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Influence of skin hydration level on the occurrence of blisters on the foot during hiking

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Abstract

Friction blisters are common among outdoor enthusiasts, yet their causes remain uncertain. This study aimed to compare foot hydration in long-distance hikers with and without blisters, and to assess variability based on age and sex. An observational case–control study involving 86 hikers was conducted. Skin hydration was measured using a corneometer on various foot zones. Data on blister count, footwear, sex, age, and temperature were recorded. The most hydrated zones were the digital area, forefoot, and heel. Higher hydration was found in the blister group (61.6%) compared to the control group (38.4%). A significant relationship between hydration and blisters was observed in the left foot ($p = 0.032$). Total foot hydration was higher in women ($p = 0.007$) and inversely related to age ($r = -0.333$; $p = 0.002$). Hydration values above 30.40 a.u. in the right foot and 27.37 a.u. in the left foot were linked to blisters with 80% sensitivity. This study highlights the variability in foot hydration and its relationship with blisters. The influence of age and wet socks underscores the complexity of blister formation, emphasizing the need for future research on effective prevention.

KEYWORDS

blister, foot, friction, skin, skin physiological phenomena

Key Messages

- The objective of this study was to compare foot skin hydration levels in long-distance hikers with and without blisters to understand the relationship between skin hydration and blister formation.
- An observational case–control study was conducted with 86 hikers. Skin hydration levels were measured using a corneometer on various foot zones.

Data on blister count, footwear type, gender, age, and ambient temperature were recorded.

- The study identifies that higher levels of foot skin hydration are associated with a greater incidence of blisters, particularly in areas like the digital region. This finding highlights the importance of monitoring foot hydration levels to prevent blisters, suggesting practical applications such as the use of devices by hikers and outdoor enthusiasts to manage and control foot moisture.
- The study reveals significant differences in foot hydration based on sex and age, with women and younger individuals showing higher hydration levels. This underscores the need for customized blister prevention strategies, such as recommending moisture-wicking socks and breathable footwear specifically tailored for these groups to reduce the risk of blister formation.
- The research provides specific hydration thresholds (30.40 a.u. for the right foot and 27.37 a.u. for the left foot) that are linked to an 80% sensitivity for blister development. These thresholds can be used to develop practical guidelines to assess the risk of blisters.

1 | INTRODUCTION

Friction blisters on the foot represent a highly common injury among hikers.[1–3] Their prevalence ranges from 16% to 76% among runners and from 29% to 95% among hikers, underscoring the widespread impact of this issue.[4,5] At times posing a significant challenge that hinders the completion of a journey.

Blisters form as a result of abrasion caused by friction forces directly applied to the upper epidermis,[6] transmitted from the granular layer to the spinous layer, causing micro-tears between different layers of the skin.[7] Identified risk factors include excess moisture,[8,9] temperature,[7,9] heavy load-bearing,[2,10] activity duration,[11] inappropriate footwear,[9,11,12] and socks,[13] as well as inadequate adaptation and conditioning to the undertaken route.[7,9,11]

Despite the lack of widespread consensus on effective preventive strategies,[14,15] the overarching goal is to reduce the coefficient of friction, pressure, and force application frequency. Recommended preventive measures include using specific sock fibres, multiple layers of socks, barriers such as tapes and dressings, antiperspirants, lubricants, and/or orthopaedic devices.[15]

However, despite various published studies, friction blisters remain a common and debilitating injury among individuals engaging in outdoor activities,[16] occurring across different sports,[17] and in people of all ages.

Skin hydration significantly influences the physiology of these dermal injuries. Several studies suggest that increased hydration of the stratum corneum alters the mechanical properties of the skin, leading to increased tissue flexibility and enhanced shear stresses between the epidermis and dermis, predisposing to friction blister formation.[18] Additionally, when the skin is exposed to a humid environment, corneocytes absorb significant amounts of water,[19,20] resulting in skin swelling, which could further promote blister formation.

Previous publications emphasize the importance of understanding hydration levels in managing certain dermatological conditions such as eczema.[21] The aim of this study was to compare foot hydration levels in long-distance hikers who developed blisters during the trek versus those who did not, to determine the relationship between hydration levels and the presence of injury. The study also aimed to establish hydration differences in various foot locations (digital area, forefoot, and hindfoot), assess variability based on age and gender, and determine the optimal skin hydration range to prevent blister formation during hiking.

2 | MATERIALS AND METHODS

2.1 | Study design

An observational case–control study conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Participants were recruited in September 2023. This study received approval from the Ethics Committee (Code: DCC.ECL.230531).

2.2 | Participants

Study participants were adult pilgrims staying at the San Nicolás de Flüe hostel (Ponferrada-León) while

undertaking the Camino de Santiago Frances in the province of León. Consecutive convenience sampling was employed. Inclusion criteria for both groups were being at least 18 years old, having walked at least 20 km in the last 2 days, arriving at the hostel with closed footwear, being available for examination upon arrival, and providing consent to participate. For the control group, an additional criterion was the absence of blister injuries on either foot, while for the case group, the inclusion criterion was the presence of at least one blister injury on the foot.

Exclusion criteria included pilgrims who had undergone lower limb surgical treatment or experienced musculoskeletal injuries in the 6 months preceding the pilgrimage.

Once confirmed as eligible for the study (in the case or control group), participants underwent an examination conducted by two experienced podiatrists specializing in dermal injuries. All study participants were informed of the study objectives. Data collection was anonymous, and ethical principles outlined in the Declaration of Helsinki were strictly adhered to.

2.3 | Outcome measurements

Sociodemographic and clinical data were collected during the clinical interview. Recorded information included the distance travelled, number of days walked, and daily maximum and minimum temperatures, obtained through the records of the Spanish Meteorological Agency (AEMET). Podiatric history, prior physical training, use of topical treatments for sweating, daily application of moisturizing creams, whether socks were wet at the end of the stage, whether they were changed during the walk, and the use of used or new footwear (less than 10 wearings) were also noted. Additionally, the type of footwear used for walking, the presence of waterproofing systems, the use of custom insoles, and/or walking poles were assessed.

All blister injuries on the feet were recorded, specifying their location on the toes, metatarsal area of the forefoot, or heel area. The number of blisters on each foot was also counted.

To assess skin surface hydration, a non-invasive instrument, the Corneometer CM 825® (Courage + Khazaka electronic GmbH, Cologne, Germany), a validated device[22] previously used in similar studies,[23] was employed. This measurement was taken right at the moment when hikers arrived at the hostel, immediately after they removed their footwear. Measurements were taken at eight points: the pulp of the first, third, and fifth toes; heads of the first, third, and fifth metatarsals; plantar-medial and plantar-lateral parts of the heel, considering these anatomical areas to have the highest blister prevalence.[3] Each zone was measured three times, and the average value was recorded to reduce measurement error. Furthermore, the assessment was conducted in the same order, first on the right foot and then on the left foot, for all participants to minimize bias. Subsequently, the hydration mean was calculated for each region (digital hydration, metatarsal hydration, and heel hydration) and the overall foot. If there was a blister or other injury that could interfere with the measurement of the intended anatomical zone, measurement was performed in an adjacent area.

2.4 | Statistical analysis

All statistical analyses were performed using SPSS v. 24.0 (SPSS Inc., Chicago, IL, USA). Quantitative variables were presented using means and standard deviations, while categorical variables were reported through frequencies, cross-tabulations, and descriptive analysis. Bivariate analysis was conducted using the Chi-square method for qualitative variables and the Student's *t*-test for quantitative variables.

The Kolmogorov–Smirnov test was employed to assess normality, considering a normal distribution with a *p*-value >0.01. The Mann–Whitney U test was used to examine the difference in means for independent samples. Median and maximum and minimum (range) hydration values were measured for the entire sample and in different foot zones. The Pearson correlation coefficient was used to assess the relationship between hydration levels and age.

The ROC curve was utilized to determine the hydration cutoff point beyond which there is a greater association with the presence of foot blisters, establishing sensitivity and the area under the curve.

Results were considered statistically significant when the p-value was <0.05.

3 | RESULTS

The sample consisted of 86 participants, including 52 males and 34 females, with a mean age of 36.52 ± 15.63 years. The most frequent nationalities were Spanish (17.4%), Italian (17.4%), American (17.4%), and French (8.1%). At the time of examination, participants had walked an average of 20.1 ± 17.8 days and covered a mean distance of 455.9 ± 354.5 km. The mean maximum temperature on study days was 30.02 ± 2.84 degrees, and the mean minimum temperature was 14.54 ± 1.89.

Observations revealed that 38.4% ($n = 33$) had no blister injuries on their feet (control group), while 61.6% ($n = 53$) presented some blisters on one or both feet (case group). Characteristics of both groups are detailed in Table 1. In bivariate analysis, a significant association with blister presence was observed only for age ($p = 0.013$) and having wet socks ($p = 0.009$). No significant differences were noted in sock changes during the hike ($p = 0.91$), footwear type ($p = 0.74$), waterproofing ($p = 0.49$), or footwear age ($p = 0.87$). No significant differences were observed in the presence of blisters with respect to gender (64.2% of women presented blisters compared to 35.8% of men, and 54.5% of women did not present blisters compared to 45.5% of men; $p = 0.37$). See Table 1.

In the case group ($n = 53$), blisters were located on the right foot in 44 participants and on the left foot in 36. Among the injured, 39.6% ($n = 21$) had blisters on some of the toes, with the 2nd and 5th toes being the most affected in both feet. In the plantar area of the forefoot, the first metatarsal head was the most commonly affected. In the hindfoot, blisters were more frequent in the lateral heel area. The distribution of injuries is presented in Table 2. The mean number of blisters detected on the right foot was 1.77 ± 1.45 (range: 0–5) and on the left foot was 1.51 ± 1.74 (range: 0–8).

In relation to the mean hydration of the entire group (cases and controls), it was 38.71 ± 12.45 (15.28–65.58) on the right foot and 38.35 ± 13.22 (15.48–83.40) on the left foot. When comparing foot hydration (toes, forefoot, and heel) in the case and control groups, higher hydration was observed in the case group for both the right foot (case group 41.19 ± 11.68 vs control group 36 ± 12.85; $p = 0.053$) and the left foot (case group 41.94 ± 15.48 vs control group 35.77 ± 10.77; $p = 0.032$). In both feet, greater hydration was observed in the case group compared to the control group (see Figure 1).

The zones with the highest hydration in both groups were the digital area, the forefoot, and, lastly, the heel area. The most hydrated part of the plantar surface was the tip of the third toe in both groups, contrasting with the lateral heel area, which was the least hydrated. See Table 3. A high correlation was observed between hydration values in the left and right feet ($r = 0.803$; $p = 0.000$).

Total foot plantar hydration (including toes, metatarsal area, and heel) was higher in women than in men, both on the right foot (women 40.87 ± 10.33 vs men 37.30 ± 13.57; $p = 0.017$) and the left foot (women 38.93 ± 9.69 vs men 37.97 ± 15.17; $p = 0.007$). In relation to age, a significant inverse relationship was observed between hydration and age ($r = -0.333$; $p = 0.002$), indicating that younger patients had higher hydration levels.

Finally, hydration values above 30.40 a.u. in the right foot and 27.37 a.u. in the left foot were associated with blister presence, with 80% sensitivity and an area under the ROC curve of 0.61 and 0.63, respectively (see Figure 2).

4 | DISCUSSION

One of the objectives of this study was to determine differences in skin hydration at different foot locations (digital area, forefoot, and heel) and its variability based on age and gender. The findings revealed that the areas with the highest hydration in both groups were the digital area, followed by the forefoot, and finally, the heel or hindfoot region.

In relation to gender, it was observed that women had higher hydration compared to men. These results align with a study by Hon et al., comparing skin hydration in children with and without eczema, showing higher skin hydration in girls compared to boys in both groups.[21] They also correspond with data found by Li et al. in a study conducted in the Chinese population, where women's skin was significantly more hydrated than that of men.[24] However, no significant relationship was found between gender and blister presence.

Concerning age, a significant inverse correlation was observed, indicating that younger participants had higher hydration and a higher risk of blister formation. With aging, there is a decrease in natural hygroscopic agents located within corneocytes, which maintain the skin's natural hydration.[25] Additionally, there is a deficit of urea in the stratum corneum,[26] explaining the substantial decrease in the skin's ability to retain water or maintain optimal hydration levels as age increases.

In relation to the influence of foot hydration on blister formation, higher hydration was associated with blister presence. Although a statistically significant relationship was only found in the left foot, the same trend was observed in the right foot, with values close to significance. Moreover, in the toes, which were the most hydrated areas, the highest number of injuries were found. These results suggest that excess hydration could predispose to blister formation, aligning with the proposals of Highley et al.[27] Moisture influences skin friction coefficients[28] and temperature in response to load application,[29] increasing the risk of injury. Therefore, as indicated by the study of Hashmi et al.,[30] controlling excess moisture, particularly using antiperspirant products in powder form, could provide a certain degree of protection.

Skin hydration was not homogenous on the foot. The toes had the highest hydration, similar to the study by

TABLE 1 Characteristics of the total group, group A and group B.

Characteristics		Total group $n = 86$	Presence of blister(s) (group A) $n = 53$	Absence of blisters (group B) $n = 33$	p
Gender *n* (%)	Male	52 (60.5)	34 (64.2)	18 (54.5)	0.37
	Female	34 (39.5)	19 (35.8)	15 (45.5)	
Nationality *n* (%)	Spain	15 (17.4)	10 (18.9)	5 (15.2)	0.74
	Italy	15 (17.4)	8 (15.1)	7 (21.2)	
	United States	15 (17.4)	10 (18.9)	5 (15.2)	
	France	7 (8.1)	3 (5.7)	4 (12.1)	
	Other nationality	34 (39.7)	22 (41.4)	12 (36.3)	
Age		36.52 ± 15.63	33.92 ± 15.50	40.70 ± 15.14	0.01
Mean ± SD (Range)		(16–79)	(16–79)	(22–69)	
BMI		23.50 ± 3.62	23.52 ± 3.74	23.46 ± 3.47	0.67
Mean ± SD (Range)		(16–32.40)	(16–32.40)	(17–31.50)	
Underweight (BMI < 18,5)		7 (8.1)	4 (7.5)	3 (9.1)	0.88
Normal weight (BMI 18,5-24,9)		52 (60.5)	33 (62.3)	19 (57.6)	
Overweight (BMI ≥25)		23 (26.7)	13 (24.5)	10 (30.3)	
Obesity (BMI ≥30)		4 (4.7)	3 (5.7)	1 (3)	
Walking days Mean ± SD (Range)		20.10 ± 17.86 (1–99)	19.66 ± 17.23 (2–99)	20.82 ± 19.11 (1–68)	0.75
Km walking		455.94 ± 354.46	480.26 ± 393.59	416 ± 281.87	0.50
Mean ± SD (Range)		(25.86–2700)	(53.66–2700)	(25.8–1075)	
Previous training *n* (%)	Yes	35 (40.7)	24 (45.3)	11 (33.3)	0.27
	No	51 (59.3)	29 (54.7)	22 (66.7)	
Diseases *n* (%)	Yes	13 (15.1)	8 (15.1)	5 (15.2)	0.99
	No	73 (84.9)	45 (84.9)	28 (84.8)	
Podiatric history *n* (%)	Yes	25 (29.1)	16 (30.2)	9 (27.3)	0.77
	No	61 (70.9)	37 (69.8)	24 (72.7)	
Smoking habit *n* (%)	Yes	17 (19.8)	12 (22.6)	5 (15.2)	0.39
	No	69 (80.2)	41 (77.4)	28 (84.8)	
Wet sock at the end of stage *n* (%)	Yes	54 (62.8)	39 (73.6)	15 (45.5)	0.01
	No	32 (37.2)	14 (26.4)	18 (54.5)	
Change socks during the trek *n* (%)	Yes	10 (11.6)	6 (11.3)	4 (12.1)	0.91
	No	76 (88.4)	47 (88.7)	29 (87.9)	
Hydration daily *n* (%)	Yes	39 (45.3)	25 (47.2)	14 (42.4)	0.66
	No	47 (54.7)	28 (52.8)	19 (57.6)	
Type of footwear *n* (%)	Trekking boot	17 (19.8)	10 (18.9)	7 (21.2)	0.74
	Trekking shoe	37 (43)	25 (47.2)	12 (36.4)	
	Trekking sandal	1 (1.2)	1 (1.9)	0 (0)	
	Running shoe	19 (22.1)	10 (18.9)	9 (27.3)	
	Trail running shoe	12 (14)	7 (13.2)	5 (15.2)	
Waterproof footwear *n* (%)	Yes	30 (34.9)	17 (32.1)	13 (39.4)	0.49
	No	56 (65.1)	36 (67.9)	20 (60.6)	
New footwear	Yes	40 (46.5)	25 (47.2)	15 (45.5)	0.87
(fewer than 10 uses) *n* (%)	No	46 (53.5)	28 (52.8)	18 (54.5)	

(Continues)

TABLE 1 (Continued)

Characteristics		Total group $n = 86$	Presence of blister(s) (group A) $n = 53$	Absence of blisters (group B) $n = 33$	p
Foot orthosis *n* (%)	Yes	6 (7)	50 (94.3)	3 (9.1)	0.54
	No	80 (93)	3 (5.7)	30 (90.9)	
Trekking pole *n* (%)	One	10 (11.6)	9 (17)	1 (3)	0.10
	Two	34 (39.5)	18 (34)	16 (48.5)	
	None	42 (48.8)	26 (49.1)	16 (48.5)	

Note: The variables studied (age, walking days and km walking) do not follow a normal distribution at 95% significance, according to the Kolmogorov–Smirnov test. The Mann–Whitney *U* test was used to study the difference in the means of independent samples. In all analyses, $p < 0.05$ (with a 95% confidence interval) was considered statistically significant.
Abbreviations: BMI, body mass index; SD, standard deviation.

TABLE 2 Location of blisters on the foot in group A.

Location of blisters		Group A ($n = 53$)	
		Right foot	Left foot
Toes *n* (%)	Toes 1st	3 (5.7)	5 (9.4)
	Toes 2nd	12 (22.6)	6 (11.3)
	Toes 3rd	4 (7.5)	2 (3.8)
	Toes 4th	4 (7.5)	5 (9.4)
	Toes 5th	11 (2.8)	9 (17)
Forefoot *n* (%)	Metatarsal head 1st	10 (18.9)	8 (15.1)
	Metatarsal head 2nd	3 (5.7)	2 (3.8)
	Metatarsal head 3rd	2 (3.8)	1 (1.9)
	Metatarsal head 4th	1 (1.9)	1 (1.9)
	Metatarsal head 5th	1 (1.9)	1 (1.9)
Heel *n* (%)	Plantar	1 (1.9)	0 (0)
	Medial	7 (13.2)	6 (11.3)
	Lateral	9 (17)	11 (20.8)
	Posterior	7 (13.2)	6 (11.3)

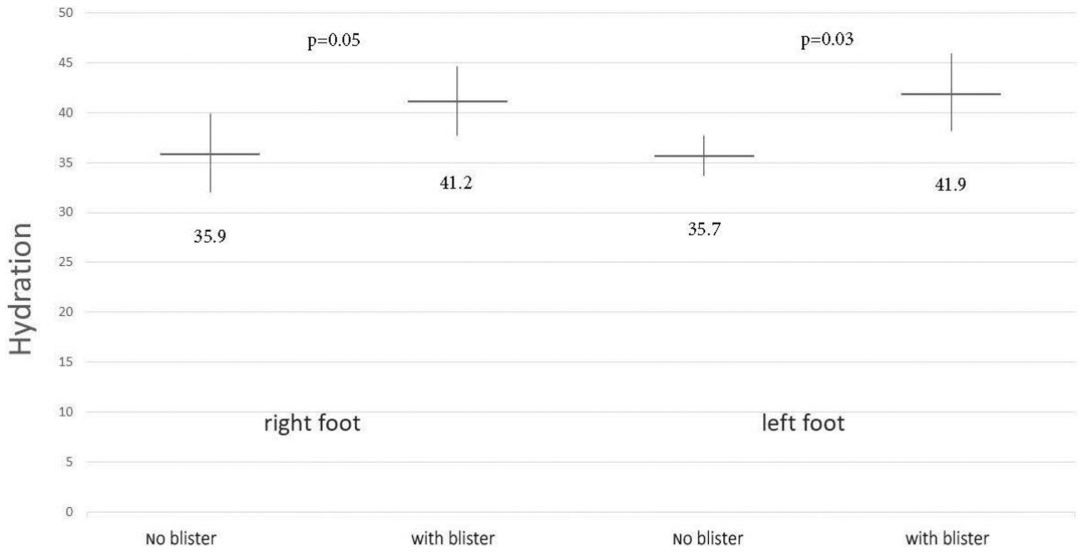

FIGURE 1 Hydration on the sole of the foot and blister formation. The *t* Student test was used to study the difference in the means of independent samples. In all analyses, $p<0.05$ (with a 95% confidence interval) was considered statistically significant.

TABLE 3 Hydration of different plantar foot areas in patients with and without blisters.

Location on the foot	Total group $n = 86$		Presence of blister(s) (group A) $n = 53$		Absence of blisters (group B) $n = 33$	
	Right foot Mean ± SD (Range)	Left foot Mean ± SD (Range)	Right foot Mean ± SD (Range)	Left foot Mean ± SD (Range)	Right foot Mean ± SD (Range)	Left foot Mean ± SD (Range)
Toes 1st	51.39 ± 19.73 (9.93–97.97)	51.94 ± 20.94 (9.40–97.67)	53.89 ± 20.43 (18.8–97.9)	51.26 ± 22.07 (14.60–97.67)	47.38 ± 18.15 (9.93–81.1)	53.05 ± 19.27 (9.40–81.23)
Toes 3rd	61.34 ± 20.72 (12.17–101.30)	60.37 ± 20.22 (16.53–100.8)	63.98 ± 19.53 (12.17–101.30)	58.69 ± 20.18 (19.87–100.8)	57.10 ± 22.16 (14.63–99.07)	63.07 ± 20.29 (16.53–96.93)
Toes 5th	50.45 ± 18.19 (14.88–86.27)	55.40 ± 17.76 (14.23–107)	50.48 ± 18.06 (14.88–86.27)	53.45 ± 18.65 (14.23–107)	50.40 ± 18.67 (16.83–84)	58.53 ± 16 (32.77–91.10)
First metatarsal head	34.78 ± 18.16 (7.13–80.7)	32.47 ± 17.5 (3.23–73.47)	36.60 ± 19.91 (7.67–80.7)	33.19 ± 18.35 (3.23–73.47)	31.87 ± 14.75 (7.13–62.37)	31.32 ± 16.25 (7.27–71.13)
Third metatarsal head	34.88 ± 19.27 (6.33–99.53)	32.16 ± 19.06 (3.10–91)	34.21 ± 18.38 (6.33–75.17)	32.38 ± 20.37 (3.10–91)	35.94 ± 20.85 (10–99.53)	31.82 ± 17.03 (6.57–73.73)
Fifth metatarsal head	27.87 ± 13.98 (3.93–73.47)	27.59 ± 14.77 (2.40–82.8)	30 ± 14.95 (3.93–59.63)	28.78 ± 16.16 (2.40–82.8)	24.45 ± 11.67 (5.10–60.73)	25.68 ± 12.21 (4.15–57.70)
Medial plantar heel area	30.44 ± 14.81 (5.57–66.67)	28.45 ± 16.81 (5.87–92.97)	33.15 ± 15.28 (6.73–63.13)	31.11 ± 17.95 (6.87–92.97)	26.09 ± 13.11 (5.57–66.67)	24.18 ± 14.04 (5.87–65.2)
Lateral plantar heel area	27.14 ± 16.38 (5.67–94.10)	28.55 ± 17.30 (5.10–86.97)	29.41 ± 17.63 (6.97–94.10)	32.28 ± 17.28 (5.10–86.97)	23.50 ± 13.60 (5.67–73.9)	22.56 ± 15.81 (5.87–83.30)

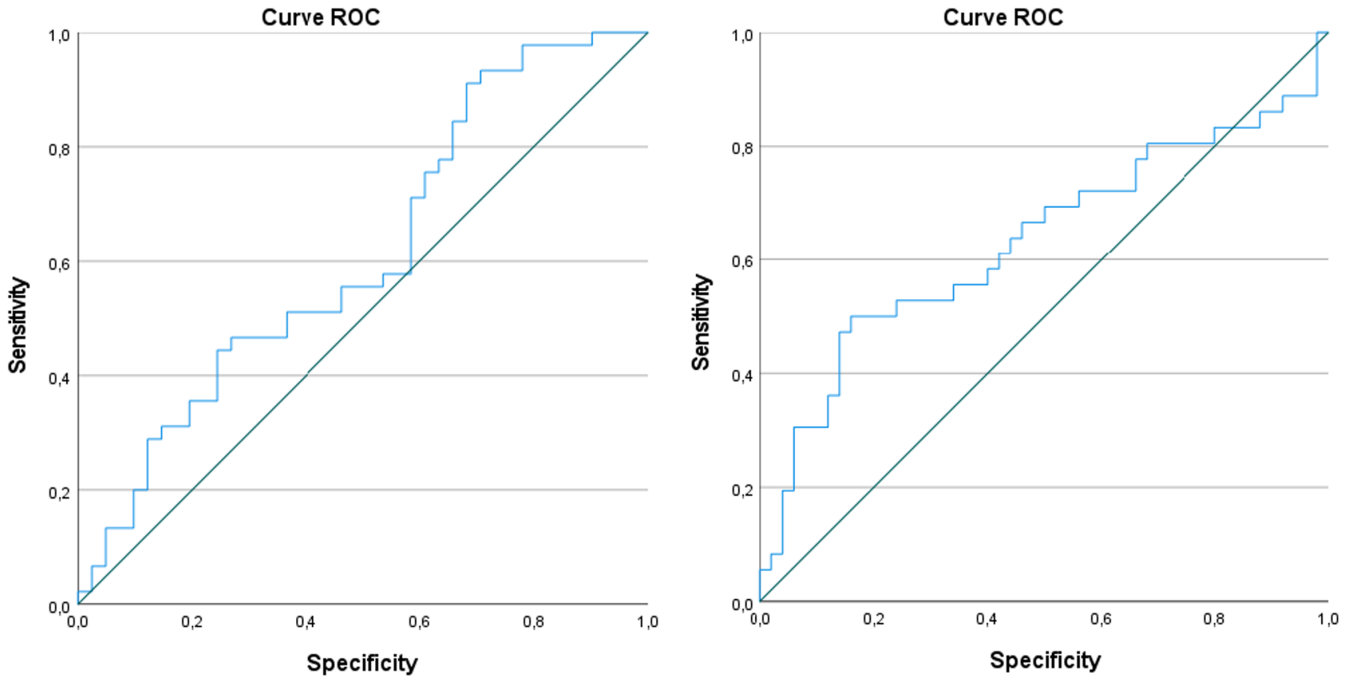

FIGURE 2 ROC Curve for right and left feet. Prediction of blister formation based on hydration level.

Cortes et al.[31] In our study, a slightly higher hydration was observed in the right foot compared to the left foot, although this difference was not significant. This could be due to the hydration being measured first in the right foot, which may have allowed the skin of the left foot more time to acclimate. However, the study by Cortes et al. detected higher hydration in the left foot.

In relation to blister location in the study sample, it was more frequent on the 2nd and 5th toes in both feet. In the forefoot plantar area, the first metatarsal head was the most affected in both feet. In the hindfoot, blisters were more frequently located in the lateral heel area. These results align with the study by Chicharro-Luna et al.,[3] which determined that the most common locations were the heads of the first or second metatarsal and the fifth toe. Chicharro-Luna et al. also associated having wet socks at the end of the journey as a risk factor, which is also related to the obtained results.

Finally, it was observed that hydration values above 30.40 a.u. in the right foot and 27.37 a.u. in the left foot were associated with blister presence with 80% sensitivity. However, it is important to note that this hydration corresponds to the level present in the foot immediately after removing the footwear, which reflects the condition of the hiker's foot while walking with the shoe on, rather than the physiological water content of the participant's skin.

The study reveals that higher levels of foot skin hydration are associated with a greater incidence of blisters, especially in areas such as the digital region. This suggests the need for monitoring hydration to prevent them. Additionally, the variation in foot hydration according to sex and age indicates the necessity for personalized care strategies. For instance, women and younger individuals, who tend to have higher foot hydration, could benefit from the use of moisture-wicking socks and footwear that allows for better breathability.

Among the study limitations, it is an observational cross-sectional study. Hydration measurements were taken at the end of the journey, and thus, the participant's hydration before starting to walk is unknown. Additionally, the amount of fluid ingested per day was not recorded, which could affect overall and foot hydration. Environmental conditions, such as temperature and humidity, could affect sweating levels and thus influence hydration and blister formation.

Another limitation is the absence of data on normal hydration levels, making it challenging to compare with the hydration obtained in our study.

This study presents insightful data in relation to foot hydration. Higher levels of hydration were associated with the presence of blisters. However, the influence of variables such as age and the use of wet socks highlights the complexity of the phenomenon.

In future research, it is crucial to design longitudinal studies that measure hydration levels before, during, and after physical activities to better understand the causal relationship between hydration and blister formation. It would be interesting to study the behaviour of skin hydration in different sports movements, as each physical

activity can have a distinct impact on the skin due to variations in friction, pressure, and perspiration. Additionally, it would be useful to investigate the efficacy of various interventions, such as the use of moisturizing creams, different types of footwear, and specific hydration techniques in the prevention of blisters. Consequently, further prospective studies are needed to more precisely understand the relationship between skin hydration and blister development in the context of hiking, providing valuable information for the implementation of preventive measures in clinical practice.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare regarding this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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