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DYNAMIC BALANCE SKILLS IN FOOTBALLERS COMPARISON OF FOOT PRESSURE DISTRIBUTION PROFILES AND ERGONOMICS

Zeynep Inci Karadenizli

Duzce University, Faculty of Sport Sciences
incikaradenizli@duzce.edu.tr

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ABSTRACT
The aim of the study was to compare foot profiles and ergonomics determined by foot pressure distributions in dynamic balance skills in footballers. The hypothesis of the study is that soccer players with a normal curved foot profile will perform better in dynamic balance skills. Thirty-three (18 males, 15 females) volunteer university student licensed footballers (age: 19 ±1 year) participated in the study. Foot pressure distributions of the athletes were classified using the Chippaux-Smirak index. Dynamic balance skills were measured using a wireless portable balance system (Sigma System Cosmo Gamma, Italy) with 30-second scoring. For statistical comparisons, One-Way Analysis of Variance (ANOVA) was used to analyse parametric data and Kruskal Wallis-H Test was used to analyse non-parametric data. Spearman Correlation Analysis was used for correlations. As a result of the study, it was observed that there were significant differences between 3 different foot profiles in the single foot (right) dynamic balance values in favour of normal arch, low arch and high arch, respectively. In addition, in the in-group comparison of foot profiles, it was found that the outward and inward tilt percentages in the right foot dynamic balance test were significantly different in favour of the outward slope in all 3 foot profiles ($p \leq 0.05$). The fact that the significant difference in dynamic balance findings originating from the foot profile is only seen in the right foot test supports the hypothesis and is thought to originate not only from having a normal hind foot, but also from the influence of the dominant leg. It can be said that foot profiles are partially effective on dynamic balance performance and the motor strategies used by footballers during this performance.

***Keywords*:** Foot pressure distribution; Foot profiles; Dynamic balance; Ergonomics

INTRODUCTION

Balance is the state of stability that occurs when the gravity line drawn perpendicular to the ground from the body centre of gravity falls on the support area between the surfaces of the body in contact with the ground. In terms of biomechanics; as the support area expands, it requires less effort for the individual to stay in balance and maintain postural control. Balance is evaluated in two ways as dynamic and static. Static balance is the maintenance of a fixed posture without being exposed to external forces, while dynamic balance is the body's attempt to maintain the posture maintained by creating the necessary motor responses against external forces aimed at disrupting the fixed posture (Riemann and Lephart, 2002; Inal, 2004; Erkmen *et al*., 2007; Simsek and Ertan, 2011; Ricotti, 2011). The body uses three common motor strategies to maintain postural control and balance. The use of these strategies, classified as stepping, hip and ankle strategies, is determined by the amount of external or internal forces (gravity line change caused by muscular movements) that will disturb the balance (Horak, 2006). Among these strategies, the ankle strategy is activated in the perturbation of balance that occurs as a result of minimal forces generated to disrupt posture. In this process, the muscles controlling the foot-ankle segment try to keep the vertical projectin of the centre of gravity in the support area to maintain balance (Winter, 1995; Inal, 2004).

The biomechanical structure of the foot-ankle segment includes the basic parameters that determine the contact surface of the sole of the foot with the ground. Among these parameters, the medial arch configuration is the line formed by the calcaneus, navicula, 1st cuneiform and 1st metatarsal bones on the medial surface of the foot. As the concavity of the medial arch configuration relative to the ground increases (high arch), the foot ground contact surface decreases, while the contact surface increases as the concavity decreases (low arch) (Redmond *et al*., 2008). The sole of the foot or foot contact surface, which determines the boundaries of the support surface area, provides a mechanical advantage in terms of the support surface and transmits sensory inputs to the central nervous system in terms of force relations between the body and the ground with the tactile receptors it has. These sensory inputs affect the activation intensity of the leg muscles that perform the ankle strategy according to the location of the sole of the foot and the order of participation in the strategy (Kavounoudias and Roll, 1998; Riemann and Lephart, 2002; Simsek and Ertan, 2011).

Plantar pressure is defined as the pressure applied to the soles of the feet in the compression phase during the contact of the feet with the earth. Plantar pressure distributions in the foot are currently recognised as a reliable biomechanical parameter for investigating and diagnosing various foot deformities. Plantar pressure distributions can be influenced by factors such as weight, gender, foot structure and posture or gait. Sole pressure measurements performed during standing, walking or other activities provide detailed information for the assessment of diseases or abnormalities involving the ankle, knee, hip, back and other pathomechanical conditions. They also provide important information on the understanding of foot mechanical behaviour in both static and dynamic conditions (Acar and Konakoglu, 2023).

Balance skill is one of the motoric characteristics included in the performance title of physical fitness, so its measurement is used as an evaluation criterion about the individual's performance (Erkmen *et al*., 2007; Simsek and Ertan, 2011; Akin *et al*., 2017; Odemıs *et al*., 2022). In addition, weakness in balance skills is considered as one of the risk factors that predispose to sports injuries. Poor neuromuscular control, inadequate motor response and inadequate segmental stability may expose athletes to musculoskeletal injuries (Plisky *et al*., 2006; Hrysomallis, 2007).

PURPOSE OF RESEARCH

Prior to this study, it was predicted that foot profile types could have different effects on balance skills. Therefore, the aim of this study was to investigate whether soccer players with normal arched foot profiles perform better in dynamic balance skills, which are a reflection of neuromuscular activation. These findings are expected to highlight the importance of foot ergonomics in sports science and contribute significantly to balance skills and athletic performance.

METHODOLOGY

Participants & Data Sample

Participants were selected using cluster sampling. The participant group consisted of 33 volunteer athletes (18 male soccer players and 15 female futsal players) studying at the Faculty of Sports Sciences at Düzce University (age: 19 ±1 year). The athletes' dominant legs (30 right, 3 left) were determined based on their statements. The inclusion criteria for the study were that participants had no orthopedic or neurological impairments and had not received medical treatment for physical or mental illness in the past year. In this cross-sectional study designed as an experimental research, foot profiles were created for both feet of the football players, and ergonomics were determined by measuring the foot contact surface (Chippaux-Smirak Index). Separate dynamic balance scores were obtained for each foot, and statistical comparisons were made to assess whether foot profile types and ergonomics had a different effect on dynamic balance ability. Additionally, the relationships between the average body mass index (BMI) value and the dynamic balance test performed with the right and left feet alone were analyzed.

Procedures

The foot pressure distribution profiles of the participants were obtained using the Chippaux-Smirak foot profile index on the graphed foot pressure distribution images using the Footscan®7 Platform System (RSscan International, Olen, Belgium), which includes a force platform that can process data at a frequency of 300 Hz in a 0.5 m × 0.4 m area and a computer program to process the data. Dynamic balance scores were determined with a wireless portable balance system (Sigma System Cosmo Gamma, Italy). BMI was calculated using the formula (body weight / height^2).

The measurement data of the participants were taken on the same day. The study was started by first creating foot pressure distribution profiles of the participants. Different methods have been used to determine foot posture, including the classification of the height of the navicular process above the ground (Evans *et al*., 2003), the classification of the angle formed by the navicular, first metatarsal head and medial malleolus points (Vinicombe *et al*., 2001) and, as in this study, the classification based on the foot contact surface or foot pressure distribution surface. The main focus of navicular-based foot type classification methods is the functional classification of the foot as either flexible or rigid based on the arch height (Abboud, 2002). In the foot profile classification based on the foot pressure distribution surface used in this study, the basic point is the ratio of the longest sections taken transversely from the forefoot and midfoot of the foot, which are examined as 3 different sections.

For the application of the test, the participants were asked to stand motionless on the force platform in an upright position in which they felt comfortable. After standing on the platform, foot pressure distributions of the footballer participants were recorded at the moment when they were observed to be immobile. The formulation known as the Chippaux-Smirak foot index was adapted from the literature (Forriol and Pascual, 1990) as follows; the contact surface of the sole of the foot with the ground during the normal standing position of the person is detected with the device and the longest section to be taken from the forefoot or metatarsal region and the shortest section to be taken along the longitidunal arch parallel to this section are divided by the line and the result is evaluated with the index. In the index classification, if the result is between 0-0.299 including 0, it is determined as a foot with high arch, if it is between 0.3-0.39 including 0.3, it is determined as a foot with normal arch and if it is 0.4 including 0.4 and above, it is determined as a foot with low arch (Mei-Dan *et al*., 2005).

The participants' dynamic balance measurements were taken for 30 seconds with a wireless portable balance system. The participants tried to stay in a certain area they saw on the screen and maintain their balance by controlling their centre of gravity for 30 seconds. In the dynamic balance test, the amount of ankle swings to the right, left, front and back and the duration of staying in the target area were categorised as percentages by the computer program processing the data from the balance platform. The obtained percentage values were recorded for statistical analysis. Similar studies that investigated dynamic balance in this way are available in the literature (Karadenizli *et al*., 2014; Akin *et al*., 2017).

Analyses

Statistical analysis of the data was performed using IBM SPSS version 22 computer programme. One-way Analysis of Variance (ANOVA) was used between groups with parametric data and Kruskal Wallis-H Test was used between non-parametric data groups for the comparison of foot pressure distribution surface profiles in right and left single leg dynamic balance parameters. Spearman Correlation Analysis was performed for the relationships between the right and left foot dynamic balance target retention parameter and BMI values of all participants. The significance value was initially accepted as ≤ 0.05.

Ethical considerations

The study was carried out in accordance with the Declaration of Helsinki within the scope of the approval of Duzce University Non-Interventional Clinical Research

Ethics Committee with decision number 2019/35 and by obtaining a signed consent form from the participants.

RESULTS

The descriptive data findings of the research are presented in Table 1 below.

Table 1. Descriptive Data of the Participants

	Sample size (n)	Minimum	Maximum	Mean ±SD
Age (years)	33	18	24	19 ±1
Body mass (kg)	33	46	86	60 ±9
Height (cm)	33	159	182	169 ±6
BMI (kg/m²)	33	16	26	21 ±2

Abbreviations = BMI: Body mass index; SD: Standart deviation

The right foot - comparison of foot profiles and dynamic balance parameters findings of the research are presented in Table 2 below.

Table 2. Right Foot - Comparison of Foot Profiles And Dynamic Balance Parameters

Right foot	**High arch** n= 10	**Normal arch** n= 15	**Low arch** n= 8	***p***
Staying on target	53±28	74±21	57±23	***0.05**** ᶦ
Outward tilt	56±5	54±2	54±2	*0.72*ᶲ
Inward tilt	44±5	45±2	45±2	*0.72*ᶲ
Forward tilt	53±8	51±4	51±9	*0.81*ᶲ
Back tilt	46±8	48±4	48±9	*0.81*ᶲ

*****: $p \leq 0.05$ ᶦ : Kruskal Wallis-H Test statistics,
ᶲ : One-way Analysis of Variance (ANOVA) statistics

A statistically significant difference was found between the mean scores of the foot pressure distribution surface profiles in three different categories and the mean scores of the right foot on target percentages among the dynamic balance parameters ($p \leq 0.05$). No statistically significant difference was found in other balance parameters ($p > 0.05$) (Table 2).

The left foot - comparison of foot profiles and dynamic balance parameters findings of the research are presented in Table 3 below.

Table 3. Left Foot - Comparison of Foot Profiles And Dynamic Balance Parameters

Left foot	**High arch** n= 13	**Normal arch** n= 11	**Low arch** n= 9	***p***
Staying on target	66±27	75±27	75±17	*0.62*ᶦ
Inward tilt	48±4	50±4	48±3	*0.44*ᶲ
Outward tilt	51±4	49±4	52±3	*0.44*ᶲ
Forward tilt	53±5	51±6	49±3	*0.30*ᶲ
Backward tilt	46±5	48±6	50±3	*0.30*ᶲ

ᶦ : Kruskal Wallis-H Test statistics, ᶲ : One-way Analysis of Variance (ANOVA) statistics

There was no significant difference (p>0.05) between the mean scores of three different categorised foot pressure distribution surface profiles and left foot dynamic balance parameters (Table 3).

The right foot - comparison of foot profiles and dynamic balance outward and inward tilt findings of the research are presented in Table 4 below.

Table 4. Right Foot - Comparison of Foot Profiles and Dynamic Balance Outward and Inward Tilt

Right foot	**ligh arch** n= 10	**Normal arch** n= 15	**Low arch** n= 8
Outward tilt (mean ±sd)	56 ±5	54 ±2	54 ±2
Inward tilt (mean ±sd)	44 ±5	45 ±2	45 ±2
p	***0.005****	***0.00****	***0.002****

*****p≤ 0.05

In intragroup comparison, it was found that there were significant differences between the right foot pressure distribution surface profiles and right foot dynamic balance outward (lateral) and inward (medial) tilt percentages in all 3 groups (p≤0.05) (Table 4).

The left foot - comparison of foot profiles and dynamic balance outward and inward tilt findings of the research are presented in Table 5 below.

Table 5. Left Foot - Comparison of Foot Profiles and Dynamic Balance Outward and Inward Tilt

Left foot	**High arch** n= 13	**Normal arch** n= 11	**Low arch** n= 9
Inward tilt (mean ±sd)	48±4	50±4	48±3
Outward tilt (mean ±sd)	51±4	49±4	52±3
p	*0.24*	*0.81*	*0.15*

No significant difference was found between the left foot pressure distribution surface profiles and the left foot dynamic balance inward and outward tilt percentages (p>0.05) (Table 5).

The right foot - comparison of foot profiles and dynamic balance forward and backward tilt findings of the research are presented in Table 6 below.

Table 6. Right Foot - Comparison of Foot Profiles and Dynamic Balance Forward and Backward Tilt

Right foot	**High arch** n= 10	**Normal arch** n= 15	**Low arch** n= 8
Forward tilt (mean ±sd)	53±1	51±3	51±3
Backward tilt (mean ±sd)	46±8	48±4	48±9
p	*0.25*	*0.11*	*0.64*

No significant difference was found between the right foot pressure distribution surface profiles and the right foot dynamic balance forward and backward tilt percentages (p>0.05) (Table 6).

The left foot - comparison of foot profiles and dynamic balance forward and backward tilt findings of the research are presented in Table 7 below.

Table 7. Left Foot - Comparison of Foot Profiles and Dynamic Balance Forward and Backward Tilt

Left foot	**High arch** n= 13	**Normal arch** n= 11	**Low arch** n= 9
Forward tilt (mean ±sd)	53±5	51±6	49±3
Backward tilt (mean ±sd)	46±5	48±6	50±3
p	*0.32*	*0.78*	*0.10*

No significant difference was found between the left foot pressure distribution surface profiles and the left foot dynamic balance forward and backward tilt percentages within the group (p>0.05) (Table 7).

The relationships between right and left foot dynamic balance target stance parameters and BMI findings of the research are presented in Table 8 below.

Table 8. Relationships Between Right and Left Foot Dynamic Balance Target Stance Parameters and BMI

			Right foot-dynamic balance standing on the target	**Left foot-dynamic balance standing on the target**	**Body mass index**
Spearman's rho	Correlation Coefficient Sig. (2-tailed) n	Right foot-dynamic balance standing on the target	1.000 . 33	.292 .099 33	-.096 .595 33
	Correlation Coefficient Sig. (2-tailed) n	Left foot-dynamic balance standing on the target		1.000 . 33	-.029 873 33
	Correlation Coefficient Sig. (2-tailed) n	Body mass index			1.000 . 33

No significant correlation was found between body mass index and right foot and left foot dynamic balance target parameters (p>0.05) (Table 8).

DISCUSSION

The starting point of the theoretical background of the study is to find out the effectiveness of different foot biomechanical profiles formed by the foot osteo-ligamental structure and the sensory inputs formed by the tactile mechanoreceptors in the sole of the foot shaped through these profiles on the motor responses formed by the muscles controlling the foot-ankle segment. Dynamic balance skill, which is a reflection of neuromuscular activation in terms of performance, is very important for athletes (Kavounoudias and Roll, 1998; Cote *et al*., 2005; Erkmen *et al*., 2007; Simsek and Ertan, 2011). The fact that the weakness of balance skill is defined as a risk factor for sports injuries can make all kinds of parameters thought to affect this skill a subject of study (McGuine *et al*., 2000; McHugh *et al*., 2006; Hrysomallis, 2007; Faude *et al*., 2013; Materne *et al*., 2022). Foot pressure refers to the pressure or force produced when the foot makes contact with the ground. This varies across different areas of the foot (Amaro *et al*., 2025). Pressure distribution changes rapidly due to the smallest movements of the human body (Koch *et al*., 2016).

As a result of this study, which was conducted with the hypothesis that dynamic balance skill would be more effective in footballers with normal arch foot profile and this would contribute to the importance of good, healthy foot ergonomics in

sports; it was found that there were significant differences between three different foot profiles in single foot dynamic balance values. However, these differences were found to be only in the ability to balance on the target with the right foot, which was in favour of normal arch, low arch and high arch respectively ($p \leq 0.05$) (Table 2). The reason for this result is thought to be that the dominant legs of all but 3 of the 33 footballers in the study were on the right side and the normal arch foot profile provided a better dynamic balance as hypothesised. It can be said that foot profiles have a partial effect on dynamic balance performance and the motor strategies used by footballers during the performance of this performance.
In the literature, Hertel *et al*. (2002) reported that the balance skills of individuals with high arch (Pes Cavus-rigid) foot profile were weaker than other foot profiles in the measurement of single leg static balance skills of 30 healthy individuals with an average age of 22 years. Cobb *et al*. (2004) also stated that individuals with forefoot varus structure, which is a feature of the Pes Cavus foot profile, had weaker single leg static balance skills than those without this structure. Olmsted *et al*. (2004) in a study with 30 adults, reported that dynamic balance scores of individuals with Pes Cavus improved when the foot pressure distribution surfaces were increased with the help of orthosis. The results of this study support the results of our study. Because in Table 2, it is seen that the lowest scores in the dynamic balance stay-stand test with the right foot are found in high arch values compared to the other two foot profiles.
Another significant result of our study was that the outward (lateral) and inward (medial) tilt percentages during the dynamic balance test in the right foot were significantly different in favour of the outward slope in all 3 foot profiles ($p \leq 0.05$) (Table 4). In the same test, no difference was found in the inward-outward tilt values in the left foot ($p > 0.05$) (Table 5).
The purpose of choosing the foot profile classification measurement method based on the foot pressure distribution surface in our study is to establish a clearer correspondence with the theory of the study. In studies on the effectiveness of foot pressure distribution areas on foot function, it has been reported that the activation of tactile mechanoreceptors in different parts of the foot on the sole of the foot affects the activation of the leg muscles specific to the parts (Kavounoudias and Roll, 1988; Kavounoudias *et al.*, 2001). This suggests that pressure distributions or surface area ratios on the sole of the foot shape the tone of the leg muscles. For example, in the high arch foot profile defined as Pes Cavus; the maximum cross-sectional length taken from the midfoot will be smaller than the maximum cross-sectional length taken from the forefoot, indicating the density of the mechano-receptors in the forefoot. This density in the forefoot will increase the tone of the plantar flexors and the person will create a forward leaning movement during balance maintenance. Of course, this explanation can be seen as an assumption and a theoretical approach developed through studies. At this point, a question can be asked; in the evaluation to be made on the assumption mentioned, how should the desired posture be scored differently from how the desired posture is maintained? In the measurement method used in the study, the participants were asked to keep the point in a field on the screen in front of them at a certain target while standing on a digital balance board on an unstable floor, and dynamic balance scoring was

performed by the device.

During this scoring, a ratio of the participant's forward, backward, inward and outward body tendencies during balance maintenance is obtained. Therefore, comments can be made about the ankle strategy used during balance maintenance and these strategies can be evaluated from a different perspective in terms of ankle biomechanics;

The ankle and its joints are important for the transfer of body weight. These joints must be able to adapt to the slightest change in the centre of gravity in all planes. The bones and joints in the foot also adapt to unstable surfaces and have shock-absorbing properties, thus supporting the body in upright posture. Maintaining balance with economic energy consumption depends on the functions of foot and ankle ergonomics (Norkin and Levangie, 1992). For this reason, stretching exercises are mostly performed to expand the range of motion around the joint. Joint range of motion is associated with balance (Ferber *et al*., 2002; Akin *et al*., 2017). On the other hand, it has been determined by studies that as people get older, changes in foot biomechanics begin to affect balance skills more significantly.

As a result of a study comparing balance skills between adults and elderly individuals, it was reported that although there was a difference in favour of adults in single leg balance tests, there was no difference in double leg balance skills (Spink *et al*., 2011; Menz *et al*., 2011). In a study conducted with elderly individuals, it was reported that midfoot pressure ratio (mfp) was significantly higher for unilateral stance than bilateral stance in the high and normal arch foot groups. In the pes planus foot group, no significant difference was observed between the postures, so it is hypothesised that in the normal and high arch groups, the arch of the foot is deformed due to increased arch load in unilateral posture, thus changing the mfp. On the other hand, in the flat foot group, it was hypothesised that the foot arch structure decreased and foot function was weakened (Imaizumi *et al*., 2014). Rome and Brown (2004) emphasised that in 20 young people with excessive subthalar pronation (low arch - Pes Planus), a decrease in inward- outward oscillations occurred in static balance skill measurements taken after arch support was provided. In a study with U12-U19 footballers, a low correlation was found between foot morphology and postural stability, so a multifaceted programme for improvements is needed (Verbruggen *et al*., 2023). Karadenizli *et al*. (2014), in a similar study conducted with football and handball players, found that the balance values of the right foot were better than the left foot in football players in the forward-backward dynamic balance test performed with one foot.

The reason why the outward tilt was higher than the inward tilt in the dynamic balance test with the right foot in all 3 foot profiles (high arch, normal arch, low arch) found in the study (Table 5) is thought to be due to the fact that all but 3 of the 33 footballers in the study had dominant legs on the right side and they usually kicked the ball with the right foot, so the left foot was the support foot and therefore their left foot balance was better. This result partially supports the literature.

Another result of the study was that the mean body mass index (BMI) was 21 ±2 kg/m². In the literature, it was observed that the mean BMI of amateur football players with an average age of 21 years was 22.77 (Erdem *et al.*, 2015). In the literature, BMI between 18.5 and 24.9 kg/m² is considered normal in adult males.

The BMI values of university student amateur football players in our study were within the normal range (Table 1). As a result of the correlation analysis in the study, no significant correlation was found between the right and left foot, the dynamic balance target retention test and BMI values (p>0.05) (Table 7). Altuntaş *et al*. (2015) reported that there was no significant difference on the right and left side of the foot in parallel with the increase in BMI, but there was an increase in the percentage of plantar pressure on the back of the foot. In another study conducted with 44 football players with an average age of 21 years, it was reported that there was no significant relationship between dynamic balance values and BMI (Erdem *et al*., 2015). The findings in our study are similar to the literature.

Mechanoreceptors on the sole of the foot have been found to have a reflex relationship with the muscles around the ankle. Stimulation of plantar cutaneous afferents in the heel causes reflex contraction in the soleus muscle and it is suggested that this may play a role in controlling balance (Sayenko *et al*., 2007). In normal standing posture, many hypotheses have been put forward regarding the control of feedback and feedforward mechanisms. It is stated that ankle stabilisation in stance is primarily controlled by the feedforward mechanism. Other hypotheses state that proprioceptive afferents from the muscles are important throughout the stance posture (Loram and Lakie, 2002). A classification system for foot arch type has been developed using foot pressure distribution data, which has shown high reliability. However, the effect of foot load changes on foot arch assessment remains unclear (Imaizumi *et al*., 2014). Full pressure distribution and full plantar contact are very important in situations such as posture analysis or balance studies. A larger contact area allows for a wider distribution of pressure (Orlin and McPoil, 2000). In biomechanical analyses, measurement devices such as those used in this study provide detailed information about plantar pressure distribution in sports such as soccer, which involve a lot of running and jumping movements (Elstub *et al.*, 2022). The maximum pressure position makes it possible to adjust the athlete's movement, reduce the risk of injury, and improve performance (Orendurff *et al*., 2007; Mann *et al.*, 2016). However, there is still no consensus on this issue in the literature. It is thought that the present study will contribute to these discussions. For example, studies indicate that programs incorporating balance training, such as FIFA 11+, significantly improve balance scores, particularly in sports that focus on the lower extremities (Daneshjoo, *et al.*, 2012; Onofrei and Amaricai, 2022). Another study emphasizes that incorporating sport-specific and core region balance exercises into training programs increases postural stability, back muscle strength, and endurance (Zemková and Zapletalová, 2022). Additionally, while the ankle is the most important determinant of the magnitude of body sway, it is also noted in another study that the trunk is the second most important factor during certain postural tasks (Duchene *et al*., 2021).

The limitations of this study are its cross-sectional design, the fact that participants were only soccer players, and the evaluation of dynamic balance performance using a single method.

CONCLUSION

It was determined that the foot profiles of the university students amateur football players who participated in the study partially affected foot ergonomics, dynamic balance performance and the motor strategies used by the athletes while performing this performance. This result supports the hypothesis in the study. In addition, it can be said that the reason why the normal arch values were better only in the right foot compared to the others in the evaluation of whether there were differences between the foot profiles in the single foot-dynamic balance test was not only due to the foot profile but also due to the effect of the dominant leg. On the other hand, it is thought that the reason for the findings that were not significant as a result of statistical analyses may have arisen due to the competent motor strategy performances of football players. Because it should not be forgotten that the central nervous system is a system and some functions are affected by many variables and their positive contributions are related to each other. It is believed that the motor power and coordination skills of the muscles controlling the ankle are related, and therefore it is assumed that the results of this study could serve as a resource for new studies.

In sports that involve physical activities requiring intense balance performance, athletes' balance performance and kinematic motor strategies can be evaluated through observations that take into account their foot posture and ergonomics. Thus, practical ideas for motor compensation strategies specific to foot pressure distribution profiles, as in the hypothesis of this study, may emerge. Furthermore, beyond the limitations of this study, if the proposed hypothesis is tested using different study designs, for example, on individuals with lower levels of physical activity, greater differences may be found between foot profiles and dynamic balance values.

REFERENCES

ABBOUD, R. (2002). Relevant foot biomechanics. *Current Orthopaedics*, 16(3): 165-179. https://doi.org/10.1054/cuor.2002.0268.

ACAR, G. & KONAKOGLU, G. (2023). Halluks Valgus Deformitesinde Plantar Basınc Degisimi. *Istanbul Gelisim Universitesi Saglık Bilimleri Dergisi*, 20: 714-723.

AKIN, M.; SALLAYICI, M.; KESILMIS, I. & KESILMIS, M.M. (2017). Determining the correlation between dynamic balance ability to plantar flexion and dorsi flexion range of motion in swimmers. *Turkish Clinics Journal of Sports Science*, 9(2): 71-76. http://dx.doi.org/10.5336/sportsci.2016-54131

ALTUNTAS YILMAZ, N.; ERDEO, F.; TAT, A.M. & ALP, H. (2015). Vucut kitle indeksinin ayak taban basınc dagılımına etkisi. *Adnan Menderes Universitesi Saglık Bilimleri Fakultesi Dergisi*, 1(2): 33-39.

AMARO, C.M.; PAULINO, M.F.; VALVEZ, S.; ROSEIRO, L.; CASTRO, M.A.; AMARO, A.M. (2025). Comparative Analysis of Pressure Platform and Insole Devices for Plantar Pressure Assessment. *Appl. Sci.*, 15, 7575. https://doi.org/ 10.3390/app15137575

COBB, S.C.; TIS, L.L.; JOHNSON, B.F. & HIGBIE, E.J. (2004). The effect of forefoot varus on postural stability. *Journal of Orthopaedic & Sports Physical Therapy*, 34(2): 79-85. https://doi.org/10.2519/jospt.2004.34.2.79

COTE, K.P.; BRUNET, M.E.; GANSNEDER, B.M. & SHULTZ, S.J. (2005). Effects of pronated and supinated foot postures on static and dynamic postural stability. *J Athl Train*, 40(1): 41-6.

DANESHJOO, A.; MOKHTAR, A.H.; RAHNAMA, N.; YUSOF, A. (2012). The effects of comprehensive warm-up programs on proprioception, static and dynamic balance on male soccer players. PLoS ONE, 7, e51568.

DUCHENE, Y., MORNIEUX, G., PETEL, A., PERRIN, P. P., and GAUCHARD, G. C. (2021). The trunk's contribution to postural control under challenging balance conditions. *Gait Posture*, 84, 102–107. doi: 10.1016/j.gaitpost.2020.11.020

ELSTUB, L.; GROHOWSKI, L.; WOLF, D.; OWEN, M.; NOEHREN, B.; ZELIK, K. (2022). Effect of pressure insole sampling frequency on insole measured peak force accuracy during running. *J. Biomech*., 145, 111387.

ERDEM, K.; CAGLAYAN, A.; KORKMAZ, O.Z.; BOZDOGAN, T. & OZBAR, N. (2015). Amator futbolcuların vucut kitle indeksi, denge ve ceviklik ozelliklerinin mevkilere göre degerlendirilmesi. *Uluslararası Spor, Egzersiz ve Antrenman Bilimi Dergisi*, 1(2): 95-103. https://doi.org/10.18826/ijsets.74084

ERKMEN, N.; SUVEREN, S.; GOKTEPE, S.A. & YAZICIOGLU, K. (2007). The comparison of balance performance who are in different branches. *Spormetre Physical Education and Sport Science Journal*, (3): 115-122. DOI:10.17155/spd.63957

EVANS, A.M.; COPPER, A.W.; SCHARFBILLIG, R.W.; SCUTTER, S.D. & WILLIAMS, M.T. (2003). Reliability of the foot posture index and traditional measures of foot position. *Journal of the American Podiatric Medical Association*, 93(3): 203-213. https://doi.org/10.7547/87507315-93-3-203

FAUDE, O.; RÖßLER, R. & JUNGE A. (2013). Football injuries in children and adolescent players: are there clues for prevention? *Sports Medicine* (Auckland, NZ), 43(9): 819-37.

FERBER, R.; OSTERNIG, L.R. & GRAVELLE, D. (2002). Effect of PNF stretch techniques on knee flexor muscle EMG activity in older adults. *J Electromyogr Kinesiol*, 12(5): 391-397. https://doi.org/10.1016/s1050-6411(02)00047-0

FORRIOL, F., & PASCUAL, J. (1990). Footprint analysis between three and seventeen years of age. *Foot Ankle International*, (11): 101-104. https://doi.org/10.1177/107110079001100208

HERTEL, J.; GAY, M.R. & DENEGAR, C.R. (2002). Differences in postural control during single-leg stance among healthy ındividuals with different

foot types. *Journal of Athletic Training*, 37(2): 129-132.
HORAK, F.B. (2006). Postural Orientation and Equilibrium: What do we need to know about neural control of balance to prevent falls? *Age and Ageing*, 35(2): 7-17. https://doi.org/10.1093/ageing/afl077
HRYSOMALLIS, C. (2007). Relationship between balance ability, training and sports injury risk. *Sports Medicine*, 37(6): 547-556. https://doi.org/10.2165/00007256-200737060-00007
IMAIZUMI, K.; IWAKAMI, Y. & YAMASHITA K. (2014). Effect of foot load changes on foot arch evaluation using foot pressure distribution data. *Journal of Foot and Ankle Research*, 7(Suppl 1): A114 http://www.jfootankleres.com/content/7/S1/A114
INAL, H.S. (2004). *Spor Biyomekanigi Temel Prensipler*. Ankara Nobel Akademik Publishing.
KARADENIZLI, Z.; ERKUT, O.; RAMAZANOGLU, N.; UZUN, S.; CAMLIGUNEY A.F.; BOZKURT, S.; TIRYAKI, C.; KUCUK, V. & SIRMEN, B. (2014). Comparision of dynamic and static balance in adolescents handball and soccer players. *Turkish Journal of Sport and Exercise*, 16(1): 47-54. https://doi.org/10.15314/tjse.21624
KAVOUNOUDIAS, A.; ROLL, R. & ROLL, J.P. (2001). Foot sole and ankle muscle inputs contribute jointly to human erect posture regulation. *Journal of Physiology*, 532(3): 869-878. https://doi.org/10.1111%2Fj.1469-7793.2001.0869e.x
KAVOUNOUDIAS, A.R. & ROLL, J.P. (1998). The plantar sole is a ‘dynamometric map’ for human balance control. *Neuroreport*, 9(14): 3247-3252. https://doi.org/10.1097/00001756-199810050-00021
KOCH, M.; LUNDE, L.-K.; ENST, M.; KNARDAHL, S.; VEIERSTED, K.B. (2016). Validity and reliability of pressure-measurement insoles for vertical ground reaction force assessment in field situations. *Appl. Ergon.*, 53, 44–51.
LORAM, I.D. & LAKIE, M. (2002) Direct measurement of human ankle stiffness during quiet standing: the intrinsic mechanical stiffness is insufficient for stability. *J Physiol*, 545 (Pt 3): 1041-1053.
MANN, R.; MALISOUX, L.; URHAUSEN, A.; MEIJER, K.; THEISEN, D. (2016). Plantar pressure measurements and running-related injury: A systematic review of methods and possible associations. Gait Posture, 47, 1–9.
MATERNE, O.; CHAMARI, K.; FAROOQ, A.; TABBEN, M.; WEİR, A.; HOLMICH, P.; et al. (2022). Shed ding light on incidence and burden of physeal injuries in a youth elite football academy: a 4-season prospective study. *Scand J Med Sci Sports*, 32(1): 165-76.
MCGUINE, T.A.; GREENE, J.J.; BEST, T. & LEVERSON, G. (2000). Balance as a predictor of ankle injuries in high school basketball players. *Clinical Journal of Sport Medicine*, 10(4): 239-244. https://doi.org/10.1097/00042752-200010000-00003
MCHUGH, M.P.; TYLER, T.F.; TETRO, D.T.; MULLANEY M.J. &

NICHOLAS, S. (2006). Risk factors for noncontact ankle sprains in high school athletes. *The American Journal of Sports Medicine*, 34 (3): 464-70. https://doi.org/10.1177/0363546505280427

MEI-DAN, O.; KAHN, G.; ZEEV, A.; RUBIN, A.; CONSTANTINI, N.; EVEN A.; NYSKA, M. & MANN, G. (2005). The medial longitudinal arch as a possible risk factor for ankle sprains: a prospective study in 83 female infantry recruits. *Foot Ankle International*, 26(2): 180-183. https://doi.org/10.1177/107110070502600211

MENZ, H.B.; MORRIS, M.E.; & LORD, S.R. (2005). Foot and ankle characteristics associated with impaired balance and functional ability in older people. *The Journals of Gerontology Series A Biological Sciences and Medical Sciences*, 60(12): 1546-1552. https://doi.org/10.1093/gerona/60.12.1546

NORKIN, C. & LEVANGIE, P.K. (1992). *Joint Structure and Function*. In: Robroy. L.; Martin, P.T. & Benjamin K. (Eds) (5th ed.) Chapter 10. The Hip Complex. (pp. 381-399). Philadelphia: FA Davis Company.

ODEMIS, M.; PINAR, Y.; BINGUL, B.M. & BULGAN ERCIN C. (2022). Effect of proprioceptive and strength exercises on calf muscle endurance, balance and ankle angle applied: Latin dancers. *South African Journal for Research in Sport, Physical Education and Recreation*, 44(1): 25-39.

OLMSTED, L.C. & HERTEL, J. (2004). Influence of foot type and orthotics on static and dynamic postural-control. *Journal of Sport Rehabilitation*, 13(1): 54-66. http://dx.doi.org/10.1123/jsr.13.1.54

ONOFREI, R.R.; AMARICAI, E. (2022). Postural Balance in Relation with Vision and Physical Activity in Healthy Young Adults. *Int. J. Environ. Res. Public Health*, 19, 5021.

ORENDURFF, M.S.; ROHR, E.S.; SEGAL, A.D.; MEDLEY, J.W.; GREEN, J.R.; KADEL, N.J. (2007). Regional foot pressure during running, cutting, jumping, and landing. *Am. J. Sports Med*., 36, 566–571.

ORLIN, M.N.; MCPOIL, T.G. (2000). Plantar Pressure Assessment. Phys. Ther. 2000, 80, 399–409.

PLISKY, P.J.; RAUH, M.J.; KAMINSKI, T.W. & UNDERWOOD, F.B. (2006). Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *Journal of Orthopaedic and Sports Physical Therapy*, 36(12): 911-919. https://doi.org/10.2519/jospt.2006.2244

REDMOND, A.C.; CRANE, Y.Z. & MENZ, H.B. (2008). Normative values for the foot posture index. *Journal of Foot Ankle Research*, 1(1): 6. https://doi.org/10.1186/1757-1146-1-6

RICOTTI, L. (2011). Static and dymanic balance in young athletes. *Journal of Human Sport and Exercise*, 6 (4): 616-628. http://dx.doi.org/10.4100/jhse.2011.64.05

RIEMANN, B. & LEPHART, S. (2002). The Sensorimotor System, Part II: The role of proprioception in motor control and functional joint stability. *Journal of Athletic Training*, 37(1): 80-84.

ROME, K. & BROWN C.L. (2004). Randomized clinical trial into the impact of rigid foot orthoses on balance parameters in excessively pronated feet.

Clinical Rehabilitation, 18(6): 624-630. https://doi.org/10.1191/0269215504cr767oa

SAYENKO, D.G.; VETTE, A.H.; KAMIBAYASHI, K.; NAKAJIMA, T.; AKAI, M. & NAKAZAWA, K. (2007). Facilitation of the soleus stretch reflex induced by electrical excitation of plantar cutaneous afferents located around the heel. *Neurosci Lett*, 415 (3): 294-298.

SPINK, M.J.; FOTOOHABADI, M.R.; WEE, E.; HILL, K.D.; LORD, S.R. & MENZ, H.B. (2011). Foot and ankle strength, range of motion, posture, and deformity are associated with balance and functional ability in older adults. *Archives of Physical Medicine and Rehabilitation,* 92(1): 68-75. https://doi.org/10.1016/j.apmr.2010.09.024

SIMSEK, D. & ERTAN, H. (2011). Postural kontrol ve spor: spor branslarına yonelik postural sensor-motor stratejiler ve postural salınım. *Spormetre Physical Education and Sport Science Journal*, 9(3): 81-90. https://doi.org/10.1501/Sporm_0000000203

VERBRUGGEN, F.F.; MARENČÁKOVÁ, J. & ZAHÁLKA, F. (2023). The relationship of three-dimensional foot morphology to clinical assessments and postural stability in adolescent male footballers. *Journal of Foot and Ankle Research*, 16(50): 2-14. https://doi.org/10.1186/s13047-023-00636-w

VINICOMBE, A.; RASPOVIC, A. & MENZ, H.B. (2001). Reliability of navicular displacement measurement as a clinical indicator of foot posture. *Journal of the American Podiatric Medical Association*, 91(5): 262-268. https://doi.org/10.7547/87507315-91-5-262

WINTER, D.A. (1995). Human balance and posture control during standing and walking. *Gait and Posture*, 3(4): 193-214. https://doi.org/10.1016/0966-6362(96)82849-9

ZEMKOVA, E., and ZAPLETALOVA, L. (2022). The role of neuromuscular control of postural and core stability in functional movement and athlete performance. Front. Physiol. 13:796097. doi: 10.3389/fphys.2022.796097