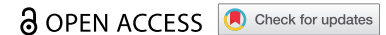







ORIGINAL RESEARCH



Illness is more prevalent than injury in trail runners participating in a mountainous ultra trail race

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ABSTRACT

Objectives: Trail running is a popular off-road sport involving running in natural environments over various terrains, often in remote locations. This study aims to investigate the epidemiology and risk factors of injuries and illnesses, i.e. medical encounters, on race day among trail runners in a high-altitude ultra trail race.

Methods: This descriptive cross-sectional study on an ultra trail race (38 km, 65 km and 100 km) in South Africa, included participants 18 years or older. Of the 331 race participants, 285 (86.1%) consented to participate in the study. Data collection included demographic details, injuries (body region, specific body area, tissue type, pathology) and illnesses (organ system, symptom cluster, etiology). Risk factor analysis includes sex, age, weight, height, race distance, illness and injury history, training and running experience. Frequency (n, %), prevalence (%) and odds ratios (OR; 95%CI) are reported.

Results: Eighty-nine (31.2%) individuals reported 131 medical encounters [49 injuries (37.4%); 82 illnesses (62.6%)]. Injuries were sustained by 14.7% of athletes, and 22.5% reported illnesses. For injuries, the lower limb was mainly involved ($n = 41$; 83.7%). Most injuries affected the foot ($n = 18$; 36.7%), ankle ($n = 10$; 20.4%) and knee ($n = 7$; 14.3%). Tissue types mainly involved skin ($n = 21$; 42.8%), ligament ($n = 7$; 14.3%) and muscle ($n = 7$; 14.3%). Multiple ($n = 45$; 54.9%) and gastrointestinal ($n = 17$; 20.7%) organ systems were mainly involved in illnesses. Only 100 km runners reported dehydration ($n = 28$; 31.5%), and one in every six of these runners ($n = 5$; 17.9%) did not finish. Runners reporting fatigue ($n = 21$; 23.6%) had a high ($n = 8$; 38.1%) did not finish rate. Two in every five participants ($n = 36$; 40.4%) with a medical encounter, did not finish. No medical encounter-associated risk factors were identified.

Conclusions: Illnesses were more common than injuries during the mountainous ultra trail race. Sustaining a medical encounter increased the chance of not completing the race. Further research on the epidemiology of race day medical encounters in trail running is required.

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Trail running; medical encounter; injury; illness; risk factor; did not finish

Introduction

Trail running is becoming an increasingly popular outdoor activity [1,2]. It involves running in a natural environment such as mountains, deserts, forests, coastal areas, and grassy plains [1]. Trail running events include a variety of terrains with a maximum of 20% synthetic surface allowed [2]. Races span a spectrum of distances, ranging from short distances (a few kilometers) to long distances, often exceeding 42.195 km (ultra trail) and extending to 322 km (200 miles) and further [2,3].

Providing medical services for trail runners on race day can be challenging due to the remoteness of the locations, large geographical areas, uneven running surfaces, steep elevations and descents, extreme weather conditions and environmental hazards [3]. These factors collectively contribute to the complexity of medical care for injured and ill trail runners. It

necessitates careful planning, resourceful strategies, and often specialized training to ensure the safety and well-being of participants.

Medical encounters (MEs), comprising injuries and illnesses suffered during an event, are common in trail running and can contribute to runners not finishing the race [4–6]. Trail running injury rates vary [4,7–9] as evidenced by a systematic review on trail running reporting the prevalence between 1.3 and 90.0% [10]. A Spanish study reported an incidence of 1.6 injuries per 1000 hours of trail race running [7]. Amongst injured trail runners, musculoskeletal and dermatological injuries are common [4,8,11]. Injuries reported in trail runners mainly affect the lower limbs and include toenails (24.4%), blisters (20.0%), knee (17.5%) and ankle (14.4%) injuries [11].

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Studies have reported more illnesses than injuries during trail running races [8,12], including potentially life-threatening conditions [13]. These include exercise-induced collapse, heat illness, hypothermia, hyponatremia, allergic reactions, exertional rhabdomyolysis, acute kidney injury, hematuria, fatigue, gastrointestinal and altitude illness [4,13]. A systematic review concluded that trail runners mostly report gastrointestinal symptoms such as nausea and vomiting [5].

Risk factors associated with MEs may be intrinsic, for example, age, sex, height, weight, nutrition, previous injury, comorbidities, running experience, and warming up, or extrinsic, for example, environment, equipment, running shoes, and training [11,14–18]. The possible risk factors for trail running injuries/illnesses include previous injury, running experience of more than six years, training on synthetic routes, and not warming up before the race [11,16].

South Africa hosts numerous trail running events involving local and international runners [19]. These endurance trail races are a serious challenge, requiring athletes to be self-sufficient and self-navigational in a remote mountain range [20]. The rugged and demanding terrain also presents unique challenges for providing medical care, particularly during race day events. Given the limited availability of ME statistics during trail races [4,7,8,19,21,22], empirical research is needed to gather data on the prevalence and nature of MEs in this context. This study aims to investigate the prevalence, clinical characteristics and risk factors of MEs on race day among runners who entered a mountainous ultra trail race (38 km, 65 km and 100 km) in South Africa. Further research in this field will assist race organizers, runners and medical teams in improving ME prevention and identifying and improving the provision of quality medical services for trail runners.

Materials and methods

Study design and ethical concerns

This research study is a descriptive cross-sectional study. Before conducting the study, the Research Ethics Committee of the Faculty of Health Sciences of the University of Pretoria (REC 431/2021) approved the study. The study followed the ethical standards of the Declaration of Helsinki for human studies.

Study setting

The ultra trail race (38 km, 65 km and 100 km distances) in our study took place on 15 November 2020 in South Africa [20]. The terrain is a rocky and grassy mountain range, with an average altitude of 2200–2500 m above sea level and elevations of 4445 m (100 km race) and 3145 m (65 km race) [20]. The minimum and maximum temperatures reported on race day were 14°C and 34°C [23].

Participant selection

All trail runners, males and females ≥ 18 years of age, who encountered and reported an injury or illness to the medical team on race day were eligible to be included in the study. Prior experience was not a requirement to participate in the trail race. All runners had to complete a COVID-19 screening questionnaire.

Data collection

On race day, the medical team captured all MEs. The medical team comprised five medical doctors, two clinical associates, one registered nurse, two assistant nurses, five paramedics and two medical students. They identified, assessed and treated all MEs. The medical team was situated at different medical checkpoints along the race route. Injured or ill athletes were managed primarily at these checkpoints, and those affected along the race course away from checkpoints proceeded to the nearest checkpoint for further treatment.

There were 12 checkpoints throughout the race, including the race start and finish points. In addition to medical support at checkpoints, fluid and food were provided. However, runners were expected to be self-sufficient and carry hydration and nutritional aids. The medical tent at ~55 km into the race, was the compulsory medical checkpoint for 100 km race runners. The 38 km and 65 km races had no compulsory medical checkpoints. Trail runners were allowed to stop voluntarily at any time during the race or by following the medical team's advice. Race participants who did not finish (DNF) the race were recorded. DNF rate is determined by the number of runners who started the race but did not cross the finish line [24].

During the two weeks before the race, all trail race entrants completed a self-reported online compulsory pre-race medical screening questionnaire shared by the race organizer. The online survey form was self-reported and covered demographics, race distance entered, past trail running participation, previous injuries/illnesses sustained in the past 12 months, current injuries/illnesses, chronic disease, medication and allergies. The questionnaire is used in pre-race medical screening at various trail running events across South Africa [22,25–27]. It includes the four main considerations of the Oslo Sports Trauma Research Center Questionnaire on Health Problems (OSTRC-H) [28]. Participants voluntarily consented to include their information collected for research purposes. Injury and illness data was linked to race numbers. All other identifiers, such as names, contact numbers and e-mail addresses, were anonymized. This data was used to determine possible risk factors for MEs.

Measurements

Data recording included demographic details (sex, age, race distance and weight). Baseline vital signs were taken on race registration day and noted on the ME forms. The main complaint, clinical examination and investigations such as blood glucose performed on the participants were used to determine the nature and severity of the injury or illness. Clinical examination of the participants during the race included their vital signs, hydration status, mental state, urine color (if passed) and the assessment of other areas of concern. Dehydration was classified as mild, moderate, severe or unspecified. Checking for hydration status, urine color was reported as normal, light, dark or unspecified. Weight loss of more than 5.0% was also used to indicate dehydration.

The medical team implemented the following Stop Criteria to withdraw runners from the race [29,30]:

- Mental state: Unconscious, confused or disorientated
- Rectal temperature < 34°C or > 40°C
- Systolic blood pressure: <100 mmHg
- Heart rate: >100 bpm (after 20 min rest and only used combined with systemic symptoms, not in isolation.)
- Blood glucose: <4 mmol/L or >12 mmol/L
- Body weight loss: >10%
- Body weight gain: >2%

Definitions

- Medical encounter (ME): any injury or illness sustained by a race participant who presents to the medical team from the official start of the race up to 24 hours after the official cutoff time [24,31].
- Illness: a symptom experienced by a runner that is not due to an injury [32].
- Injury: damage to tissues in the body [32].

We defined injuries and illnesses as the 2020 International Olympic Committee (IOC) consensus statement recommended [32]. The injury categories logged included the main anatomical body region, specific body area, tissue type and pathology. The illness categories included the main organ system, symptom cluster and etiology [32]. Intrinsic risk factors studied were sex, age, weight, height, BMI, injury/illness history, and previous running and trail running experience. Extrinsic risk factors included course altitude/elevation, race distance and climate on race day.

Data analysis

The data collected was recorded on a Microsoft Excel spreadsheet. The data analysis consisted of descriptive statistics such as mean, 95% confidence intervals, frequencies and proportions to describe the results. Graphical representations were used to visualize aspects of data. The prevalence was calculated by dividing the participants suffering from an ME by the total number of consenting participants. Comparisons between the sample of participants with and without ME were done using the Chi-

squared test for categorical variables and the independent t-test (or the nonparametric alternative, Mann Whitney U tests) for continuous variables. Continuous data were tested for normality using the Shapiro Wilk test. Possible risk factors for an ME were investigated using logistic regression models. All significance tests were done at a 5% level of significance.

Results

Participant characteristics

Of the 331 trail runners participating, 285 (86.1%) consented to take part in the study [38 km (11.9%), 65 km (27.4%), 100 km (60.7%)]. Consenting trail run entrants comprised of 221 (77.5%) males and 64 (22.5%) females (Table 1).

All MEs in trail runners

During the race, 89 (31.2%) individuals, including 68 (76.4%) males, reported MEs. Seventeen runners (19.1%) reported an injury and illness, 25 only an injury (28.1%) and 47 only an illness (52.8%). In total 131 MEs occurred [49 injuries (37.4%); 82 illnesses (62.6%)]. (Table 2) No MEs were reported for the 38 km race. In the 100 km, 82 runners (92.1%) reported 38 (42.7%) injuries and 60 (67.4%) illnesses. (Table 1) Thirty-six participants (40.4%) with an ME DNF the race. Nineteen runners (45.2%) who reported at least one injury, DNF. Similarly, 28 ill runners DNF (43.8%) (Table 2).

Prevalence and clinical characteristics of ME injury in trail runners

The prevalence of ME injuries in trail runners was 14.7% (14.0% males; 17.2% females). Trail runners reported 49 ME injuries [31 males (73.8%); 11 females (26.2%)]. In total, 36 runners (85.7%) encountered one injury, five runners (11.9%) encountered two injuries, and one runner (2.4%) encountered three injuries (Table 2).

The anatomical region most frequently involved was the lower limb (83.7%). The main injured body areas were the foot

Table 1. Demographic details of participants who entered the race.

	All consenting participants (n = 285) ^a	Participants with No ME (n = 196) ^a	Participants with ME (n = 89) ^a	p-value ^b
Sex (n, %)				
Male	221 (77.5%)	153 (78.1%)	68 (76.4%)	0.87
Female	64 (22.5%)	43 (21.9%)	21 (23.6%)	
Age (years)				
Min; Max	21; 65	22; 65	21; 65	0.33
mean (95% CI) ^c	40.04 (39.07–41.00)	40.30 (39.12–41.48)	39.45 (37.80–41.10)	
Distance entered (n, %)				
38 km	34 (11.9%)	34 (17.3%)	0 (0.0%)	^d
65 km	78 (27.4%)	71 (36.2%)	7 (7.9%)	
100 km	173 (60.7%)	91 (46.4%)	82 (92.1%)	
Starting weight (kg) ^e				
Min; Max	31; 128	31; 128	44; 113	0.26
mean (95% CI)	76.99 (75.35–78.63)	77.59 (75.53–79.65)	75.65 (73.02–78.27)	

^an: number of trail runners.

^bp-value: No ME vs. ME.

^cCI: Confidence Interval.

^dSignificance not reported due to group(s) with n < 5 participants.

^eMissing values: n = 1 with no ME, n = 2 with ME.

Table 2. Trail runners' race day MEs and DNF rate.^a

	All	Male	Female	DNF ^b
Total number of participants with an ME	89 (31.2%)	68 (76.4%)	21 (23.6%)	36 (40.4%)
Total number of participants with an injury	42	31 (73.8%)	11 (26.2%)	19 (45.2%)
Number of participants with one injury	36 (85.7%)			17 (89.5%)
Number of participants with two injuries	5 (11.9%)			2 (10.5%)
Number of participants with three injuries	1 (2.4%)			0 (0.0%)
Total number of participants with an illness	64	48 (75.0%)	16 (25.5%)	28 (43.8%)
Number of participants with one illness	47 (73.4%)			21 (75.0%)
Number of participants with two illnesses	16 (25.0%)			7 (25.0%)
Number of participants with three illnesses	1 (1.6%)			0 (0.0%)
Total number of MEs reported	131	99 (75.6%)	32 (24.4%)	- ^c
Number of injuries reported (<i>n</i> = 49)	49 (37.4%)	37 (75.5%)	12 (24.5%)	-
Number of illnesses reported (<i>n</i> = 82)	82 (62.6%)	62 (75.6%)	20 (24.4%)	-

^aParticipants with ME.illness and injury: *n* = 17 (19.1%)illness only: *n* = 47 (52.8%)injury only: *n* = 25 (28.1%)^bDNF: did not finish.^cNumber of participants with MEs used to calculate DNF rate and not number of MEs reported.

(36.7%), ankle (20.4%) and knee (14.3%). Tissue-type injuries reported mainly included skin (42.8%). The most common pathology type was abrasions (40.8%) and unspecified (22.4%). (Table 3) Foot blisters (a type of skin abrasion) accounted for 32.7% of injuries and 18% of all MEs. Table 4

Table 3. Injury encounters and clinical characteristics of trail runners on race day.

	Total number of injury MEs (<i>n</i> = 49%) ^a	Number of injury MEs reported by males (<i>n</i> = 37%)	Number of injury MEs reported by females (<i>n</i> = 12%)
Anatomical region			
Upper limb	1 (2.0%)	1 (2.7%)	0 (0.0%)
Trunk	2 (4.1%)	1 (2.7%)	1 (8.3%)
Lower limb	41 (83.7%)	31 (83.7%)	10 (83.8%)
Unspecified	5 (10.2%)	4 (10.8%)	1 (8.3%)
Body area			
Elbow	1 (2.0%)	1 (2.7%)	0 (0.0%)
Chest	1 (2.0%)	0 (0.0%)	1 (8.3%)
Lumbosacral	1 (2.0%)	1 (2.8%)	0 (0.0%)
Hip	1 (2.0%)	0 (0.0%)	1 (8.3%)
Thigh	1 (2.0%)	1 (2.7%)	0 (0.0%)
Knee	7 (14.3%)	5 (13.5%)	2 (16.7%)
Lower leg	4 (8.2%)	4 (10.8%)	0 (0.0%)
Ankle	10 (20.4%)	9 (24.3%)	1 (8.3%)
Foot	18 (36.7%)	12 (32.4%)	6 (50.0%)
Unspecified	5 (10.2%)	4 (10.8%)	1 (8.3%)
Tissue type			
Skin	21 (42.8%)	14 (37.8%)	7 (58.3%)
Ligament	7 (14.3%)	6 (16.2%)	1 (8.3%)
Muscle	7 (14.3%)	7 (18.9%)	0 (0.0%)
Tendon	3 (6.1%)	1 (2.7%)	2 (16.7%)
Unspecified	11 (22.4%)	9 (24.3%)	2 (16.7%)
Pathology type			
Abrasion	20 (40.8%)	13 (35.1%)	7 (58.3%)
Muscle injury	7 (14.3%)	7 (18.9%)	0 (0.0%)
Sprain	7 (14.3%)	6 (16.2%)	1 (8.3%)
Tendon injury	3 (6.1%)	1 (2.7%)	2 (16.7%)
Laceration	1 (2.0%)	1 (2.7%)	0 (0.0%)
Unspecified	11 (22.4%)	9 (24.3%)	2 (16.7%)

^aSome runners reported more than one injury ME.

presents the body area and pathology type per specific anatomical region.

ME illness prevalence and characteristics in trail runners

The prevalence of ME illness in trail runners was 22.5% (21.7% males; 25.0% females). A total of 64 trail runners reported 82 ME illnesses [48 males (75.0%); 16 females (25.0%)]. In total, 47 runners (73.4%) encountered one illness, 16 runners (25.0%) encountered two illnesses, and one runner (1.6%) encountered three illnesses (Table 2).

The organ system most frequently involved was multiple systems (54.9%), followed by the gastrointestinal (20.7%), ophthalmological (4.9%), and respiratory (4.9%) systems (Table 5).

The etiology of illness was mainly unspecified (*n* = 42, 51.2%). Environmental-related factors accounted for 40.2% of illnesses (Table 6).

Twenty-eight (31.5%) trail runners reported dehydration during the 100 km race. No runners presented with dehydration during the 38 km and 65 km races. Most runners had mild dehydration (*n* = 17, 60.7%), but two runners (7.1%) showed signs of severe dehydration. Five dehydrated participants (17.9%) DNF the race. Among 14 runners passing urine, the urine color was normal (*n* = 1, 3.6%), light (*n* = 2, 7.1%), dark (*n* = 3, 10.7%) and not specified (*n* = 8, 28.6%) (Supplementary Table S1).

Mental and physical fatigue were reported among 21 (23.6%) ill runners [13 males (61.9%); eight females (38.1%)]. Twenty (95.2%) fatigued runners participated in the 100 km race and one (4.8%) in the 65 km race. Thirteen participants (61.9%) with fatigue DNF the race. (Supplementary Table S2). The majority of participants reported normal mental status (*n* = 62, 69.7%) followed by mentally fatigued (*n* = 4, 4.5%), impatient (*n* = 1, 1.1%), stressed (*n* = 1, 1.1%) and unspecified (*n* = 21, 23.6%).

ME risk factors

Univariate analysis of categorical and continuous variables was used to analyze risk factors (Table 7). None of the analyzed variables had a significant association with an ME sustained on

Table 4. Injury encounters and characteristics of trail runners on race-day (38 km, 65 km and 100 km distances).

Anatomical Region	Body Area	n = 49%) ^a	Pathology Type	n = 49%) ^a	
Upper Limb	All	1 (2.0%)			
	Elbow	1 (2.0%)	Abrasion	1 (2.4%)	
Trunk	All	2 (4.1%)			
	Chest	1 (2.0%)	Unspecified	1 (2.4%)	
Lower Limb	Lumbosacral	1 (2.0%)	Unspecified	1 (2.4%)	
	All	41 (83.7%)			
	Hip	1 (2.0%)	Unspecified	1 (2.4%)	
	Thigh	1 (2.0%)	Muscle injury	1 (2.4%)	
	Knee		7 (14.3%)	Abrasion	2 (4.1%)
				Tendon injury	3 (6.1%)
				Unspecified	2 (4.1%)
	Lower leg	4 (8.2%)	Laceration	1 (2.4%)	
			Muscle injury	3 (6.1%)	
	Ankle	10 (20.4%)	Sprain	7 (14.3%)	
Foot		18 (36.7%)	Unspecified	3 (6.1%)	
			Abrasion	16 (32.7%)	
Unspecified	All	5 (10.2%)	Unspecified	2 (4.1%)	
	Unspecified	5 (10.2%)	Abrasion	1 (2.4%)	
			Muscle injury	3 (6.1%)	
			Unspecified	1 (2.4%)	

^an = number of trail runners.

Table 5. Illness encounters by organ system and symptom clusters in trail runners on race day.^a

Organ System	Symptoms	Number of illness encounters (n = 82)	Number of illness encounters reported by males n = 62	Number of illness encounters reported by females n = 20
Multiple systems	Pins and needles, collapse, headache, cramps, feeling hot, dehydrated, thirsty, dry, dry tongue, altitude sickness, fatigue, unspecified	45 (54.9%)	34 (54.8%)	11 (55.0%)
Gastrointestinal	Vomiting, nausea, lack of appetite, abdominal cramps, bloated, eating difficulty, light-headed	17 (20.7%)	14 (22.6%)	3 (15.0%)
Ophthalmological	Temporary blindness, red eyes, vision changes	4 (4.9%)	2 (3.2%)	2 (10.0%)
Respiratory	Sore throat, headache, chills, malaise, shortness of breath, chest tightness	4 (4.9%)	2 (3.2%)	2 (10.0%)
Thermoregulatory	Unspecified, cold	3 (3.7%)	2 (3.2%)	1 (5.0%)
Psychiatric/psychological	Stress, mentally not well	2 (2.4%)	2 (3.2%)	0 (0.0%)
Cardiovascular	Chest pain	1 (1.2%)	1 (1.6%)	0 (0.0%)
Oral/Dental	Mouth cramps	1 (1.2%)	1 (1.6%)	0 (0.0%)
Endocrinological	Dizzy, fatigue	1 (1.2%)	0 (0.0%)	1 (5.0%)
Unspecified	Dizzy, cramps, feeling hot, sweating, pale	4 (4.9%)	4 (6.5%)	0 (0%)

^aSome runners reported more than one symptom.

Table 6. Illness encounters by etiology in trail runners on race day.

Aetiology	Number of illness encounters (n = 82)	Illness specified
Unspecified	42 (51.2%)	
Environmental- exercise related	28 (34.1%)	Dehydration
Environmental- non-exercise related	5 (6.1%)	Altitude sickness, Hypothermia
Chronic disease	2 (2.4%)	Asthma, Coronary artery disease
Drug side effect	1 (1.2%)	
Food poisoning	1 (1.2%)	
Hyperglycaemia	1 (1.2%)	
Infection	1 (1.2%)	Pharyngitis
Metabolic/nutritional	1 (1.2%)	Hypoglycaemia

race day ($p > 0.05$). Therefore, a multivariate analysis was not included.

Discussion

This study investigated the prevalence, nature and risk factors of MEs on race day among trail runners who participated in a mountainous ultra trail race. We reported an ME prevalence

of 31.2% on race day, i.e. approximately one in every three trail runners suffered an ME, with no encounters reported in the 38 km distance. Our study further found a higher illness prevalence than injuries. Lower limb injuries were most common, with the foot, ankle, and knee as the most commonly injured body areas. We reported that skin, ligament and muscle were the most common tissue types, and abrasions were the most reported pathology type. Multiple systems and

Table 7. Univariate risk factors analysis of race day data linked to the pre-race questionnaire.

Risk factors	Pre-race Questionnaire [#]	
	OR (2.5%; 97.5%) ^b	p-value
Sex (Male)	1.06 (0.58; 1.91)	0.84
Age (years)	1.01 (0.98; 1.05)	0.37
Distance entered (km)^a		
65	0.00 (0.00; large)	0.98
100	0.00 (0.00; large)	0.98
Height (m)	1.01 (0.98; 1.04)	0.55
Weight (kg)	1.01 (0.99; 1.03)	0.42
BMI (kg/m²)	1.02 (0.94; 1.11)	0.57
Chronic disease	0.94 (0.46; 2.04)	0.88
Running related injury in the past 12 months	1.61 (0.86; 3.15)	0.15
Running as a sport (less than 5 years)	1.14 (0.63; 2.12)	0.68
Trail running as a sport (less than 5 years)	0.97 (0.58; 1.60)	0.89
Average weekly running distance (km)		
21–40	1.09 (0.15; 5.01)	0.92
41–60	0.41 (0.06; 1.71)	0.27
61–80	0.40 (0.06; 1.70)	0.26
81–100	0.33 (0.04; 1.65)	0.21
more than 100	0.26 (0.03; 1.53)	0.16
Running sessions (3 or more)	0.73 (0.40; 1.30)	0.30
Running sessions on trails (0–3)	0.77 (0.41; 1.47)	0.42

^aNo MEs reported for 38 km distance.

^bOR (2.5%; 97.5%): Odds ratio value and confidence interval.

[#]One of the 89 participants who suffered MEs on race day could not be linked to pre-race questionnaire data (Table 1).

gastrointestinal systems were mainly involved in illness encounters. One in every six dehydrated runners and two-thirds of fatigued runners DNF the race. A high DNF rate is reported in our study, with two out of every five trail runners with an ME not finishing the race. None of the variables included in the univariate analysis showed a significant association with MEs sustained on race day.

We reported a total of 131 MEs amongst 89 runners. Of all consenting race participants, approximately one in seven runners sustained an injury, and one in five had an illness. Our results relate to ultra trail runners ($n = 77$) in the 65 km Vigolana Trail, who reported 132 MEs with slightly more illnesses (50.3%) than injuries [8]. In the latter study, MEs amongst runners who DNF the race were not accounted for. It also included only one race distance, unlike our study, which included multiple race distances and runners with MEs irrespective of race completion status. MEs contribute to DNF rate. During a 2010 ultra trail race, nine of the 69 runners (13.0%) could not complete the race, mainly due to MEs [4]. Most trail runners take the sport seriously for enjoyment and recreation and will continue the race despite an ME [33]. Navigating MEs during the race poses a challenge for these runners.

Our study showed an injury prevalence of 14.7% on race day, in keeping with the injury prevalence range reported in a recent systematic review study [10]. The lower limb (83.7%) was the most injured anatomical region, with the majority of injuries localized to the foot (36.7%), ankle (20.4%) and knee (14.3%). Our findings concur with a study on mountain running races over 5 seasons that reported 78% of injuries were lower limb injuries [7]. Our results differ from the 5-day 219 km Al Andalus ultra trail, which reported 22.2% lower limb musculoskeletal injuries [4]. The difference may be that the latter study classified foot blisters as a dermatological injury, not a lower limb injury. In Greek trail runners, injuries

mostly involved the lower back (42.5%) and the knee (40%) [16]. The higher prevalence of lower limb injuries compared to other body regions reported in studies could be due to the uneven surface, the high elevations and technically challenging navigation of the trail races. The running surface may cause loss of balance and instability while running, which may lead to injury. A previous injury may tend to transfer the role of joint mobility to an adjacent stable joint, such as a knee joint, which can result in joint pathology [34]. However, additional research is needed to aid future comparisons of injuries in single-day and multi-stage races.

In our study, the tissue type most reported was skin (42.8%), followed by ligament (14.3%) and muscle (14.3%) injuries. Abrasions (40.8%), which include blisters, are the most reported pathology type. Foot blisters accounted for 18% of all MEs in our study. The 65 km Vigolana Trail race authors reported 16.9% skin disorders, and foot blisters accounted for 53.8% of these skin disorders [8]. During the Al Andalus ultra trail, 33.3% of runners reported foot blisters [4]. Skin injuries are common and mainly affect the foot, causing blisters [4,8]. This may be due to external factors such as shoe type, orthotics, foot mechanics and course surface. A retrospective study on trail runners found that running surfaces slightly influenced trail running-related injury risk but not shoe type [35]. Also, the type of socks worn and the application of antiperspirant/talcum powder/taping/anti-friction cream do not seem to reduce the risk of foot blisters among trail runners [36,37].

Amongst runners with a ME, we reported 62.6% illness encounters that mainly involved multiple (54.9%) and gastrointestinal (20.7%) systems. Trail runners frequently experience gastrointestinal symptoms [5]. Acute diarrhea was the most common ME during a trail race in the Himalayas [12]. Our study did not report diarrhea; however, it is important to remember that not all runners with symptoms presented to

the medical team. The etiology of illness was unspecified in 51.2% of illness MEs. For these runners, the medical team noted and addressed the runner's symptoms related to illness but provided no further detail on etiology or diagnosis. Forty percent of the etiology of illness encounters was environmental-related, with dehydration as the leading specified cause (34.1%). A systematic review of ultramarathon trail runners reported a high prevalence of dehydration in endurance running [21]. Fatigue had a major impact in our study, with 21 runners (32.8%) reporting fatigue. Ultimately, 17.9% of dehydrated and 61.9% of fatigued runners DNF the race. In contrast, a study on Western States Endurance Run 161 km ultramarathon trail runners on race day over 4 years reported a low prevalence of fatigue and dehydration [9]. One (0.1%) race starter had fatigue and finished the race [9]. One (0.1%) race starter had dehydration and DNF the race [9]. This may be due to different criteria for classifying fatigue and dehydration, race distances, and environmental conditions. Correct fluid management is essential for race completion [13]. Further research on illnesses reported on race day is necessary with a standardized method of data collection used.

Although we did not investigate whether the runners trained at low or high altitudes, acclimatization to high altitudes during training and living at high altitudes is crucial for better performance during mountain climbing [38] and helps to reduce altitude sickness. In ultramarathon races, altitude illness usually occurs when the elevation exceeds 2500 m [39]. In our study, the ultra trail race reached an average 2200–2500 m above sea level [20]. Only two (2.4%) runners suffered altitude sickness. Although extreme temperatures of 34°C were reported, no runners encountered hyperthermia on race day. Instead, three participants with illness MEs (3.7%) experienced hypothermia, probably due to high altitude contributing to heat loss and hence leading to hypothermia [39].

Medical teams of trail races encounter challenges of limited road access to several checkpoints and race routes in between due to the geographical region and steep elevations. Withdrawal from a race may occur where there is no medical staff nearby. Reaching and providing medical assistance to these runners is often delayed. Race completion is the goal for runners, but MEs may affect performance [13]. Although most trail running injuries and illnesses are minor and allow participants to complete the race, those runners who need to withdraw due to an ME use the already challenged and strained medical services [5,7,13,40]. In this study, two in every five trail runners ($n = 36$; 40.4%) with an ME, DNF the race. Amongst the 42 runners who reported an injury, 19 (45.2%) DNF. Of the 64 runners who reported an illness 28 (43.8%) DNF. During the 161 km Western States Endurance race, 55.0% of trail runners continued the race (i.e. 45.0% DNF) after consulting the medical team on the race course. However, a further 25.0% of the runners with an ME who chose to continue, DNF the race [9]. The impact of MEs on the DNF rate highlights the importance of ME encounter prevention and treatment.

ME risk factors are multifactorial (intrinsic and extrinsic factors) and can assist in checking the susceptibility to ME during participation in sport [17]. Approximately a third of all female (32.8%) and all male race entrants (30.7%) had an ME.

However, sex was not a risk factor for sustaining an ME ($p = 0.8442$). Running-related injury 12 months before the race was not a risk factor for sustaining an ME ($p = 0.1469$) in our study. A study on trail races over 4 years reported statistically significantly more gradual-onset running-related injuries amongst trail runners on race day participating in the 20 km vs 10 km race ($p < 0.0001$) [41]. In our study, no MEs were reported in the shorter 38 km trail distance compared to 7 (7.9%) in the 65 km and 82 (92.1%) in the 100 km distances. However, race distance did not significantly contribute to MEs (100 km; $p = 0.9795$ and 65 km; $p = 0.9821$). As demonstrated in our study, the absence of identifiable risk factors doesn't preclude MEs. Further research on risk factors for trail running MEs on race day is necessary.

Limitations

Our study has several limitations. Firstly, the reported MEs were over a single race event. Coverage of additional trail races might provide an understanding of risk factors and the medical needs of trail runners on race day. Secondly, data that went unreported and incomplete data provided by the medical team could have adversely affected the interpretation of results. Thirdly, the shorter race distances had no reported ME, probably due to the absence of compulsory checkpoints for the 38 km and 65 km races. Therefore, MEs were less likely to be reported by the runners or diagnosed by the medical team. The additional data might have added more power to detect differences during risk factor analysis. Lastly, implementing a standardized approach to data collection during trail running events could facilitate the identification of risk factors for MEs in future.

Conclusions

MEs are common amongst trail runners on race day, though shorter distances are associated with fewer reports. Illness was more common than injury. Injuries mainly affected the lower limb, especially the foot. Illness MEs mainly involved multiple systems, with dehydration and fatigue frequently reported. One in every six dehydrated runners and two-thirds of fatigued runners DNF the race. Sustaining an ME in this ultra trail race increased the chance of not completing the race by > 40%. The risk factors (i.e. sex, age, weight, height, race distance, illness and injury history, training and running experience) included in the analysis were not predictive of MEs.

Recommendations

- Focus on dehydration and fatigue prevention and treatment in trail running. Monitoring weight is key for diagnosing and preventing dehydration and overhydration [13]. Adequate fluid intake and nutrition are important in endurance events [6,13,21]. Runners are advised to drink to thirst but to avoid overhydration, which may lead to exercise-associated hyponatremia [13,21].
- Races with scarce water points and expecting runners to be self-sufficient should have minimum fluid requirements to be carried by runners.

- Uniform definitions of methods used for data collection are recommended [18].
- Further research on the epidemiology of MEs in shorter distance trails, multi-day trail races, and younger trail runners is suggested.

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Consent to participate

Informed consent forms were signed voluntarily by race participants to participate in this research study. The participants' information is kept anonymous.

Data sharing statements

The data obtained in this study is available on reasonable request due to privacy and ethical restrictions.

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References

- Scheer V, Basset P, Giovanelli N, et al. Defining off-road running: a position statement from the ultra sports science foundation. *Int J Sports Med.* 2020;41(5):275–284. doi: 10.1055/a-1096-0980
- Association ITR [Internet]. Itra discover trail running. [cited 2024 Jul 3]. Available from: <https://itra.run/About/DiscoverTrailRunning>
- Costa RJS, Knechtle B, Tarnopolsky M, et al. Nutrition for ultramarathon running: trail, track, and road. *Int J Sport Nutr Exerc Metab.* 2019;29(2):130–140. doi: 10.1123/ijsnem.2018-0255
- Scheer BV, Murray A. Al andalus ultra trail: an observation of medical interventions during a 219-Km, 5-day ultramarathon stage race. *Clinical Journal Of Sport Medicine.* 2011;21(5):444–446. doi: 10.1097/JSM.0b013e318225b0df
- Viljoen CT, Janse van Rensburg DC, Verhagen E, et al. Epidemiology of injury and illness among trail runners: a systematic review. *Sports Med.* 2021;51(5):917–943. doi: 10.1007/s40279-020-01418-1
- Krabak BJ, Waite B, Schiff MA. Study of injury and illness rates in multiday ultramarathon runners. *Medicine & Science In Sports & Exercise.* 2011;43(12):2314–2320. doi: 10.1249/MSS.0b013e318221bfe3
- González-Lázaro J, Arribas-Cubero HF, Rodríguez-Marroyo JA. Muskuloskeletal injuries in mountain running races: a 5 seasons study. *Injury.* 2020;52(4):747–749. doi: 10.1016/j.injury.2020.10.045
- Vernillo C, Savoldelli A, La Torre A, et al. Injury and illness rates during ultratrail running. *Int J Sports Med.* 2016;37(7):565–569. doi: 10.1055/s-0035-1569347
- McGowan V, Hoffman MD. Characterization of medical care at the 161-Km western states endurance run. *Wilderness Environ Med.* 2015;26(1):29–35. doi: 10.1016/j.wem.2014.06.015
- Viljoen C, Rensburg D, Mechelen W, et al. Trail running injury risk factors: a living systematic review. *Br J Sports Med.* 2022;56(10):577–587. doi: 10.1136/bjsports-2021-104858
- Matos S, Silva B, Clemente FM, et al. Running-related injuries in Portuguese trail runners: a retrospective cohort study. *J Sports Med Phys Fitness.* 2021;61(3):420–427. doi: 10.23736/s0022-4707.20.11304-5
- Dawadi S, Basyal B, Subedi Y. Morbidity among athletes presenting for medical care during 3 iterations of an ultratrail race in the himalayas. *Wilderness Environ Med.* 2020;31(4):437–440. doi: 10.1016/j.wem.2020.08.001
- Hoffman MD, Pasternak A, Rogers IR, et al. Medical services at ultra-endurance foot races in remote environments: medical issues and consensus guidelines. *Sports Med.* 2014;44(8):1055–1069. doi: 10.1007/s40279-014-0189-3
- van der Worp MP, ten Haaf DS, van Cingel R, et al. Injuries in Runners; a Systematic Review on Risk Factors and Sex Differences. *PLOS ONE.* 2015;10(2):e0114937. doi: 10.1371/journal.pone.0114937
- Saragiotto BT, Di Pierro C, Lopes AD. Risk factors and injury prevention in elite athletes: a descriptive study of the opinions of physical therapists, doctors and trainers. *Braz. J. Phys. Ther.* 2014;18(2):137–143. doi: 10.1590/s1413-35552012005000147
- Malliaropoulos N, Mertyri D, Tsaklis P. Prevalence of injury in ultra trail running. *Hum Mov.* 2015;16(2):52–59. doi: 10.1515/humo-2015-0026
- Bahr RK, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med.* 2005;39(6):324–329. doi: 10.1136/bjism.2005.018341
- Bahr R, Holme I. Risk factors for sports injuries—a methodological approach. *Br J Sports Med.* 2003;37(5):384–392. doi: 10.1136/bjism.37.5.384
- McKay T, McEwan L, Baker M. The rise of trail running in South Africa: possibilities for small-scale sports tourism. *Geoj Tour Geosites.* 2019;26(3):930–942. doi: 10.30892/gtg.26320-408
- SkyRun [Internet]. 2021 [cited 2021 Oct 15]. Available from: <https://skyrun.co.za/>
- Oosthuizen IA, Paul Y, Ellapen TJ, et al. Common ultramarathon trail running injuries and illnesses: a review (2007–2016). *Int J Med Med Sci.* 2019;11(4):36–42. doi: 10.5897/IJMMMS2018.1386
- Viljoen CT, van Rensburg J, Jansen DC, et al. One in four trail running race entrants sustained an injury in the 12 months training preceding the 2019 skyrun race. *Phys Ther Sport.* 2021;47:120–126. doi: 10.1016/j.ptsp.2020.11.029
- AccuWeather [Internet]. 2021 [cited 2021 Feb 20]. Available from: <https://www.accuweather.com/en/za/lady-grey/297578/weather-forecast/297578>
- Schwellnus M, Kipps C, Roberts WO, et al. Medical encounters (including injury and illness) at mass community-based endurance sports events: an international consensus statement on definitions and methods of data recording and reporting. *Br J Sports Med.* 2019;53(17):1048–1055. doi: 10.1136/bjsports-2018-100092
- Jooste M, van Rensburg J, Scheer DC, et al. One in five trail running race entrants sustained an injury in the 12 months training period before the 2021 Mac Mac ultra race. *Appl Sci.* 2023;13(17):9586. doi: 10.3390/app13179586
- Viljoen C, du Toit E, van Niekerk T, et al. Training for shorter ultra-trail races results in a higher injury rate, a more diverse injury profile, and more severe injuries: 2022 Mac ultra races. *Phys Ther Sport.* 2024;65:7–13. doi: 10.1016/j.ptsp.2023.10.004
- Viljoen CT, Janse van Rensburg DC, Verhagen E, et al. Clinical characteristics, and risk factors for running-related injuries among

- south African trail runners. *Int J Environ Res Public Health*. 2021;18(23):12620. doi: [10.3390/ijerph182312620](https://doi.org/10.3390/ijerph182312620)
28. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo sports trauma research centre (ostrc) overuse injury questionnaire. *Br J Sports Med*. 2013;47(8):495–502. doi: [10.1136/bjsports-2012-091524](https://doi.org/10.1136/bjsports-2012-091524)
29. Asplund CA, O'Connor FG, Noakes TD. Exercise-associated collapse: an evidence-based review and primer for clinicians. *Br J Sports Med*. 2011;45(14):1157–1162. doi: [10.1136/bjsports-2011-090378](https://doi.org/10.1136/bjsports-2011-090378)
30. Schwellnus M. *Olympic textbook of medicine in sport*. Vol. 508. Chichester: Blackwell Publishing Ltd; 2008.
31. Killopps J, Schwellnus M, Janse van Rensburg DC, et al. Medical encounters, cardiac arrests and deaths during a 109 km community-based mass-participation cycling event: a 3-year study in 102 251 race starters-SAFER IX. *Br J Sports Med*. 2020;54(10):605–611. doi: [10.1136/bjsports-2018-100417](https://doi.org/10.1136/bjsports-2018-100417)
32. Bahr R, Clarsen B, Derman W, et al. International Olympic committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including stroke extension for sport injury and illness surveillance (STROBE-SIIS)). *Br J Sports Med*. 2020;54(7):372–389. doi: [10.1136/bjsports-2019-101969](https://doi.org/10.1136/bjsports-2019-101969)
33. McEwan L, McKay T, Baker M. Trail running: exploring south africa's serious leisure economy. *Afr J Hosp Tour And Leisure*. 2020;9(6):1027–1043. doi: [10.46222/ajhtl.19770720-66](https://doi.org/10.46222/ajhtl.19770720-66)
34. Dudziński K, Mulsson M, Cabak A. The effect of limitation in ankle dorsiflexion on knee joint function. a pilot study. *Ortop Traumatol Rehabil*. 2013;15(2):159–168. doi: [10.5604/15093492.1045944](https://doi.org/10.5604/15093492.1045944)
35. Hamill J, Hercksen J, Salzano M, et al. The prevalence of injuries in trail running: influence of trails, terrains and footwear. *Footwear Sci*. 2022;14(2):113–121. doi: [10.1080/19424280.2022.2048901](https://doi.org/10.1080/19424280.2022.2048901)
36. Damoisy JB, Destombes V, Savina Y, et al. Epidemiology, prevention methods, and risk factors of foot blisters in French trail ultramarathons. *J Sports Med Phys Fitness*. 2023;63(8):921–926. doi: [10.23736/s0022-4707.23.14937-1](https://doi.org/10.23736/s0022-4707.23.14937-1)
37. Scheer BV, Reljic D, Murray A, et al. The enemy of the feet: blisters in ultraendurance runners. *Journal Of The American Podiatric Medical Association*. 2014;104(5):473–478. doi: [10.7547/0003-0538-104.5.473](https://doi.org/10.7547/0003-0538-104.5.473)
38. Millet GP, Jornet K. On top to the top-acclimatization strategy for the “fastest known time” to mount everest. *Int J Sports Physiol Perform*. 2019;14(10):1438–1441. doi: [10.1123/ijspp.2018-0931](https://doi.org/10.1123/ijspp.2018-0931)
39. Khodaei M, Ansari M. Common ultramarathon injuries and illnesses: race day management. *Current Sports Medicine Reports*. 2012;11(6):290–297. doi: [10.1249/JSR.0b013e318272c34b](https://doi.org/10.1249/JSR.0b013e318272c34b)
40. Joslin J, Mularella J, Bail A, et al. Mandatory rest stops improve athlete safety during event medical coverage for ultramarathons. *Prehosp. Disaster Med*. 2016;31(1):43–45. doi: [10.1017/s1049023x15005555](https://doi.org/10.1017/s1049023x15005555)
41. Viljoen CT, Sewry N, Schwellnus MP, et al. Independent risk factors predicting gradual onset injury in 2824 trail running race entrants: SAFER XVIII study. *Wilderness Environ Med*. 2021;32(3):293–301. doi: [10.1016/j.wem.2021.04.002](https://doi.org/10.1016/j.wem.2021.04.002)