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Biomechanical Adaptations of Plantar Pressure and Postural Control after a Half-Marathon Run

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Abstract

The aim of this study was to analyze the acute effects of a half-marathon run on plantar pressure, the medial longitudinal arch, and postural control in recreational female runners. Twelve adult women participated in the study and were assessed before and after a 21-km run. The analyses included the navicular drop test, static and dynamic baropodometry, and stabilometry in a bipedal stance. Data were subjected to descriptive statistics, paired Student's t-test, effect size (Cohen's d), and the Kappa index to assess agreement in foot type and foot strike classifications. The results revealed a significant reduction in right navicular height during bipedal support ($P = 0.014$; $d = -1.05$), as well as an increase in maximum static plantar pressure during bipedal stance ($P = 0.024$; $d = 0.93$) and in dynamic mean pressure on the left foot ($P = 0.035$; $d = -0.85$; negative value reflects the calculation order, but the direction of change was an increase). There was low agreement in foot type classification (Kappa = 0.077; 50%) and in foot strike classification for the left (Kappa = 0.143; 41.7%) and right foot (Kappa = 0.111; 33%). Stabilometric variables showed no statistically significant changes, suggesting that static postural control was maintained after prolonged exertion. It is concluded that the 21-km run induced acute changes in plantar structure and function, impacting the medial longitudinal arch and plantar pressure distribution, without impairing static postural control.

Keywords

Running, Biomechanics, Plantar Arch, Plantar Pressure, Foot Strike, Postural Control

1. Introduction

Road running is one of the most popular physical activities worldwide, widely recognized for its benefits to cardiovascular health, weight management, and mental well-being. However, the growing number of participants has led to a proportional increase in the incidence of running-related injuries, particularly in the lower limbs, such as the knees, ankles, and feet [1]. It is estimated that between 24% and 65% of runners experience some form of injury, often associated with poor biomechanics, muscular fatigue, or repetitive overload. These injuries include plantar fasciitis, medial tibial stress syndrome, and Achilles tendinopathy, and are commonly influenced by factors such as plantar pressure distribution and the function of the medial longitudinal arch (MLA) [2]-[5].

The navicular drop test is widely used to assess changes in the medial longitudinal arch and serves as a direct indicator of the foot's dynamic functionality [6]. During running, the foot arch plays a critical role in absorbing and redistributing impact forces. Its height may temporarily decrease due to muscle fatigue, leading to increased plantar contact area and altered pressure distribution. These changes may be associated with biomechanical patterns that elevate the risk of running-related injuries [7]-[9].

Furthermore, baropodometry is a technological tool that enables precise analysis of plantar pressure distribution under both static and dynamic conditions. Studies have shown that long-distance running can induce acute alterations in plantar pressure, such as increased loading on the medial heel and forefoot—changes that are important indicators of muscular fatigue and adaptive biomechanics [3] [10] [11].

In light of the above, the present study aims to investigate the acute effects of a 21-km run (half marathon) on biomechanical variables in recreational female runners. Specifically, it seeks to analyze changes in plantar pressure distribution, medial longitudinal arch height, foot type and foot strike classification, as well as stabilometric variables. Understanding these modifications may contribute to the development of preventive and recovery strategies aimed at reducing the risk of running-related injuries.

2. Methods

2.1. Participants

The volunteers for this cross-sectional study design were amateur recreational road runners. Participants were considered eligible if they were over 18 years of age and had no history of orthopedic surgery. Potential participants were excluded if they presented with any of the following: antalgic gait, occupational or physical limitations due to a lower limb condition, were currently seeking medical treatment for a lower limb injury, or had an open wound or skin disease on the plantar region of either foot. Individuals with a significant history of lower limb trauma (fractures, surgery, or burns) or recurrent overuse injuries resulting in an asymmetric gait pattern were also excluded.

All participants were fully informed about the procedures involved in the study, and each was provided with a written informed consent form (ICF). Participation was entirely voluntary, and participants were free to withdraw from the study at any point without any consequence. After the assessments, participants were informed of their individual results. Participant identities were kept strictly confidential. All participants had at least 2 years of recreational running experience, trained between 2 and 4 times per week, and regularly participated in local races ranging from 5 km to half-marathon distances. None were competitive or elite-level athletes, which supports their classification as recreational runners.

This study was approved by the Ethics Committee of the Physical Education Department at the Federal University of Maranhão. All participants signed an Informed Consent Form in accordance with the principles outlined in the Declaration of Helsinki.

2.2. Data Collection

Assessments were conducted at the Department of Physical Education of the Federal University of Maranhão. All volunteers underwent a medical history interview and baropodometric examination.

2.3. Anamnesis

During the anamnesis, the following information was collected from the volunteers: name, age, sex, weight, height, occupation, educational level, address, and phone number. Additionally, participants were asked whether they engaged in any physical activity other than running.

2.4. Baropodometry

Plantar pressure parameters during gait and static stance were collected using a pressure platform model S-PLATE (length: 610 mm, width: 580 mm, height: 40 mm, thickness: 10 mm, active sensor area: 400 mm × 400 mm). The system is equipped with resistive sensors (sensor size: 10 mm × 10 mm), comprising 1,600 sensors, with a sampling frequency of 100 Hz and a sensor pressure range from 0.4 N to 100 N (components developed by Medicapteurs). The device does not require batteries or an external power source, as it is powered through a Universal Serial Bus (USB) port on the computer [12].

2.5. Plantar Pressure Assessment

The test was conducted in two modes: static and dynamic. For the static evaluation, a bipedal plantar pressure map was recorded. Participants were instructed to step onto the platform to become familiar with the equipment. Once properly positioned, they were asked to remain with their arms alongside the body, heels aligned, eyes facing forward, and to avoid any movement during the assessment [13]. The recording was performed once the participant maintained a stable posture without swaying for 5 seconds. The following parameters were measured:

peak and mean pressure in each foot (kPa), the load supported by each foot (kg), and the total and individual foot contact area (cm^2). (**Figure 1**)

Figure 1. Participant positioning during the examination.

During the examination, plantar force distribution is displayed in real time, allowing for the analysis of plantar load distribution throughout the assessment. If necessary, the test can be paused.

For the dynamic evaluation, the progression of the foot across the platform throughout the gait cycle was recorded. The patient was instructed to step onto the platform several times to become comfortable and accustomed to stepping correctly on the device [14]. Then, the patient was asked to walk across the platform (ensuring contact with its central area) using the left foot, and the entire process was repeated with the right foot. The high acquisition frequency (up to 100 frames per second) allows for precise analysis of plantar support progression. The default acquisition time is set to 1 second, which is the approximate time required for the patient to complete a full step across the platform. (**Figure 2**)

Figure 2. Positioning during dynamic baropodometry.

The decision was made to use barefoot measurements instead of in-shoe sensor insoles to accommodate a larger number of participants. Although in-shoe sensors may have been more advantageous for directly investigating kinetic parameters inside the running shoe during locomotion, they are affected by external factors such as the type of running shoe. Additionally, insoles may shift position within the shoe, and runners may not feel comfortable running any distance with the insole inserted [15].

Barefoot measurements may only indirectly reflect any lasting effects, but they were much easier to apply to a large group of individuals. Nevertheless, barefoot measurements are validated for assessing foot loading characteristics and are a valuable tool for detecting differences between repeated measurements.

Pre-training plantar pressure measurements were conducted before the predetermined running volume for each individual. Participants were instructed to walk barefoot over the platform at a self-selected pace. A visual target was placed at eye level to discourage looking down at the platform during gait and to standardize head and eye position. Participants were positioned so that the second step after gait initiation was recorded from heel strike to toe-off [16]. A trial was repeated if the full footprint was not captured or if the researcher deemed the participant's gait to be grossly asymmetrical.

Post-run measurements were performed at the same location, and participants were asked to return for retesting no more than 5 minutes after completing the run. The approach distance used for the pre-run measurement was recorded and reused for the post-run assessment. Once again, care was taken to ensure the recording of a trial that reflected a normal gait pattern, as much as possible for the individual.

2.6. Foot Posture and Functional Assessment

The foot posture was assessed using the Arch Index (AI), initially described by Cavanagh and Rogers [16]. Based on the image of the participant's relaxed bipedal stance peak pressure, the AI was calculated as the ratio between the area of the middle third of the plantar footprint and the total footprint area (excluding the toes), with higher values indicating a flatter foot (*i.e.*, lower arch) (**Figure 3**). AI scores have been shown to be highly correlated with measurements of navicular height [17] and medial longitudinal arch angle [18] obtained from foot radiographs. AI scores were divided into quintiles separately for men and women, and foot posture was categorized as cavus (those in the lowest 20%), normal reference group (those in the middle 60%), or planus (those in the highest 20%). The cutoff points for each category were as follows: cavus (0 - 0.171), reference group (0.172 - 0.294), and planus (0.295 - 0.491) for men, and cavus (0 - 0.157), reference group (0.158 - 0.286), and planus (0.287 - 0.486) for women.

Foot strike patterns were determined from dynamic baropodometry data by analyzing the initial contact region of the footprint. Strikes were classified as rearfoot, midfoot, or forefoot based on whether first contact occurred predominantly at the heel, midfoot, or forefoot region, respectively. This classification has been widely used in plantar pressure research (Hamzavi & Esmaeili, 2021).

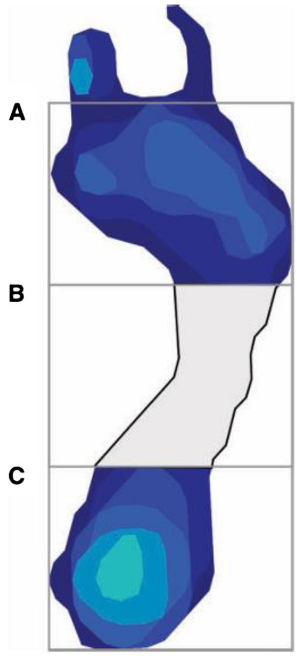

Figure 3. Arch Index (AI) calculation. The length of the static footprint, excluding the toes, is divided into three equal parts. The AI is then calculated as the area of the middle third of the footprint divided by the total footprint area (AI = B / [A + B + C]) [19].

Foot function was assessed by calculating the Center of Pressure Excursion Index (CPEI) from walking trials. The CPEI represents the degree of lateral deviation of the center of pressure in the anterior third trisect of the foot relative to a line connecting the first and last center of pressure data points (see **Figure 4**). For CPEI calculation, the peak pressure image of a dynamic footprint was divided into thirds. A reference line was drawn from the first to the last center of pressure data point. Another line (AD) was constructed at the anterior trisect of the foot's first third. The distance between the intersection of the reference line with line AD (point B) and the point where the center of pressure intersects line AD (point C) was measured. The CPEI was then calculated by normalizing distance BC to the width of the foot (AD), using the formula CPEI = (BC/DA) × 100. In a pronated foot, the concavity of the center of the pressure curve is reduced, resulting in a lower CPEI value. Conversely, in a supinated foot, the concavity of the center of the pressure curve is increased, leading to a higher CPEI value [20]. (**Figure 4**)

Similar to AI scores, CPEI scores were divided into sex-specific quintiles, and participants were categorized as having supinated foot function (top 20%), reference foot function group (middle 60%), or pronated foot function (bottom 20%). The cutoff points for each category were as follows: supinated (23.6 - 42.2), reference group (10.3 - 23.4), and pronated (−25.3 - 10.2) for men; and supinated (19.3 - 37.9), reference group (6.2 - 19.2), and pronated (−11.2 - 6.1) for women. Typical examples of cavus, normal, and planus foot postures, as well as supinated, reference, and pronated foot function categories using this classification system, are shown in **Figure 5**.

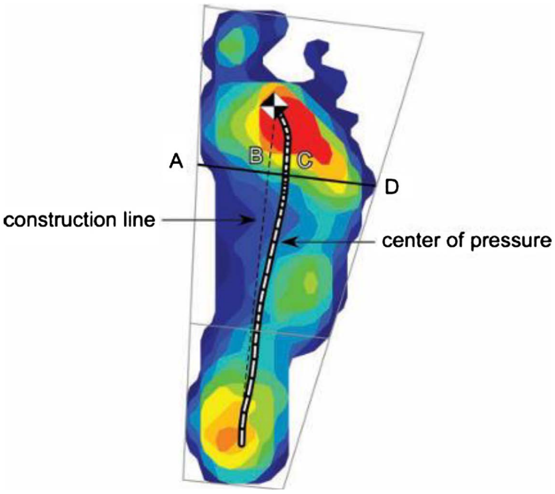

Figure 4. Calculation of the Center of Pressure Excursion Index. (CPEI)

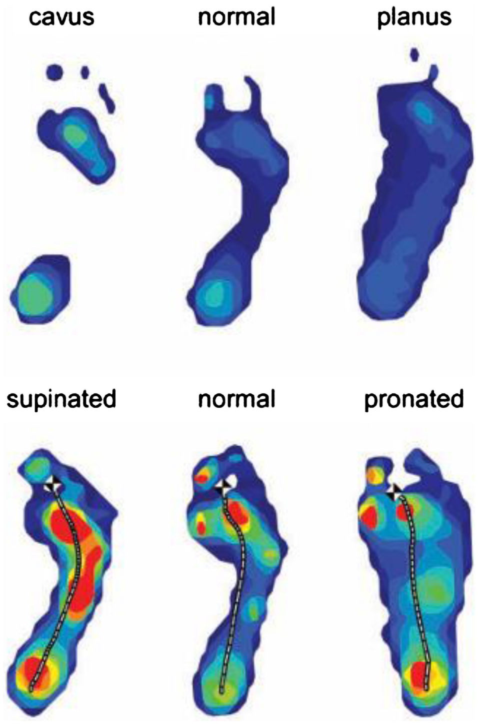

Figure 5. Typical examples of foot posture categories: cavus, normal, and planus (top panel), and foot function categories: supinated, normal, and pronated (bottom panel) [19].

The following parameters were determined for the entire foot as well as for specific areas of interest: static maximum plantar pressure, static mean plantar pressure, unilateral dynamic plantar pressure, static and dynamic plantar contact area, Arch Index, and Center of Pressure Excursion Index.

2.7. Navicular Drop Test (NDT)

With participants seated and their feet resting on the floor, the most prominent palpable region of the navicular tuberosity was marked with a small dot using a blue ballpoint pen. The subtalar joint was then placed in a neutral position using the talus palpation method [21], and the vertical distance from the navicular tuberosity marking to the floor was measured. The neutral position of the subtalar joint was defined as the point at which the examiner, while inverting and everting the participant's foot, could palpate the talus equally on both the medial and lateral sides [21]. After the initial measurement, the participant was instructed to stand in a relaxed, double-leg stance on a firm surface, allowing the foot to move out of the neutral position. The height of the navicular tuberosity relative to the floor was then measured again. The difference between the two measurements was recorded in millimeters [22]-[25].

2.8. Statistical Analysis

Data were analyzed using the R statistical package, version 4 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were initially calculated for all variables, including frequencies, means, standard deviations, minimum, and maximum values. Data normality was assessed using the Shapiro-Wilk test. To compare the values obtained before and after the 21 km run, a paired t-test for dependent samples was performed. Effect sizes were calculated using Cohen's d. Agreement between foot type and foot strike classifications before and after the run was evaluated using the unweighted Cohen's Kappa coefficient. A significance level of 5% was adopted for all tests ($P < 0.05$).

3. Results

Twelve female volunteers with a mean age of 41.42 ± 5.5 years were included in this study. As shown in **Table 1**, descriptive measurements of the anthropometric variables of the women enrolled in the study are presented. The average body weight was 58.13 ± 6.91 kilograms, the mean height was 1.62 ± 0.03 meters, and the average body mass index (BMI) was 22.6 ± 2.05 kg/m^2, indicating that most participants were within the normal weight range according to the criteria of the World Health Organization.

Table 1. Anthropometric characteristics of the evaluated sample.

Variables	Mean	±SD	minimum - maximum
Age (years)	41.2	5.55	29.0 - 48.0
Body weight (kg)	58.1	6.91	47.5 - 69.1
Height (m)	1.62	0.03	1.57 - 1.68
BMI (kg/m^2)	22.0	2.05	18.7 - 26.0

±SD = standard deviation. BMI = body mass index.

As shown in **Table 2**, the results of the agreement analysis between foot type and foot strike classifications before and after the half-marathon run were assessed using the unweighted Cohen's Kappa index. The agreement for foot type classification was 50.0%, with a Kappa value of 0.077, indicating weak and non-significant agreement (P = 0.565). The frequency of cavus feet decreased from 41.7% to 33.3%, while the frequency of planus feet increased from 0% to 8.3% after the run, suggesting a slight redistribution in morphofunctional foot typology.

For left foot strike classification, the agreement was 41.7%, with a Kappa value of 0.143 (P = 0.501), also indicating weak and statistically non-significant agreement. Supinated foot strike remained predominant at both time points (50.0%), but a decrease was observed in cases of highly supinated strike (from 25.0% to 8.3%), along with a modest increase in neutral strike (from 8.3% to 25.0%).

For the right foot, the agreement was 33.3%, with a Kappa value of 0.111 (P = 0.508), reflecting low consistency between classifications. Variation was observed among categories, notably an increase in pronated strike (from 8.3% to 25.0%) and a reduction in cases of highly supinated strike.

These results reinforce the instability in foot strike and foot type classification following prolonged exertion, suggesting that running may have influenced plantar load distribution and ground contact patterns, with no consistent maintenance of the initial postural profiles.

Table 2. Agreement analysis of foot type and foot strike classification before and after the half-marathon run in the evaluated sample.

Variable	Pre-training		DPost-training		% Agreement (Kappa)	P-value
	n	(%)	n	(%)		
Foot Type					50.0% (0.077)	0.565
Normal	7	(58.3)	7	(58.3)		
Cavus	5	(41.7)	4	(33.3)		
Planus	0	(0)	1	(8.3)		
Left Foot Strike Pattern					41.7% (0.143)	0.501
Neutral	1	(8.3)	3	(25.0)		
Supinated	6	(50.0)	6	(50.0)		
Highly Supinated	3	(25.0)	1	(8.3)		
Pronated	2	(16.7)	2	(16.7)		
Right Foot Strike Pattern					33% (0.111)	0.508
Neutral	3	(25.0)	4	(33.3)		
Supinated	5	(41.7)	3	(25.0)		
Highly Supinated	3	(25.0)	2	(16.7)		
Pronated	1	(8.3)	3	(25.0)		

P-value calculated using the unweighted Cohen's Kappa statistic.

Table 3 presents a comparative analysis of the biomechanical variables evaluated before and after the half-marathon run. Among the findings, three variables showed statistically significant differences (P < 0.05).

A significant reduction was observed in right navicular height during bipedal stance, decreasing from a mean of 4.00 ± 0.63 cm before the run to 3.48 ± 0.77 cm after the run (P = 0.014), associated with a large effect size (d = 1.05). This result suggests a drop in the medial longitudinal arch of the right foot during weight-bearing following prolonged exertion.

A significant increase in maximum plantar pressure during static bipedal stance was also observed, rising from 2169 ± 338 g/cm^2 to 2435 ± 396 g/cm^2 ($P = 0.024$; $d = 0.93$), indicating greater vertical loading on the feet after running.

Additionally, the mean dynamic plantar pressure in the left foot showed a significant increase, from 2547 ± 1355 g/cm^2 to 3596 ± 2096 g/cm^2 ($P = 0.035$), with a large effect size ($d = -0.85$), suggesting functional overload on the left lower limb during the stance phase of running.

Other variables—including navicular height in the seated position, plantar contact areas, and plantar pressures in both the right and left feet—did not show statistically significant differences. However, some demonstrated moderate effect sizes (such as static contact area in the left foot, $d = 0.61$), suggesting potential biomechanical changes that were not statistically significant but may be clinically relevant.

These findings indicate specific changes in foot mechanics following prolonged running, with evidence of arch collapse, increased static load, and asymmetric redistribution of dynamic pressure. Such alterations may reflect structural fatigue and carry important implications for injury prevention and post-run recovery strategies.

Table 3. Comparative analysis of biomechanical variables before and after the Half-marathon run.

Variables	Pre-training		Depois da corrida		Cohen's d	P-value
	Mean	±SD	Mean	±SD		
Right Navicular Height Sitting (cm)	4.70	0.78	4.17	0.89	0.74	0.05*
Right Navicular Height Bipedal (cm)	4.00	0.63	3.48	0.77	1.05	0.014*
Difference in Right Navicular Height Sitting–Bipedal (cm)	0.70	0.32	0.69	0.42	0.03	0.937
Left Navicular Height Sitting (cm)	4.71	0.56	4.47	0.76	0.49	0.183
Left Navicular Height Bipedal (cm)	4.07	0.84	3.69	0.83	0.54	0.142
Difference in Left Navicular Height Sitting–Bipedal (cm)	0.64	0.46	0.78	0.44	0.24	0.498
Maximum Static Pressure Bipedal (g/cm^2)	2169	338.19	2435.2	396.8	0.93	0.024*
Mean Static Pressure Bipedal (g/cm^2)	924.5	124.75	1042.5	160.06	−0.71	0.067
Maximum Dynamic Pressure (Left Foot) (g/cm^2)	3708.3	416.19	4045	1358.5	−0.22	0.519
Maximum Dynamic Pressure (Right Foot) (g/cm^2)	4600.5	922.84	4240.3	936.49	0.38	0.286
Mean Dynamic Pressure Left (g/cm^2)	2547.4	1355.5	3596.4	2096.0	−0.85	0.035*
Mean Dynamic Pressure Right (g/cm^2)	4600.5	922.84	4240.3	936.49	0.38	0.286
Dynamic Area (Left Foot) (cm^2)	37.89	12.16	40.0	7.92	−0.16	0.638
Dynamic Area (Right Foot) (cm^2)	54.44	11.57	45.22	11.55	0.46	0.202
Static Area (Left Foot) (cm^2)	32.0	7.12	29.78	6.91	0.61	0.107
Static Area (Right Foot) (cm^2)	29.8	8.4	30.89	10.31	0.17	0.631

±SD = standard deviation. *Statistically significant differences determined by paired t-test ($P < 0.05$).

Table 4 presents the comparative analysis of stabilometric variables before and after the half-marathon run. None of the analyzed variables showed statistically significant differences between the pre- and post-run time points (P > 0.05 for all comparisons). Cohen's d values ranged from −0.08 to 0.22, indicating negligible to small effects.

The total length of the center of pressure (COP) sway varied from 312.45 ± 88.64 mm before the run to 301.57 ± 69.72 mm after the run (P = 0.686; d = 0.12). The sway area showed a slight decrease, from 124.33 ± 96.75 mm^2 to 106.47 ± 75.31 mm^2 (P = 0.618; d = 0.15), also without statistical significance.

Other variables—such as the length-to-area ratio (L/S), mean velocity, lateral and anterior velocities, and average displacements along the X and Y axes—remained similar before and after exertion, with no relevant differences.

These results suggest that, from a stabilometric standpoint, the half-marathon run did not induce significant changes in participants' static postural control. This may indicate the presence of effective compensatory mechanisms for maintaining postural stability, even after prolonged physical exertion.

Table 4. Comparative analysis of stabilometric variables before and after the Half-marathon run.

Variables	Pre-training		Post-training		Cohen's	P-value
	Mean	±SD	Mean	±SD		
Length	312.45	88.64	301.57	69.72	0.12	0.686
Area	124.33	96.75	106.47	75.31	0.15	0.618
L/S	4.37	3.21	4.74	3.82	−0.08	0.798
Avg. Q Speed	9.54	2.72	9.16	2.15	0.14	0.644
Lateral Speed	7.58	2.33	7.04	1.79	0.22	0.463
Anterior Speed	5.71	1.82	5.78	1.57	−0.04	0.896
X Lateral	2.33	0.99	2.45	1.54	−0.06	0.83
Y Anterior	3.14	2.16	2.94	1.95	0.07	0.814

±SD = standard deviation.

4. Discussion

Previous studies have reported that asymmetry in foot posture is associated with stability during static standing (Z. Chen *et al.*, 2020) [26], and asymmetric high-arched feet exhibit unequal limb loading and shoulder height while standing (Wozniacka *et al.*, 2019) [27]. Changes in foot posture induced by long-distance running have also been demonstrated in earlier research. In contrast to the present study, Cowley and Marsden reported that foot posture shifted toward a more pronated position in the left foot only after completing a half marathon compared to pre-run assessments (Cowley & Marsden, 2013). In the current study, a greater percentage of functional change was observed in the left foot, although not specifically related to foot pronation [28].

Fukano *et al.* reported that the medial longitudinal arch decreased and dorsal foot height increased immediately after a full marathon, with foot volume increasing one day post-race [29]. The female runners in the present study exhibited a significant reduction in right navicular height in both positions and in its difference; although reductions were also noted on the left side, they were not statistically significant. A similar trend of arch height reduction has been demonstrated by Cowley & Marsden (2013) and Fukano *et al*. (2018) following long-distance runs in response to the mechanical load imposed on the feet.

This study found that arch height asymmetry ratio increased after the half marathon, while both natural arch height and the height ratio decreased after the full marathon. These findings are consistent with previous research reporting increased asymmetry and decreased plantar arch height following prolonged running. Although asymmetry in navicular height tended to increase, statistical significance was not reached on the left side; however, a moderate effect size was observed. Similar results were reported by Fukano *et al*. (2021).

The results in **Table 4** show that, despite the absence of statistically significant differences, there was a reduction in the values of some biomechanical variables post-run. This finding suggests that the runners maintained effective control of stability and plantar pressure distribution even after prolonged exertion, which may be interpreted as an indicator of good physical conditioning. Previous studies suggest that trained athletes exhibit smaller variations in center of pressure (COP) displacement and plantar pressure due to improved neuromuscular activation and proprioceptive adaptation (Paillard, 2012; Federolf *et al*., 2013) [30] [31]. Moreover, the non-significant reductions further support the hypothesis that the runners employed an efficient biomechanical strategy to minimize the effects of fatigue, avoiding postural compensations that could increase the risk of injury (Moreno-Pérez *et al*., 2021) [32].

The asymmetrical response observed in this study—namely, the reduction in right navicular height and the increase in left dynamic plantar pressure—may be explained by limb dominance and compensatory load shifting. Previous studies have shown that runners often rely on their dominant limb for propulsion, while the contralateral limb assumes a greater role in support and load absorption (Powell *et al*., 2014; Mei *et al*., 2019). Such compensatory mechanisms could account for the structural fatigue observed in the right arch and the functional overload detected on the left side.

Despite the relevance of these findings, this study has some limitations that must be considered. The small sample size (n = 12) limits the generalizability of the results, although the within-subject experimental design and use of highly sensitive biomechanical measures contribute to strong internal reliability. Additionally, external variables such as terrain type, ambient temperature, running duration, and pace were not strictly controlled, which may have influenced individual biomechanical responses. Future studies are recommended to include larger samples, stratification by running experience level, and the monitoring of environmental parameters and perceived exertion in order to deepen the understanding of the acute effects of prolonged running on foot structure and function.

5. Concclusions

It should be noted that the present study evaluated only static postural control.

While stabilometric measures did not show significant changes, dynamic postural control is more functionally relevant to running and may be affected differently. Previous research indicates that dynamic tasks impose greater demands on balance and neuromuscular coordination (Paillard, 2012), suggesting that further studies using dynamic stabilometric assessments are warranted.

The results of this study indicate that running a half marathon induces significant biomechanical changes in the feet of adult women, even in the absence of alterations in static postural control. A significant reduction in right navicular height during bipedal stance was observed, suggesting a drop in the medial longitudinal arch, possibly related to structural fatigue. In addition, there was a significant increase in maximum static plantar pressure during bipedal stance and in mean dynamic plantar pressure in the left foot, indicating greater plantar overload and potential functional asymmetry during stance.

The agreement analysis of foot type and foot strike classifications revealed low consistency between pre- and post-run assessments, with relevant shifts in the distribution of cavus and planus feet, as well as marked changes in foot strike patterns, particularly in the right foot. These findings suggest that prolonged running acutely affects plantar morphology and function. The low agreement observed in foot type and foot strike classifications highlights the acute instability of plantar mechanics after prolonged running. Such variability may represent a transient risk factor for overuse injuries, as the temporary loss of mechanical consistency can increase stress on musculoskeletal structures. These findings reinforce the need for individualized monitoring of runners, particularly during recovery after long-distance events.

On the other hand, stabilometric variables did not show significant differences, suggesting that static postural control was preserved even after prolonged exertion. This may reflect the presence of efficient compensatory mechanisms among the runners evaluated.

These findings have important implications for injury prevention, fatigue monitoring, and the planning of recovery strategies. Further studies with larger sample sizes and longitudinal designs are recommended to enhance the understanding of biomechanical and postural adaptations induced by long-distance running.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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