contributed to the conception, design of the study, data collection, data analysis, and assembly. The manuscript was written and approved by all authors.

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