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Correlation between the medial longitudinal arch and foot-related quality of life in recreational runners: a cross-sectional study

Correlação entre o arco longitudinal medial e a qualidade de vida relacionada ao pé em corredores recreacionais: um estudo transversal

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ABSTRACT | BACKGROUND: The foot's anatomical structure, specifically the medial longitudinal arch (MLA), is critical in running biomechanics, as it absorbs impact forces and facilitates movement. Alterations in MLA structure can lead to abnormal foot kinematics, increasing susceptibility to injuries and negatively impacting foot functionality. **AIM:** This study aims to explore the potential impact of MLA height on recreational runners' quality of life (QoL) and determine the correlation between MLA height and foot-related QoL. **METHODOLOGY:** A cross-sectional study was conducted on 38 recreational runners aged 18-30, classified into three MLA groups (low, normal, high) using the Arch Height Index (AHI). Foot functionality and QoL were assessed using the Foot and Ankle Ability Measure (FAAM) questionnaire, including 22 items for Activities of Daily Living (ADL) and 8 for sports-related activities. **RESULTS:** Low MLA was positively correlated with higher FAAM scores in both ADL (AHI-Right = 0.79, AHI-Left = 0.71) and sports subscales (AHI-Right = 0.67, AHI-Left = 0.53; p<0.01). Conversely, high MLA showed a negative correlation with ADL (AHI-Right = -0.44, AHI-Left = -0.44) and sports subscales (AHI-Right = -0.60, AHI-Left = -0.70; p>0.05). **CONCLUSION:** MLA height is inversely correlated with QoL in recreational runners, suggesting that both high and low MLA heights may impact functional quality of life.

KEYWORDS: Running. Biomechanics. Medial Longitudinal Arch. Quality of Life. Recreational Runners.

RESUMO | INTRODUÇÃO: A estrutura anatômica do pé, especialmente o arco longitudinal medial (ALM), desempenha um papel fundamental na biomecânica da corrida, pois absorve forças de impacto e facilita o movimento. Alterações na estrutura do ALM podem levar a uma cinemática anormal do pé, aumentando a suscetibilidade a lesões e impactando negativamente a funcionalidade do pé. **OBJETIVO:** Este estudo tem como objetivo investigar o impacto potencial da altura do ALM na qualidade de vida (QV) de corredores recreacionais e determinar a correlação entre a altura do ALM e a QV relacionada ao pé. **METODOLOGIA:** Um estudo transversal foi realizado com 38 corredores recreacionais, com idades entre 18 e 30 anos, classificados em três grupos de ALM (baixo, normal, alto) com base no Índice de Altura do Arco (IAA). A funcionalidade do pé e a QV foram avaliadas usando o questionário Foot and Ankle Ability Measure (FAAM), que inclui 22 itens para Atividades da Vida Diária (AVD) e 8 itens para atividades esportivas. **RESULTADOS:** O ALM baixo apresentou uma correlação positiva com escores mais altos no FAAM tanto nas AVD (IAA-Direito = 0,79, IAA-Esquerdo = 0,71) quanto nas subescalas esportivas (IAA-Direito = 0,67, IAA-Esquerdo = 0,53; p<0,01). Por outro lado, o ALM alto mostrou uma correlação negativa com as AVD (IAA-Direito = -0,44, IAA-Esquerdo = -0,44) e as subescalas esportivas (IAA-Direito = -0,60, IAA-Esquerdo = -0,70; p>0,05). **CONCLUSÃO:** A altura do ALM está inversamente correlacionada com a QV em corredores recreacionais, sugerindo que tanto alturas elevadas quanto reduzidas do ALM podem afetar a qualidade de vida funcional.

PALAVRAS-CHAVE: Corrida. Biomecânica. Arco Longitudinal Medial. Qualidade de Vida. Corredores Recreacionais.

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1. Introduction

The foot is an anatomically complex structure that provides support, shock absorption, and stability during walking and running.[1-4] Comprised of various bones, joints, and ligaments, the foot's arches, particularly the MLA, are essential for gait efficiency and body balance during physical activities, the MLA plays a pivotal role in distributing impact forces and enhancing propulsion, which minimizes stress on the foot and ankle joints.[5-8]

Running is a popular physical activity that confers multiple health benefits, yet it has a high injury risk due to various factors, including lack of professional guidance, overuse, and abnormal foot mechanics.[9-11] Differences ignored as low (planus), normal (rectus), or high (cavus) can affect foot biomechanics, leading to variations in pronation and supination tendencies.[9-11] While low arches are generally associated with overpronation, high arches often result in excessive supination, both of which are linked to different injury patterns in runners.[12-16]

Despite the MLA's importance ignited research has addressed its correlation with foot-related QoL in recreational runners. This study aims to bridge this gap by examining the association between MLA height and QoL in recreational runners, with a focus on understanding how different MLA types might influence functional outcomes and injury risk.

2. Materials and methods

The study conducted in the Sports Complex, Haryana, India, from April 2022 to April 2023, received approval from the Institutional Ethical Committee (IEC) of the Maharishi Markandeshwar Deemed to be University (Approval Number: IEC/MMU/2020/1928). A cross-sectional study, involving 38 recreational runners (run 1 or 2 times a week for 3-4 km in a single day) aged 18-30 years (21.7, 24) with BMI values (20.6, 25.9). Participants were recruited using a purposive sampling method based on predefined eligibility criteria from Ambala City, Haryana, India (Figure 1 and Table 1). The procedure of the study was well-explained to the participants and an informed consent form was provided for reading and signing to willingly participate in the study. Data related to demographics, and questionnaire responses were collected and recorded from qualified Physiotherapists with an experience of more than 12 years (Table 2), and clinical anthropometric foot measurements were shown in Figure 2.

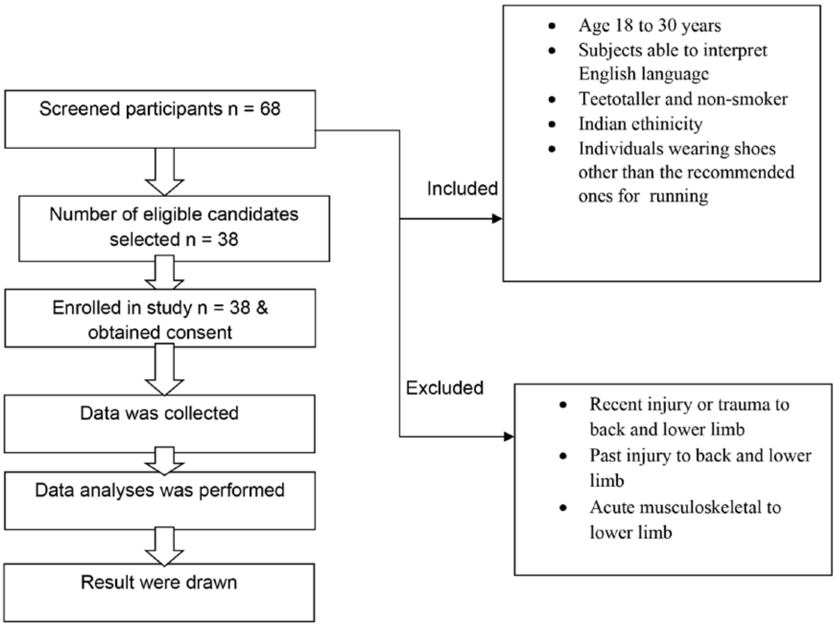
For the primary objective, the sample size calculated was 38 with an expected correlation coefficient of r = 0.5 with a level of significance of 0.05 and the power of the study set at 0.10.4 The study also carries a Universal Trial Number: U1111-1275-8995.

Table 1. Shows the eligibility criteria for participants' selection

S. No.	Inclusion criteria	Exclusion criteria
1.	Age 18 to 30 years and Male.	Recent injury or trauma to the back and lower limb
2.	Subjects able to interpret the English language	Acute musculoskeletal conditions to lower-limb
3.	Teetotaller and Non-smokers	Past history of any back or lower limb surgery
4.	Recreational runners Individuals having Indian ethnicity	
5.	Individuals wearing footwear other than the recommended ones for running	
6.	Individuals running on the concrete ground surface	

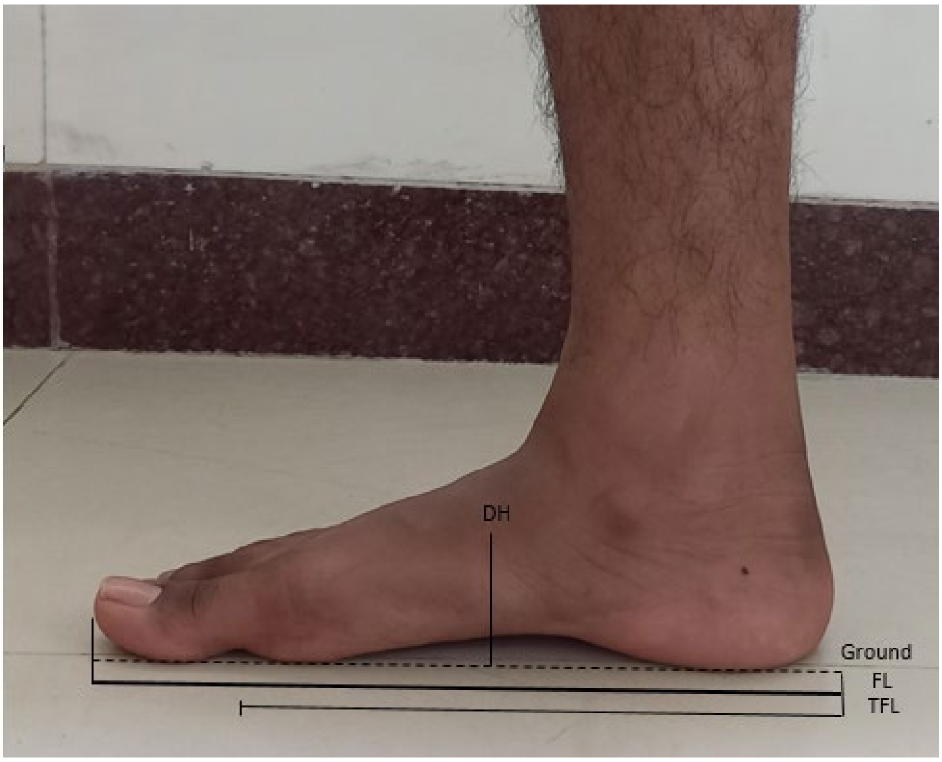
Source: the authors (2024).

Figure 1. Shows the study protocol



Source: the authors (2024).

Figure 2. Shows the Foot measurements



Source: the authors (2024).

2.1 Data measurement

The ankle Height (AH) of each participant was calculated using AHI. Following the protocol by Williams and Mcclay, the index was categorized into three groups low arch (<0.31), normal arch (0.31-0.37), and high arch (>0.37).[9,11] A self-reported questionnaire Foot and Ankle Ability Measure (FAAM) was incorporated to assess QoL.[17]

2.2 Foot length (FL)

Measurement was taken at the distance from the greater toe to the heel of the same foot, alongside the medial aspect, with the participant having equal distribution of weight on both feet. A measuring tape is used to measure the distance between the two points in centimeters. Measurements were taken for both feet.

2.3 Truncated foot length (TFL)

The measurement was taken at the distance from the center of the first head of the metatarsophalangeal joint to the posterior-most aspect of the heel, alongside the medial aspect of the foot, with the participant having equal distribution of weight on both feet. A measuring tape was used to measure the distance between the two points in centimeters. Measurements were taken for both feet.

2.4 Dorsal height (DH)

Measurement was taken from the floor to the top of the foot at 50% of the total heel-to-toe length, marked by a water-soluble pen. A sliding digital calliper was then used to measure the vertical dorsal arch height in the medial aspect. Measurements were taken for both feet.[11]

2.5 Arch height index (AHI)

AHI is calculated as the dorsum height ratio divided by the truncated foot length, where the lower arch is represented by the value that is closest to zero. AHI value was further divided into three groups (high, normal, and low).[11] AHI demonstrates validity [Intraclass Correlation Coefficient (ICC) = 0.844 with 10% of weight bearing, ICC = 0.851 with 90% of weight bearing) and reasonably high intertester reliability (ICC = 0.811 along with 10% of weight bearing, ICC = 0.848 with 90% of weight bearing].[9-11]

$$AHI = DH \text{ (at 50\% of FL)} / TFL$$

2.6 Foot and ankle ability measure (FAAM)

FAAM is a self-reported region-specific, non-disease-specific outcome instrument consisting of 21 items for Activities of Daily Living (standing, walking on even or uneven ground, walking up or down hills, going up and down on stairs, stepping up and down curbs, squatting, coming up on your toes, walking initially, walking 5 minutes or less, walking approximately 10 minutes, walking > 15 minutes, home responsibilities, ADL, personal care, light-moderate work, heavy work and recreational activities) and 8 items (running, jumping, landing, starting and stopping quickly, lateral movements, low impact activities, ability to perform the activity with your normal technique, and ability to participate in your desired sport as long as you would like) for sports subscales. Each item is scored on a 5-point Likert scale (4 to 0), from 4 signifying "no difficulty at all" to 0 signifying "unable to do". Higher scores represent a higher level of function.[17] The FAAM scale is a highly reliable, responsive and valid tool for assessing the physical functions of the lower leg, foot and ankle reliability is 0.89 and 0.87 for ADL and sports subscales.[17]

3. Statistical analysis

Data was analyzed using IBM SPSS version 20.0 on Windows 10. Descriptive statistics have been expressed in terms of median and IQR. Normality was tested using the Shapiro-Wilk test as a sample size <50. As the data did not follow a normal distribution, the study used a non-parametric test for analysis.

Statistical analyses, including the Kruskal-Wallis correlation analysis, were performed to explore relationships between AHI and FAAM subscales, which were considered p<0.05 statistically significant as shown in Tables 2 and 3.

4. Results

Table 2 presents the baseline characteristics of 38 participants aged between 18-30 years, with BMI values ranging from 18-30kg/m^2. Table 3 details the scores for DH-Right, DH-Left, AHI-Right, AHI-Left, ADL, and sports subscale across the MLA groups.

Statistical analysis revealed significant differences in BMI, as well as in DH-Right, DH-Left, AHI-Right, AHI-Left, ADL, and sports subscale scores among the MLA groups (p=<0.05) as indicated in Table 2 and 3.

Table 2. Shows the participant demographics (N=38)

S.No.	Characteristics	Total Participants Median (IQR) N = 38	Low Arch Median (IQR) N = 20	Normal Arch Median (IQR) N =13	High Arch Median (IQR) N=5	Kruskal Wallis (p-value)
1.	Age (year)	22 (21.7, 24)	22.5 (22, 23.7)	22 (21, 24.5)	24 (21, 25)	0.66
2.	Height (m)	1.72 (1.68, 1.76)	1.71 (1.68, 1.76)	1.75 (1.72, 1.8)	1.70 (1.68, 1.77)	0.13
3.	Weight (kg)	71 (62.7, 74.5)	69 (57.5, 71.7)	71 (63, 77.5)	81 (76.5, 88)	0.05
4.	[1]BMI ((kg/m2)	22.6 (20.6, 25.9)	21.7 (20.2, 24.2)	22.4 (20.7, 26)	28.8 (24.5, 30.5)	0.03

[1]BMI: Body Mass Index.
Source: the authors (2024).

Table 3. Shows the Clinical Foot Anthropometric Characteristics of Enrolled Participants (N=38)

S.No.	Characteristics	Total Participants Median (IQR) N = 38	Low Arch Median (IQR) N = 20	Normal Arch Median (IQR) N =13	High Arch Median (IQR) N=5	Kruskal Wallis (p-value)
1.	[2]FL-Right (cm)	25.7 (25.2, 26)	25.8 (25.2, 26)	25.5 (25.2, 26.3)	25.3 (24.9, 25.8)	0.45
2.	[3]TFL-Right (cm)	20.5 (20, 21)	20.5 (20.06, 21)	21 (20.05, 21)	20.6 (20.3, 20.8)	0.94
3.	[4]DH-Right (cm)	6.01 (5.42, 7.02)	5.4 (4.9, 5.9)	6.9 (6.4, 7.2)	7.9 (7.7, 7.9)	<0.001
4.	[5]AHI-Right (cm)	0.30 (0.26, 0.33)	0.26 (0.23, 0.28)	0.33 (0.31, 0.33)	0.38 (0.37, 0.38)	<0.001
5.	FL-Left (cm)	25.8 (25.2, 26.2)	25.9 (25.3, 26.4)	25.9 (20, 21.4)	25.4 (24.8, 25.8)	0.46
6.	TFL-Left (cm)	20.5 (20, 20.9)	20.5 (20.7, 21)	20.4 (20, 21.4)	20.5 (20.3, 20.8)	0.65
7.	DH-Left (cm)	6.06 (5.41, 7.03)	5.4 (5.05, 5.8)	6.9 (6.3, 7.3)	7.7 (7.7, 7.8)	<0.001
8.	AHI-Left (cm)	0.30 (0.25, 0.33)	0.26 (0.24, 0.28)	0.32 (0.32, 0.33)	0.383 (0.37, 0.38)	<0.001
9.	[6]ADL subscale (%)	94 (84.5, 98.2)	84.5 (74.3, 94)	99.08 (98.08, 99.09)	85.7 (78.01, 88.6)	<0.001
10.	Sports subscale (%)	85.9 (74.2, 96.8)	81.1 (69.4, 86.7)	97.06 (95.05, 98)	71.8 (68.5, 81.2)	<0.001

[2]FL: foot length; [3]TFL: total foot length; [4]DH: dorsal height; [5]AHI: ankle height index; [6]ADL: Activities of Daily Living.
Note: *Correlation is significant at the p < 0.05 level. The data has been represented as 'N' represents the number of participants, Median and interquartile ranges (IQR), % denotes the scores of FAAM consisting of 2 parameters Activities of Daily Living and sports subscales.
Source: the authors (2024).

Low MLA was positively correlated with ADL (AHI-Right = 0.79, AHI-Left = 0.71) and sports (AHI-Right = 0.67, AHI-Left = 0.53) subscales, with a statistical significance of p<0.01. In contrast, high MLA showed a negative, albeit non-significant, correlation with ADL (AHI-Right = -0.44, AHI-Left = -0.44) and sports subscales (AHI-Right = -0.60, AHI-Left = -0.70; p>0.05), as shown in Tables 4 and 5. These findings suggest that MLA height impacts QoL differently across groups, with low MLA associated with higher functionality scores and high MLA correlating with lower scores.

Table 4. Spearman rank correlation coefficients between ADL and sports subscale with FL & AHI (Right side)

S. No.	Variables	FL				AHI			
		Total Participants (38) r (p-value)	Low arch (20) r (p-value)	Normal arch (13) r (p-value)	High Arch (5) r (p-value)	Total participants (38) r (p-value)	Low arch (20) r (p-value)	Normal arch (13) r (p-value)	High Arch (5) r (p-value)
1.	[7]ADL subscale (%)	0.02 (0.44)	0.20 (0.19)	-0.16 (0.29)	0.22 (0.35)	0.55** (<0.01)	0.79** (<0.001)	0.49* (0.04)	-0.44 (0.22)
2.	Sports subscale (%)	0.01 (0.47)	0.04 (0.42)	-0.17 (0.28)	0.40 (0.25)	0.44** (0.003)	0.67** (0.001)	-0.02 (0.47)	-0.60 (0.14)

[7]ADL: Activities of Daily Living.
Note: **Correlation is significant at the 0.01 level (1-tailed), *Correlation is significant at the 0.05 level (1-tailed). The data has been represented as 'N' represents the number of participants, % denotes the scores of FAAM consisting of 2 parameters Activities of Daily Living and sports subscales.
Source: the authors (2024).

Table 5. Spearman rank correlation coefficients between ADL and sports subscale with FL & AHI (Left side)

S.No.		FL				AHI			
		Total Participants (38) r (p-value)	Low arch (20) r (p-value)	Normal arch (13) r (p-value)	High Arch (5) r (p-value)	Total participants (38) r (p-value)	Low arch (20) r (p-value)	Normal arch (13) r (p-value)	High Arch (5) r (p-value)
1.	[8]ADL subscale (%)	0.203 (0.11)	0.266 (0.12)	-0.06 (0.42)	0.44 (0.22)	0.465 (0.002)**	0.712** (<0.001)	0.57* (0.019)	-0.44 (0.22)
2.	Sports subscale (%)	0.15 (0.185)	0.045 (0.42)	-0.12 (0.34)	0.70 (0.94)	0.335 (0.02)*	0.53** (0.007)	0.12 (0.34)	-0.70 (0.94)

[8]ADL: Activities of Daily Living.
Note: **Correlation (r) is significant at the 0.01 level (1-tailed) *Correlation is significant at the 0.05 level (1-tailed). The data has been represented as 'N' represents the number of participants, % denotes the scores of FAAM consisting of 2 parameters Activities of Daily Living and sports subscales.
Source: the authors (2024).

5. Discussion

This study aimed to investigate the correlation between MLA height and foot-related QoL in recreational runners. The findings reveal that MLA height, particularly low MLA, is positively correlated with QoL scores in the FAAM subscales, indicating that low arches might provide certain functional advantages in daily and sports-related activities. Conversely, high MLA was associated with reduced QoL scores, reflecting potential limitations in functionality due to excessive arch height. Data concerning the relationship between the medial longitudinal arch and foot-related quality of life descended to be empirical. The average values of foot characteristics measurement in the present study were in good agreement with the values reported in previous literature.[4]

In the present study, we found AHI generally to have a significant unfavorable impact on foot-related QoL ($p<0.001$). Simultaneously, it was also interpreted that the low AHI group had a significant positive relationship with both domains of the questionnaire taken in the context of ADL and sports subscales ($p<0.05$). Therefore, we state that any alteration from normal AHI values can negatively impact the runner's foot function and QoL in the long run.

In the past, studies performed on adults, it is suggested that particularly foot and health-related QoL in general, not being affected by arch height categorized into low, normal and high feet archer heights. The sample population previously taken did not show any considerable statistically significant difference ($p > 0.05$) among all domains of foot health-related quality of life. On the contrary, a study conducted among children between the 6 to 12 years showed groups with high, low and normal arch recording lower scores in section one for the general foot health and footwear domains and higher scores in foot pain and foot function. In the other domain, there were low scores in general health and higher scores in physical activity, social capacity and vigour. A comparison of the scores obtained unveiled that arch height negatively influences foot-related quality of life and previous studies were also supporting our results.[1,16] Another study suggested functionality and quality of life among patients with flatfoot accounting to be lower than those having normal arched feet and also concluded that these effects are retained after adjusting for age, sex and comorbidities using the foot function index and foot and health status questionnaire.[18]

Ribeiro et al. conducted a study to compare rare foot alignment and MLA during static positions in runners with and without a history and symptoms of plantar fasciitis and they found that increased arches lead to greater strain on plantar fascia in runners due to the repetitive ground and foot contact. To an extent, it results in microtraumas and further progresses to the occurrence of plantar fasciitis.[19] Several studies are determining the association between MLA height and knee and ankle injuries among professional runners, where it was concluded that having a lower or higher than a normal MLA is not a definite risk factor for sports-related injuries.[2] Results of the present study bring forth the summation that having a higher or a lower arch than normal is not a decisive or definite risk factor for injuries related to the sports arena.

Extremes of high and low arch height have been reported in association with a higher risk of various lower extremity injuries than a medium arch. Another study proceeded to categorize the arch height of 40 recreational and team runners into high and low-arch groups, consequently revealing high-arch individuals pose more foot and ankle injuries, while low-arch-height individuals had more soft tissue and knee injuries.[10] However, our results can partially prove the assumption made at first and the fact it is relentlessly conflicted in literature. In the present study, we found that the FAAM questionnaire with a high arch and normal arch individuals showed non-significant connections, while significant associations were seen in low arch participants on both the right and left sides.

Previous literature reviews and studies report that MLA with non-symptomatic, plantar pressure, foot arch height, children and alterations in the medial longitudinal arch leads to health-related issues.[16,20-22] which supports the results of our study.

Furthermore, further research should consider our limitations, the inclusion of only male recreational runners reduces the homogeneity and lastly, an unequal number of participants demonstrated in the categorized groups. The relationship between lower extremity injuries and height of MLA was inquired in several other aspects such as regions and type of injuries. A decrease or increase in arch height is discovered to be an eventual risk factor for injuries of the lower extremities.

6. Conclusion

The present study highlights a significant correlation between MLA height and foot-related QoL in recreational runners. Low MLA was associated with better functional scores, suggesting potential advantages in terms of daily living and sports activities. In contrast, high MLA was linked to reduced QoL scores, reflecting limitations in functionality. These findings underscore the importance of foot morphology in recreational runners and suggest the need for targeted interventions to optimize foot health. Future research should employ longitudinal designs to assess causality and further explore the impact of MLA height on foot-related QoL.

Authors contributions

The authors declared that they have made substancial contributions to the work in terms of the conception or design of the research; the acquisition, analysis or interpretation of data for the work; and the writing or critical review for relevant intellectual content. All authors approved the final version to be published and agreed to take public responsability for all aspects of the study.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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