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Illness is common in trail runners during training: a prospective cohort study

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ABSTRACT

Objectives: Trail runners often experience illness during event preparation. We aimed to prospectively determine prevalence, incidence, clinical characteristics, severity (time-loss, burden) and associated illness risk factors amongst South African male and female recreational trail runners of different ages over a 30-week training period.
Design: Prospective cohort.
Methods: Illness and training data from 152 trail runners (120 males, 32 females) were collected every 14 days over 30 weeks using the updated OSTRC-H questionnaire. Illness prevalence (%), incidence (I: per 1000 trail running exposure-days), incidence ratio (IR), severity [% time-loss; illness burden (IB: days lost/1000 trail running exposure-days)], and associated risk factors are reported.
Results: Over 30 weeks, 52 % of runners reported illness, with a mean two-week all-illness prevalence of 10.1 %. The overall illness incidence was 7.2 (95 % CI: 5.7–9.2). The winter-to-summer IR was 1.6 ($p = 0.022$). Illness incidence in females ($I = 9.7$) was higher than in males ($I = 6.6$), with a female:male IR of 1.5 ($p < 0.05$). Most illnesses affected the respiratory (64.3 %), digestive (15.9 %) and musculoskeletal (5.7 %) systems. Moderate illness severity (8–28 days time-loss) occurred in 29.3 % of runners. The overall IB was 43.2 days lost. BMI ≥25 kg/m^2 was associated with illness, but no significant illness risk factors were identified via Poisson regression.
Conclusions: During a 30-week training period, 52 % of runners reported illness, with a higher incidence in females. The respiratory tract accounted for > 60 % of illnesses. One in three trail runners experienced > one week time-loss. A higher BMI > 25 kg/m^2 was associated with illness. Further research is needed to identify risk factors and develop prevention strategies.

Practical implications

- Prioritise respiratory health monitoring
- Screen for high-risk profiles early
- Tailor strategies for females and higher-BMI runners
- Inform trail running guidelines

1. Introduction

Trail running is a popular outdoor running mode categorised as off-road running.[1] The International Trail Running Association (ITRA) defines trail running as running primarily on natural terrains, such as forests, mountains, or deserts, with no more than 20 % of the route on paved roads.[2] It often involves longer distances and significant elevation changes.[1,2] Trail runners are exposed to environmental hazards, including extreme weather, water crossings, insect-borne infections, and wildlife.[3] Participants often must be self-sufficient or semi-self-sufficient concerning clothing, communication, and nutrition.[1]

Although running, including trail running, offers positive health benefits,[4,5] runners frequently participate in remote environments associated with higher physical demands and potential risks of serious injury, illness, and even death.[6–9] Current literature mainly addresses

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illness medical encounters (MEs) in trail runners on race days. During the 2023 World Mountain and Trail Running Championships, 16 % of athletes from the Spanish and French trail running teams reported illness, and 12 % were forced to withdraw due to major health issues.[10] A recent systematic review found that the overall illness incidence ranged between 65.0 and 95.4 illnesses/1000 running hours, with trail runners mostly reporting digestive system symptoms such as nausea and vomiting.[6]

Training load changes may increase an athlete's risk of injury and illness.[11] Whilst training for extreme conditions, the training load often increases in race preparation, subsequently increasing the trail runner's susceptibility to illness.[10] Exercise intensity also contributes to a change in core body temperature.[12] A slight decrease in hydration levels can negatively affect physiological functioning and performance during trail running in hot conditions.[12] The remote locations, steep elevations, descents, and logistical problems to evacuate trail runners with illness encounters justify the need for clear information specifically on illness amongst trail runners during their training and race preparation.[1,3,13] The inability to complete a race was associated with an existing pre-race acute systemic illness amongst road runners.[13]

The current body of literature on trail running primarily addresses running-related injuries[9,14–16] and, to a lesser extent, illness,[17] with most studies focusing on occurrences either immediately before or during race-day events.[6] Only one study specifically explored the frequency of injuries and illnesses in trail runners during the four weeks of training immediately preceding a competition.[18] This study also compared illness rates between male and female trail runners and found no differences between the sexes.[18] However, no studies have prospectively investigated the incidence or burden of illness in trail runners during training, nor have any explored the association between age and illness risk in this athletic population. This study aimed to address these gaps by prospectively determining the prevalence, incidence, clinical characteristics and illness severity (time-loss and burden) amongst South African male and female trail runners across various age groups over a 30-week training period. Additionally, the study also explored the potential associations and risk factors for illness amongst trail runners.

2. Methods

2.1. Study design

A prospective cohort study was conducted amongst recreational trail runners in South Africa between 20 November 2018 and 19 August 2019. This study formed part of an investigation that focused on the epidemiology, clinical characteristics, and associated injury risk factors amongst trail runners and followed the same methodology.[19]

2.2. Participants and data collection

The updated Oslo Sports Trauma Research Center Questionnaire for Health Problems (OSTRC-H) was used once every 14 days to collect illness and training history data.[20] South African recreational trail runners were targeted via selected social media platforms, TRAIL magazines, and the South African trail running organisation. Participants had to be 18+ years old, training towards a trail race of 21 km or more, reflecting a clear intent to train mainly on trail terrain. Individuals had to be proficient in English and have fortnightly email access (once every 14 days) to enable them to receive the secure link to the follow-up questionnaires. Participants were not excluded based on the type or amount of training in preparation for their selected race. Respondents who submitted an incomplete baseline questionnaire or did not submit at least one follow-up questionnaire were excluded from the study. The study was approved by the Research Ethics Committee of the Faculty of Health Science at the University of Pretoria approved this study (REC469/2018) and conducted in accordance with the Declaration of Helsinki.

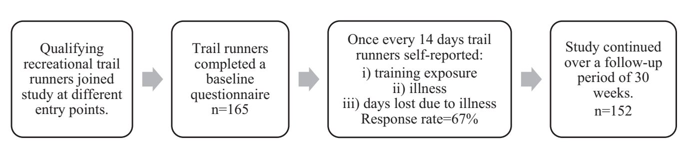
The information and consent form and baseline questionnaire (Supplementary File S1: Online consent form and baseline questionnaire) were completed using any internet-connected device, such as a computer, tablet, or smartphone. Responses were automatically recorded and stored in real-time on the Qualtrics platform. Baseline demographic information (sex, age and weight), running experience (years of actively running, years of trail running), training history and current chronic conditions were recorded. Standard BMI categories were used.[21,22] Data from the baseline questionnaire were used to screen for eligibility to participate in the study.

Subsequently, participants received a link via email once every 14 days to an online follow-up questionnaire hosted on the Qualtrics platform (Supplementary File S2: Online follow-up questionnaire). This process continued for a constant follow-up period of 30 weeks. In each questionnaire, trail runners provided self-reported data covering the previous two weeks, including the following information: (1) training exposure [total number of training sessions on trails (n) and road (n); total running distance (km); average running pace (min/km)]; (2) illness (body system, any symptoms and specific clinical diagnoses), new and recurring over the preceding two weeks; (3) time-loss illness (no time-loss, time-loss ≥1 day), and illness severity in time clusters of mild (1–7 days), moderate (8–28 days) and severe (>28 days). Participants not responding to the email within three days received a reminder email in an attempt to gather missing data.

Dynamic sampling allowed participants to enter the study at different time points with a constant follow-up period of 30 weeks, i.e. the first "two-week period" for one participant aligned with the first "two-week period" for another participant.

In this study, illness was defined as a health problem experienced by participants unrelated to an injury.[23] Runners presenting with illness were included in the analysis regardless of the presence of concurrent injury. Injury data were recorded but not analysed, as the study focuses exclusively on illness. Since athletes remain at risk of contracting illnesses outside of sport participation, exposure for the period of participation in this study, rather than time engaged in training, was considered.[23] If athletes enrolled with an illness, it was counted as a new illness. Accounting for the potentially prolonged nature of illness symptoms when calculating incidence rates, illnesses were considered recurring if the same person reported the same illness within a 4-week period. Illness reported outside of the 4-week period was recorded as new illnesses. In participants suffering from more than one illness, the first illness was recorded as the primary illness and the second illness as a secondary illness. Trail runners were grouped into males and females, and the following age categories: Open (18–39 years), Veterans (40–49 years) and Masters (50+ years). Trail runners who did not report any illness in the two weeks before data collection were classified as part of the non-ill control group, against whom comparisons were made.

2.3. Participant flow diagram



2.4. Outcome measures

The *response rate* (%) for the 15 two-week periods was calculated by dividing the number of respondents by the total number of invites for each period, averaged across the 15 time periods. If participants failed to respond within a two-week interval, it was considered a "no response". These participants were not included in calculating response rate results within each two-week period.

For *trail running exposure*, the average running pace (min/km) multiplied by the running distance (km) was used to calculate the mean running duration (hours) for each specific two-week period. A period of 60 min running was recorded as 1 h exposure.

The *illness prevalence* (% runners; 95 % CI) was calculated by dividing the number of participants reporting an illness by the total number of respondents during each specific two-week period multiplied by 100. The mean prevalence was calculated by totalling the illness prevalence across all two-week periods and dividing the total by the number of two-week periods.

Total *running exposure-days* was calculated as the total number of two-week exposure periods completed by the runner multiplied by 14 days, indicative of the assessment period, e.g. if a participant completed all 15 two-week exposure periods, each lasting 14 days, the total exposure-days would be 210. Exposure-days were used to calculate *illness incidence* (per 1000 trail running exposure-days; 95 % CI) for all new and recurrent illnesses. The *incidence ratio* (IR; 95 % CIs) is a relative difference measure used to compare the incidences of illnesses between two different groups, as reported by the IOC consensus statement.[19]

The *frequency of illness* (n; %) for body systems, clinical symptoms, specific diagnoses, time-loss illness, and illness severity time clusters was reported as specified by the 2020 International Olympic Committee (IOC) consensus statement for methods of reporting epidemiological data of illness in sports.[23]

Time-loss was documented two-weekly at the time of entry and categorised as no time-loss or ≥1-day time-loss to running or training. For *illness severity*, time-loss was grouped in time clusters of mild (1–7 days), moderate (8–28 days) and severe (>28 days). *Illness burden* (IB) was reported as the number of days lost per 1000 trail running exposure-days (95 % CI).

Regarding *associated illness risk factors* in trail running, the participants' demographic profile (sex, age and BMI), running experience (years of actively participating in running, years of trail running), chronic disease, and two-weekly running exposure (number of running sessions, hours of running, running distance, and running pace) were used.

2.5. Statistical analysis

All data were analysed via counts using SAS statistical software (version 9.4; Cary, NC), with only complete forms included. The response rate (%) for each of the two-week periods (total of 15 periods), baseline demographics, running experience and medical history of all participants are presented as mean (SD) or counts.[19] Participants' running exposure for frequency, distance and duration of running are presented as mean and 95 % CI. Illness data were reported as the total number of illnesses, percentage of total illness, total number of athletes with an illness, illness prevalence and illness incidence for total participants, male and female participants, age categories, and further categorised as new or recurring illnesses. Illness incidence for running-related variables is categorised by the 25th, 50th and 75th percentiles. Frequency and illness incidence for the primary organ systems, and frequency of a specific diagnosis and doctor confirmed diagnosis are also provided. The Chi-square test was used to explore statistically significant associations between demographic and training-related variables of males vs. females (road and trail running experience, presence of chronic disease, two-weekly frequency of running sessions, distance run, and duration of running). Incidence analyses were performed using Poisson regression with the PROC GENMOD procedure and a log link function. To account for trail runners who reported multiple illnesses during the prospective study period, a repeated subject statement was incorporated into the model. All results reported were from univariate Poisson models and included a scale parameter, due to some modest overdispersion. Univariate unadjusted incidence (with 95 % CI) was reported for overall illness, as well as by sex, age, and affected organ systems. The IR (with 95 % CI) was provided where significant differences were observed between subgroups. Seasonal illness incidence was calculated for the summer/spring and winter/autumn months with an associated IR. A Chi-square test was used to explore if associations between ill and non-ill participants existed for age category, BMI category (<25.0 and ≥25.0 kg/m^2), running experience, trail running experience and previous chronic disease. Risk factors for illness were investigated using Poisson regression modelling. Only variables showing a significant univariate association were included in the model, and gender and age categories were adjustment variables. Significance was set at $p \leq 0.05$.

3. Results

3.1. Response rate

Of the 165 runners who completed the baseline questionnaire, 152 were eligible (92.1 %). The mean participant response rate over 15 two-week periods was 67.4 % (95 % CI: 59.8–74.9). The lowest response rate was recorded in the 15th period (37.5 %) and the highest in 1st period (100 %). Overall, 1660 questionnaires were received, of which 74 were incomplete, and 26 had no follow-up questionnaires.

3.2. Demographics and trail running exposure

In total, 152 qualifying participants [78.9 % males (n = 120); 21.1 % females (n = 32)] completed 1560 valid questionnaires over 15 two-week periods. Although 41.4 % (n = 63) of runners had more than 5 years of total running experience, only 16.4 % (n = 25) had similar years of experience in trail running. Twenty-six (17.1 %) participants reported having a chronic disease, including hypercholesterolemia (28.9 %), hypertension (21.1 %), asthma (18.4 %), hypothyroidism (7.9 %), and diabetes (5.3 %). The mean running session frequency was 6.5 (95 % CI: 6.0–7.0), considering all forms of running per two-week period. The mean trail running session frequency per two-week period was 2.6 (95 % CI: 2.3–3.0). On average, participants ran distances of 70.2 km (95 % CI: 62.8–77.7) with an average running duration of 6.5 h (95 % CI: 5.8–7.1). The BMI amongst males was significantly higher compared to females ($p < 0.001$) (Table 1).

3.3. Prevalence and incidence of illness

In total, 79 participants (52 %) contracted 157 illnesses in the 30 weeks. A total of 121 new illnesses and 36 recurring illnesses were recorded. Of the 157 illnesses reported, 154 (98.1 %) were primary, and 3 (1.9 %) were secondary. The mean prevalence of all illnesses assessed every two weeks was 10.1 % (95 % CI: 8.6–11.5). Females had a higher mean prevalence for illness, 13.1 % (95 % CI: 9.5–17.0), than males, 8.9 % (95 % CI: 7.6–10.8).

The incidence of all illnesses was 7.2/1000 trail running exposure-days (95 % CI: 5.7–9.2). Females presented with a statistically significantly higher illness incidence (9.7/1000 trail running exposure-days) than males (6.6/1000 trail running exposure-days). The IR of females to males was 1.5 (95 % CI: 0.9–2.5; $p < 0.05$) (Table 2). Illness incidence was significantly higher in autumn/winter (8.8; 95 % CI: 6.6–11.7) compared to spring/summer (5.7; 95 % CI: 4.3–7.6), with a winter-to-summer IR of 1.6 (95 % CI: 1.1–2.2; $p = 0.022$).

3.4. Incidence of new and recurring illness between age groups

There was no statistically significant difference in the illness incidence between the age categories of participants who reported new and recurring illnesses. Although not statistically significant, runners aged 18–39 years had a lower incidence of all (IR = 0.8), and new illnesses (IR = 0.7), but a higher incidence of recurring illnesses than the 50+ aged runners (IR = 1.3). Similarly, the 40–49 age category had a 21 % and 30 % lower incidence for all illnesses and new illnesses, and a 32 % higher incidence for recurring illness, compared to the 50+ aged trail runners (Table 3).

Table 1
Baseline data (demographic profile, running experience, medical history) and trail running exposure (frequency, distance, and duration of running) of all study participants over 15 two-week periods (n = 152).

Characteristics		All participants n = 152	Female n = 32	Male n = 120	p-Value (Male vs. female)
Baseline data (demographic profile, running experience, medical history)					
Age (yrs) Mean (SD)		37.1 (9.1)	35.9 (8.8)	37.4 (9.2)	0.402
Height (cm) Mean (SD)		177.6 (8.4)	167.8 (5.6)	180.2 (7.0)	<0.001[a]
Weight (kg) Mean (SD)		76.3 (11.7)	63.4 (7.3)	79.7 (10.2)	<0.001[a]
BMI (kg/m^2) Mean (SD)		24.1 (2.8)	22.5 (2.4)	24.6 (2.7)	<0.001[a]
Total running experience *n* (%)	0–2 yrs	37 (24.3)	10 (31.2)	27 (22.5)	0.396
	>2 to 5 yrs	52 (34.2)	8 (25.0)	44 (36.7)	
	>5 yrs	63 (41.4)	14 (43.8)	49 (40.8)	
Trail running experience *n* (%)	0–2 yrs	66 (43.4)	12 (37.5)	54 (45.0)	0.745
	>2 to 5 yrs	61 (40.1)	14 (43.8)	47 (39.2)	
	>5 yrs	25 (16.4)	6 (18.8)	19 (15.8)	
Chronic disease[b] *n* (%)	Yes	26 (17.1)	7 (21.9)	19 (15.8)	0.588
	No	126 (82.9)	25 (78.1)	101 (84.2)	
Trail running exposure (frequency, distance, and duration of running)					
Frequency (running sessions/two-week period) Mean (95 % CI)		6.5 (6.0–7.0)	6.4 (5.3–7.6)	6.5 (5.9–7.1)	0.744
Frequency (trail running sessions/two-week period) Mean (95 % CI)		2.6 (2.3–3.0)	2.5 (1.9–3.0)	2.6 (2.2–3.1)	0.909
Distance (km/two-week period) Mean (95 % CI)		70.2 (62.8–77.7)	59.1 (45.7–72.5)	73.2 (64.5–81.9)	0.175
Duration (h/two-week period) Mean (95 % CI)		6.5 (5.8–7.1)	5.8 (4.7–6.9)	6.7 (5.9–7.4)	0.419

n – number of runners; % – percentage; mean (SD) – standard deviation; mean (with 95 % confidence interval); BMI – body mass index; p-value – male vs. female study participants.
[a] Statistically significant.
[b] Chronic disease: A disease or condition of long duration and generally slow progression that requires ongoing medical attention.[24]

3.5. Illness organ systems

Table 4 presents the frequencies (n; %) of all illnesses and all athletes with illnesses in categories of the main organ system. The highest incidence of illness (per 1000 trail running exposure-days) was reported for the respiratory 4.7 (95 % CI: 3.6–6.1), digestive 1.2 (95 % CI: 0.7–1.8) and musculoskeletal 0.4 (95 % CI: 0.2–0.8) systems.

3.6. Diagnosis of illness (self-reported)

A specific diagnosis was self-reported in 82 (52 %) illness cases. In 49 (60 %) of these cases, a medical doctor made the diagnosis, 25 (31 %) were self-diagnosed, and 8 (10 %) were diagnosed by other health care professionals (Supplementary File S3: Table S1A: Specific diagnoses of a self-reported illness). Based on doctors' diagnoses of specific

Table 2
Total number (n) of questionnaire responses that reported an illness (new and recurring), prevalence (%), and illness incidence (per 1000 trail running exposure-days; with 95 % CI).

	Illness[a]	All participants (*n* = 152)	Female (*n* = 32)	Male (*n* = 120)	IR (95 % CI)	p-Value
All illnesses	Number of illnesses registered (n)	157	43	114	–	–
	Number of runners with illness (n)	79	17	62	–	–
	Illness prevalence Mean (95 % CI)	10.1 (8.6–11.5)	13.1 (9.5–17.0)	8.9 (7.6–10.8)	–	–
	Illness incidence per 1000 trail running exposure-days (95 % CI)	7.2 (5.7–9.2)	9.7 (6.3–15.0)	6.6 (5.0–8.7)	1.5 (0.9–2.5)	<0.05[b]
New illness	Number of illnesses registered (n)	121	31	90	–	–
	Number of runners with illness (n)	78	17	61	–	–
	Illness prevalence Mean (95 % CI)	7.5 (6.1–8.9)	9.5 (6.2–12.7)	6.6 (5.2–7.9)	–	–
	Illness incidence per 1000 trail running exposure-days (95 % CI)	5.6 (4.6–6.8)	7.0 (4.8–10.3)	5.2 (4.2–6.5)	1.4 (0.9–2.1)	0.189
Recurring illness	Number of illnesses registered (n)	36	12	24	–	–
	Number of runners with illness (n)	18	8	10	–	–
	Illness prevalence Mean (95 % CI)	2.3 (1.6–3.1)	3.5 (1.5–5.6)	2.0 (1.2–2.8)	–	–
	Illness incidence per 1000 trail running exposure-days (95 % CI)	1.7 (0.9–3.0)	2.7 (0.1–5.5)	1.4 (0.6–3.0)	2.0 (0.7–5.7)	0.258

n – number of runners; % – percentage; *I* – incidence (per 1000 trail running exposure-days); IR – incidence ratio; 95 % CI – 95 % confidence interval; p-value – male vs. female study participants.
[a] Data was collected every 14 days. In 11 instances, the runners registered 14 days of training lost; in 1 instance, the runner registered 15 days of training lost. No repeat illness or overlap period was registered for any of these runners. One runner registered 30 days of training lost. There was an overlap in this instance, but different primary organ systems were affected, and therefore, these were considered two different first-time illness entries.
[b] Statistically significant.

Table 3
Incidence of new and recurring illness by age group for trail runners who reported an illness.

	Age group (years)	All participants (n = 152)	Number of runners with illness (n = 79)	Proportion of runners with illness (%)	Total number of illnesses (%)	Incidence/1000 trail running exposure-days (95 % CI)	IR (95 % CI)	p-Value
All illnesses	Age 18–39	102	47	46.1	101 (64.3)	7.1 (5.2–9.8)	0.8 (0.5–1.5)	0.501
	Age 40–49	33	20	60.6	36 (22.9)	6.9 (4.3–10.9)	0.8 (0.4–1.6)	0.491
	Age 50+	17	12	70.6	20 (12.7)	8.7 (5.3–14.2)	Ref	–
New illness	Age 18–39	102	46	45.1	77 (63.6)	5.4 (4.2–7.1)	0.7 (0.4–1.2)	0.247
	Age 40–49	33	20	60.6	27 (22.3)	5.2 (3.8–7.0)	0.7 (0.4–1.2)	0.195
	Age 50+	17	12	70.6	17 (14.0)	7.4 (4.7–11.6)	Ref	–
Recurring illness	Age 18–39	102	13	12.7	24 (66.7)	1.7 (0.9–3.2)	1.3 (0.3–5.6)	0.728
	Age 40–49	33	3	9.1	9 (25.0)	1.7 (0.4–7.8)	1.3 (0.2–9.7)	0.788
	Age 50+	17	2	11.8	3 (8.3)	1.3 (0.4–4.8)	Ref	–

n – number of runners; % – percentage; age categories – Open (18–39 years), Veterans (40–49 years), Masters (50+ years); incidence (per 1000 trail running exposure-days); IR – incidence ratio; 95 % CI – 95 % confidence interval; p-value *Ref* – age 50+ category.

illnesses, males (61 %), the autumn/winter season (51 %), and individuals with a normal (49 %) or overweight (37 %) BMI showed the highest rates of illness. Respiratory illness was most frequent amongst these groups (45 %, 37 %, 35 % and 20 %, respectively). Digestive issues were slightly more common in females (6 %), and during spring/summer (10 %) (Supplementary File S3: Table S1B: Specific diagnoses of an illness by a medical doctor.

3.7. Severity of illness (time-loss and illness burden)

Of all 157 illnesses reported during the study period, 150 illnesses (95.5 %) prevented trail runners from training for an estimated period of ≥1 day (time-loss due to illness). Of those causing time-loss, 106 (70.7 %) required 1–7 days exclusion from training, followed by 43 (28.7 %) classified as moderate (8–28 days lost) and 1 (0.7 %) as severe (>28 days). This one serious illness involved the brain and nervous system, and the diagnosis was depression.

The overall illness burden (IB) was 43.2 days lost per 1000 trail running exposure-days (95 % CI: 33.5–55.9). Participants older than 50 had the highest IB, but the IB between age categories was not statistically significantly different ($p = 0.915$). Females had a higher IB than males, but the difference was not statistically significant ($p = 0.149$) (Table 5).

Table 4
Primary illness organ system and incidence of illness (per 1000 trail running exposure-days; with 95 % CI).

Primary organ system	Number of participants with illness[a]	Number of illnesses n (%)	Incidence/1000 trail running exposure-days (95 % CI)
Total	79	157 (100)	7.2 (5.7–9.2)
Respiratory	61	101 (64.3)	4.7 (3.6–6.1)
Digestive	9	25 (15.9)	1.2 (0.7–1.8)
Musculoskeletal	5	9 (5.7)	0.4 (0.2–0.8)
Brain & nervous	3	6 (3.8)	0.3 (0.1–0.6)
Heart & blood vessels	2	2 (1.3)	–
Kidney & bladder	2	2 (1.3)	–
ENT	1	1 (0.6)	–
Metabolic & endocrine	1	1 (0.6)	–
Skin	1	1 (0.6)	–
Unknown	5	9 (5.7)	0.4 (0.2–0.8)

n – number; % – percentage; incidence (with 95 % confidence interval); ENT – ear, nose & throat.
[a] Three runners listed a secondary illness.

Table 5
The illness burden (IB; days lost per 1000 trail running exposure-days; with 95 % CI) of illness over 15 two-week periods.

Illness burden (IB)	Number of illnesses n = 157 (%)	IB days lost/1000 trail running exposure-days (95 % CI)	p-Value
Overall IB	157	43.2 (33.5–55.9)	
Age (years)			
Age 18–39	101 (64.3)	42.1 (29.5–60.1)	0.915
Age 40–49	36 (22.9)	43.9 (28.7–67.2)	
Age 50+	20 (12.7)	48.3 (29.1–80.3)	
Sex			
Female	43 (27.4)	58.8 (37.2–28.6)	0.149
Male	114 (72.6)	39.3 (29.0–53.2)	

n – number of illnesses; % – percentage; age categories – Open (18–39 years), Veterans (40–49 years), Masters (50+ years); IB – illness burden (days lost per 1000 trail running exposure-days) (with 95 % confidence interval).

3.8. Association of age category, BMI category, pre-existing chronic disease, all running experience and trail running experience between ill and non-ill runners

Associations between trail runners reporting or not reporting an illness were investigated under the following categories: demographic profile, running experience, and medical history. There was a statistically significant association between the BMI category of trail runners ($p = 0.011$) and whether they had an illness or not. Sixty-six percent of trail runners with a BMI exceeding 25 kg/m^2 were ill during the prospective study period, whilst only 44 % of trail runners with a BMI lower than 25 kg/m^2 were ill. No statistically significant association existed between participants who reported illness and those who did not, with respect to sex ($p = 0.883$), age ($p = 0.092$), prior running experience ($p = 0.406$), prior trail running experience ($p = 0.152$), and pre-existing chronic disease ($p = 0.858$) (Table 6).

Table 6
Chi-square analysis of the association between ill and not-ill trail runners for age category, BMI, total running experience, trail running experience and previous chronic disease.

Characteristics		Ill n (%)	Not-ill n (%)	Chi-square p-value
Sex	Male	62 (51.7)	58 (48.3)	0.883
	Female	17 (53.1)	15 (46.9)	
Age (years)	Age 18–39	47 (46.1)	55 (53.9)	0.092
	Age 40–49	20 (60.6)	13 (39.4)	
	Age 50+	12 (70.6)	5 (29.4)	
BMI (kg/m^2)	<25 kg/m^2	44 (44.4)	55 (55.6)	0.011[a]
	≥25 kg/m^2	35 (66.0)	18 (34.0)	
Total running experience	0–2 yrs	16 (43.2)	21 (56.7)	0.406
	>2 to 5 yrs	27 (51.9)	25 (48.1)	
	>5 yrs	36 (57.1)	27 (42.9)	
Trail running experience	0–2 yrs	34 (51.5)	32 (48.5)	0.152
	>2 to 5 yrs	36 (59.0)	25 (41.0)	
	>5 yrs	9 (36.0)	16 (64.0)	
Chronic disease	No	70 (52.2)	64 (47.8)	0.858
	Yes	9 (50.0)	9 (50.0)	

n – number of runners; % – percentage; BMI – body mass index.
[a] Statistically significant.

Table 7
Overall statistical summary of all results (Tables 2 to 6 as well as Supplementary Table S2).

	Description	Outcomes
Incidence of illness	Sex (*male/female*)	Incidence higher in females than males IR = 1.5; 95 % CI: 0.9–2.5; $p < 0.05$
	Age (*years*)	No significant difference in incidence between age categories
	Season (*autumn/winter vs. spring/summer*)	Incidence higher in autumn/winter than spring/summer IR = 1.6; 95 % CI: 1.1–2.2; $p = 0.022$
Primary organ system:	All diagnoses	Respiratory (64 %)
	Doctor diagnoses	Influenza (27 %) Sinusitis (15 %)
Illness burden	Sex (*male/female*)	No significant difference
	Age (*years*)	No significant difference
Associations (*Ill vs. non-ill*)	Sex (*male/female*)	No significant association
	Age (*years*)	No significant association
	BMI category (*<25 kg/m^2 vs. ≥25 kg/m^2*)	Runners with BMI ≥25 kg/m^2 were associated with illness $p = 0.011$
	Total running experience	No significant association
	Trail running experience	No significant association
	Chronic disease	No significant association
Risk factors	Age category (*years*)	No significant association
	Sex (*male/female*)	No significant association
	BMI category (*kg/m^2*)	No significant association
	Previous chronic disease	No significant association
	Training load:	
	Training sessions	No significant association
	Running distance	No significant association
	Running pace	No significant association
	Training experience:	
	Total running experience	No significant association
	Trail running experience	No significant association

IR – incidence ratio; 95 % CI – 95 % confidence interval.

3.9. Illness incidence and incidence ratio explored for running-related variables (univariate analysis)

The incidence of illness did not show a statistically significant difference with changes in training variables. Specifically, there was no significant change in illness incidence with a two-session increase in the average two-weekly training sessions. Similarly, no significant difference was observed with each 25 km increase in average two-weekly running distance ($p = 0.151$) or with each 1 km/h increase in the average two-weekly running speed ($p = 0.259$) (Supplementary File S4: Univariate analysis).

3.10. Risk factors of illness (multiple regression analysis)

No univariate risk factors [age, gender, BMI, previous chronic disease, training exposure (number of training sessions, running distance or running pace) or running experience (years of actively running, years of trail running] predicted illness incidence. Thus, a multiple regression model was not performed, and no risk factors were identified.

3.11. Summary of all statistical findings

Table 7 provides a summary of all statistical findings.

4. Discussion

This prospective study investigated the incidence, prevalence, clinical characteristics, illness burden and associated illness risk factors amongst South African trail runners. The main findings include that females had a significantly higher incidence of illness than males, the incidence of illness was significantly higher in winter than in summer, the respiratory system is most often affected, a higher percentage of runners with a BMI ≥25 kg/m^2 suffered illness during this period, and training load (number of sessions, running distance, running pace) had no association with illness.

Fifty-two percent of participants contracted an illness across 30 weeks, with a two-week illness prevalence of 10.1 % and an overall illness incidence of 7.2/1000 trail running exposure-days. The majority of these illnesses (60 %) were physician-confirmed, with the remaining cases either self-diagnosed (31 %) or diagnosed by other healthcare professionals (10 %). The only other published study that recorded training data in trail runners reported an illness frequency of 22.3 % in the final 4 weeks before a competition.[18] Although not entirely comparable, some training data are documented for road runners. In a prospective cohort study, 19 % of road runners reported an acute illness in the 8–12 days before an endurance race.[25] In a self-reported study of road runners, 17 % reported an illness episode during the 3 weeks before the Stockholm Marathon in 2000.[26] In endurance athletes from various sport codes during a 16-week winter training period, an illness frequency of 7.2 % was reported.[27] It is important to note that a direct comparison of these illness frequencies may not be entirely valid due to varying definitions of illness across studies and differences in the time periods and seasons over which symptoms were reported. Despite these methodological variations, the data suggest that a notable percentage of trail and other endurance athletes encounter acute illness symptoms within the weeks leading up to a race. Furthermore, trail runners often travel for training and competitions, which may increase their illness risk.[28]

Winter illness incidence was significantly higher ($p = 0.022$) than summer illness incidence, with an IR of 1.6 (1.1–2.2). Illness in athletes shows clear seasonal patterns, with certain illnesses and health risks peaking at specific times of the year. Respiratory infections and allergies are particularly influenced by seasonal changes, which can impact performance and health.[29,30] In elite Finnish runners, mild exercise-induced bronchospasm is closely associated with allergic conditions like asthma and allergic rhinitis. Its occurrence often follows a seasonal pattern. The authors report that training load typically increases with the seasonal transition from winter to summer, intensifying during the precompetitive and competitive periods.[31] During 2018–2019 in South Africa, several seasonal infectious agents affected adults, particularly respiratory viruses. Influenza A (H3N2) was the most significant, with the season running from May to September and peaking between June and August 2019. Respiratory syncytial virus (RSV) showed a defined season from February to mid-May, preceding influenza, and though more common in children, also caused severe infections in adults. Other respiratory viruses, including rhinovirus and parainfluenza, circulated year-round with seasonal peaks, whilst adenoviruses and enteroviruses were present year-round with less seasonality. These pathogens represent key contributors to the annual burden of illness in South African adults and are relevant considerations in our study.[32–36]

An acute systemic illness in the weeks leading up to competition may alter the quantity and quality of training, impact competition performance, lead to health complications, and increase the risk of not completing the race.[18,25,37] In addition, extended periods of high-intensity exercise or a sudden escalation in training load in preparation for a competition may increase the risk of infection (due to immune system changes), thereby enhancing susceptibility to contracting an illness during the event and potentially leading to a subsequent health risk.[11,38] The J-shaped curve hypothesis suggests that moderate training may reduce the risk of illness, whilst very high training loads are associated with an increased risk of infection.[11,39,40] Based on this model, one might expect trail runners with higher training volumes or intensities to experience more illness episodes. Interestingly, our results did not support this pattern; illness prevalence was not clearly associated with higher training load amongst the trail runners studied. This discrepancy may be explained by several factors, including the unique characteristics of our cohort, differences in exposure to environmental factors, athlete fitness, immune system adaptation, or the self-selection of more resilient individuals who can tolerate higher training loads without an increased risk of illness, as has been observed in elite and well-trained populations. Mixed evidence suggests that whilst excessive or rapidly increased training loads may elevate illness risk, well-managed chronic high loads may be protective, indicating a "sweet spot" where optimal training enhances resilience and lowers illness susceptibility.[41–44]

Females had a 50 % higher chance of experiencing illness, with an IR of females to males of 1.5 ($p < 0.05$). Although not statistically significant, females also had a higher IB than males ($p = 0.149$). In another study, male and female trail runners reported similar proportions of illness in the final 4 weeks before a competition.[18] Although not comparable to trail runners, illness did not differ between male and female endurance athletes during a 16-week winter training period.[27] In recent years, illness data published on large cohorts of athletes attending international competitive events suggest that illness episodes are more prevalent in females than males. Further studies are needed to clarify illness incidence in female and male trail runners.

Although not statistically significant, trail runners aged <50 years had a lower incidence of all and new illnesses, but had a higher incidence of recurring illnesses. In contrast, in a study of trail runners competing in a 7-day, 250 km off-road ultra-marathon, each successive 10-year increase in the runner's age was associated with experiencing less than half the number of MEs.[8] Another study on road runners reported at least one infectious illness episode during the two months preceding the Los Angeles Marathon, with younger runners at significantly higher risk.[45] More research is needed to determine the importance of age in contracting an illness during training for a trail event.

The highest frequency of illness affected the respiratory system (64.3 %), followed by the digestive (15.9 %) and musculoskeletal (5.7 %) systems. Although to a lesser extent, these results concur with a study following trail runners in the final 4 weeks before a competition that reported the respiratory tract as the most frequent organ system affected by illness (82.9 %).[18] No studies on trail runners have reported specific illness diagnosis. Amongst road runners, 12.7 % reported respiratory symptoms, 3.5 % gastrointestinal symptoms, and 1.3 % both, during the 8–12 days preceding a race.[25] URI were reported by 40 % of participants in the 1987 Los Angeles Marathon in the 8 weeks before the event.[45] A recent systematic review of trail running events identified the digestive system as the most frequently affected organ system. However, this may reflect a reporting bias, as some studies focused primarily on gastrointestinal symptoms.[6] Amongst road runners training for a half or full marathon, overall illness symptom prevalence ranged from 28.3 % to 71.2 %, with more severe symptoms reported in 12.4 % to 47.5 % of cases.[46] At the 2019 Indian Ocean Island Games, a multisport competition, overall illness prevalence was 6 %, with respiratory conditions being the most common.[47] These findings are consistent with broader evidence from multiple sporting disciplines, indicating that acute respiratory illnesses are the most frequently reported conditions before and during competitive events.[6,18,25–27,48,49] Interestingly, estimates of illness prevalence in non-athletic adult populations suggest an annual prevalence of URI of approximately 22 %.[50,51]

Almost a third (28.0 %) of the reported illnesses caused trail runners a training time-loss of more than one week, with an overall training IB of 43.2 days lost per 1000 trail running exposure-days. No other trail study has defined illness severity in terms of the number of days lost to running or training. Therefore, no comparisons are possible. It is essential to note that interruptions to the training routine and a reduced training load may increase the risk of injury on race day.[52] In addition, a sudden escalation in training load and intensity immediately preceding competition may elevate the risk of immune system changes, heightening the susceptibility to contracting an illness.[11,38] In a prospective cohort study of road runners, the authors found that an acute illness reported in the 8–12 day period before a race increased the risk of not finishing the race by 1.9 times for those runners who started the race.[25] It is crucial to highlight that any illness impairing a trail runner's ability to continue can have serious consequences. For runners who begin an event whilst unwell, these effects may be worsened by the demands of remote mountainous terrain, exposure to extreme weather conditions, and the need to be semi- or fully self-sufficient with limited access to medical support. Future studies should adhere to established guidelines for reporting illness severity, enabling meaningful comparisons across research endeavours.

BMI category (<25 kg/m^2 and ≥ 25 kg/m^2) was significantly associated with having an illness or not ($p = 0.011$). Sixty-six percent of trail runners with a BMI exceeding 25 kg/m^2 were ill, whilst only 44 % of trail runners with a BMI lower than 25 kg/m^2 were ill. Although an association was found between the BMI of ill and non-ill runners, the univariate risk factor analysis showed no significant difference in illness incidence between the two BMI groupings. A study following trail runners in the final 4 weeks before a competition found no differences in BMI between athletes who reported an illness and those who did not.[18] The impact of BMI on health is multifaceted, and athletes with a high BMI may have a different body composition, including a higher proportion of muscle mass, which can influence health outcomes differently than excess body fat alone.[53] Further research is therefore advised.

Demographic information (sex, age, and weight), running experience (years of actively running and years of trail running), training history, and current chronic variables were not identified as risk factors through univariate regression analyses. Larger studies are needed to determine the risk factors identified with illness in trail runners training for an event. Differences in reporting compliance may partly account for the observed sex differences in illness incidence.

4.1. Strengths & limitations

The main strength of our study is the novel prospective cohort design following trail runners over 30 weeks. This is also the first study reporting the incidence, prevalence, clinical characteristics, illness burden and risk factors associated with illness amongst male and female South African trail runners during training. Additionally, our data includes illnesses confirmed by a physician, which enhances the reliability and validity of our findings. Limitations include the fact that in South Africa, most trail running events operate independently of Athletics South Africa, allowing runners to engage without requiring membership to any specific trail running governing body. Due to the absence of a defined population size, a convenience sample was employed, making it challenging to ascertain the representativeness of our study within the broader South African trail-running population. Whilst our internal control group allows for valid comparisons, it remains difficult to compare directly with external population-based studies due to different definitions and self-reporting methods. The study focused specifically on the South African context, where trail runners are exposed to the country's distinctive geographic remote environments, with challenging terrain, variable climatic conditions (such as heat, humidity, or altitude), contaminated or polluted water sources and limited access to immediate medical support. These distinctive circumstances may differ from those in other countries, and caution should be exercised when extrapolating our findings to the global trail-running community. We only included runners training for trail races of at least 21 km to ensure participants intended to run on trail terrain. Nonetheless, we recognise that some may still have conducted a portion of their training on non-trail surfaces. We used an arbitrary cutoff point of 28 days to distinguish between new and recurring illnesses. Also, trail runners estimated time-loss days at the time of illness. Entering the study with an illness was captured as a new illness in the study. This could have led to an overestimation of illness in the first period of the study. We did not capture data on other illness risk factors such as stress, fatigue, or exposure to infections. The added strain of intense or pre-event training may increase runners' susceptibility, particularly to URIs. Also, we did not have a non-athlete control group. Although the sample size was sufficient for meaningful inference and exceeded commonly recommended thresholds for applied research,[54,55] the study may still have been underpowered to detect meaningful inference, and the exploratory findings should therefore be interpreted with caution.

5. Conclusion

This study provides important, novel descriptive information regarding the epidemiology of illnesses in trail runners, utilising a 30-week prospective study design. Illness is common amongst trail runners, and females suffer a significantly higher incidence than males ($p < 0.05$). Illness mainly affects the respiratory system, and has a higher incidence during the winter months. Nearly one in three trail runners experienced moderate illness severity that caused >8 days time-loss across 30 weeks. A higher BMI $> 25\ kg/m^2$ was associated with illness. Future research should investigate risk factors and prevention strategies for illness in trail runners, considering environmental, training, and individual factors, with particular attention to female athletes, BMI, and experience. Our study provides a foundation for exploring how the burden of illness during training can be mitigated.

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CRediT authorship contribution statement

Dina C (Christa) Janse van Rensburg: study concept, study planning, data cleaning, data interpretation, writing of the manuscript (first draft), manuscript review & editing.

Audrey Jansen van Rensburg: study planning, data cleaning, data interpretation, writing of the manuscript (first draft), manuscript review & editing.

Pieter Henk Boer: data cleaning, statistical analysis, data interpretation, writing of the manuscript (first draft), manuscript review & editing.

Precious Serero: data interpretation, manuscript review & editing.

Tanita Botha: data interpretation, manuscript review & editing.

Marlene Schoeman: data interpretation, manuscript review & editing.

Carel Viljoen: study concept and design of the study, study planning, data collection, data cleaning, data interpretation, writing of the manuscript (first draft), manuscript review & editing.

Consent to participate

Informed consent was obtained from all participants involved in this study.

Confirmation of ethical compliance

The Research Ethics Committee of the Faculty of Health Science of the University of Pretoria approved this study (REC469/2018).

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Submission statement

All authors have reviewed and given their consent for this version to be published.

Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data obtained in this study is available upon reasonable request.

References

1. 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.
2. International Trail Running Association [Internet]. Discover trail running. [Dec 2024]. Available from: https://itra.run/About/DiscoverTrailRunning 2013.
3. Laskowski-Jones L, Caudell MJ, Hawkins SC et al. Extreme event medicine: considerations for the organisation of out-of-hospital care during obstacle, adventure and endurance competitions. *Emerg Med J* 2017;34(10):680-685.
4. Lee D-C, Brellenthin AG, Thompson PD et al. Running as a key lifestyle medicine for longevity. *Prog Cardiovasc Dis* 2017;60(1):45-55.
5. Lincoln S. Building resilience through trail running: women's perspectives. *Leisure/Loisir* 2021;45(3):397-421.
6. Viljoen CT, Janse van Rensburg DC, Verhagen E et al. Epidemiology of injury and illness among trail runners: a systematic review. *Sports Med* 2021;51:917-943.
7. Hespanhol Junior LC, Van Mechelen W, Verhagen E. Health and economic burden of running-related injuries in Dutch trailrunners: a prospective cohort study. *Sports Med* 2017;47:367-377.
8. Krabak BJ, Waite B, Schiff MA. Study of injury and illness rates in multiday ultramarathon runners. *Med Sci Sports Exerc* 2011;43(12):2314-2320.
9. Scheer BV, Murray A. Al Andalus Ultra Trail: an observation of medical interventions during a 219-km, 5-day ultramarathon stage race. *Clin J Sport Med* 2011;21(5):444-446.
10. Drew MK, Finch CF. The relationship between training load and injury, illness and soreness: a systematic and literature review. *Sports Med* 2016;46:861-883.
11. Schwellnus M, Soligard T, Alonso J-M et al. How much is too much? (part 2) International Olympic Committee consensus statement on load in sport and risk of illness. *Br J Sports Med* 2016;50(17):1043-1052.
12. Casa DJ, Stearns RL, Lopez RM et al. Influence of hydration on physiological function and performance during trail running in the heat. *J Athl Train* 2010;45(2):147-156.
13. 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;44:1055-1069.
14. Jooste M, Janse van Rensburg DC, Scheer V 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.
15. Viljoen CT, van Rensburg DCCJ, van Rensburg AJ 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.
16. Viljoen C, van Rensburg DCCJ, Van Mechelen W et al. Trail running injury risk factors: a living systematic review. *Br J Sports Med* 2022;56(10):577-587.
17. Boshielo PM, Jansen van Rensburg A, Viljoen C et al. Illness is more prevalent than injury in trail runners participating in a mountainous ultra trail race. *Phys Sportsmed* 2025;53(1):27-35.
18. Gajardo-Burgos R, Monrroy-Uarac M, Barría-Pailaquilén RM et al. Frequency of injury and illness in the final 4 weeks before a trail running competition. *Int J Environ Res Public Health* 2021;18(10):5431.
19. Viljoen CT, Janse van Rensburg DC, Verhagen E et al. Epidemiology, clinical characteristics, and risk factors for running-related injuries among South African trail runners. *Int J Environ Res Public Health* 2021;18(23):12620.
20. Clarsen B, Rønsen O, Myklebust G et al. The Oslo Sports Trauma Research Center questionnaire on health problems: a new approach to prospective monitoring of illness and injury in elite athletes. *Br J Sports Med* 2014;48:754-760.
21. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation*, 2000.
22. Identification EPot, Overweight To, Adults Oi et al. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*, National Institutes of Health, National Heart, Lung, and Blood Institute, 1998.
23. 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 STROBE Extension for Sport Injury and Illness Surveillance (STROBE-SIIS)). *Br J Sports Med* 2020;54(7):372-389.
24. Bernell S, Howard SW. Use your words carefully: what is a chronic disease? *Front Public Health* 2016;4:212747.
25. Van Tonder A, Schwellnus M, Swanevelder S et al. A prospective cohort study of 7031 distance runners shows that 1 in 13 report systemic symptoms of an acute illness in the 8–12 day period before a race, increasing their risk of not finishing the race 1.9 times for those runners who started the race: SAFER study IV. *Br J Sports Med* 2016;50(15):939-945.
26. Ekblom B, Ekblom O, Malm C. Infectious episodes before and after a marathon race. *Scand J Med Sci Sports* 2006;16(4):287-293.
27. He CS, Bishop NC, Handzlik MK et al. Sex differences in upper respiratory symptoms prevalence and oral-respiratory mucosal immunity in endurance athletes. *Exerc Immunol Rev* 2014;20:8-22.
28. Janse van Rensburg DC, Jansen van Rensburg A, Fowler PM et al. Managing travel fatigue and jet lag in athletes: a review and consensus statement. *Sports Med* 2021;51(10):2029-2050.
29. Derman W, Badenhorst M, Eken M et al. Risk factors associated with acute respiratory illnesses in athletes: a systematic review by a subgroup of the IOC consensus on 'acute respiratory illness in the athlete'. *Br J Sports Med* 2022;56(11):639-650.
30. Yeargin SW, Dompier TP, Casa DJ et al. Epidemiology of exertional heat illnesses in National Collegiate Athletic Association athletes during the 2009–2010 through 2014–2015 academic years. *J Athl Train* 2019;54(1):55-63.
31. Bussotti M, Di Marco S, Marchese G. Respiratory disorders in endurance athletes–how much do they really have to endure? *Open Access J Sports Med* 2014:47-63.

32. Reddy B, Simane A, Mthiyane H et al. Prevalence and seasonal patterns of 16 common viral respiratory pathogens during the COVID-19 pandemic in Gauteng Province, South Africa, 2020-2021. *Viruses* 2024;16(8). doi:10.3390/v16081325.
33. The National Institute for Communicable Diseases (NICD) SA [Internet]. *Update on the Influenza season: June 2019*, 2019. [updated 2019–06–25]. Available from: https://www.nicd.ac.za/update-on-the-influenza-season-june-2019/.
34. Public Health Bulletin SA [Internet]. Respiratory pathogen epidemiology from the systematic influenza-like illness and pneumonia surveillance programmes - public health Bulletin south Africa. [updated 2023–03–15]. Available from: https://www.phbsa.ac.za/respiratory-pathogen-epidemiology-from-the-systematic-influenza-like-illness-and-pneumonia-surveillance-programmes/ 2023.
35. Holtz CJ, Fitchett JM. Reconstructing the timing of South Africa's influenza season over the past century from newspaper records. *S Afr Geogr J* 2025;107(2):218-238.
36. Belizaire MRD, N'gattia AK, Wassonguema B et al. Circulation and seasonality of influenza viruses in different transmission zones in Africa. *BMC Infect Dis* 2022;22(1):820. doi:10.1186/s12879-022-07727-2.
37. Gordon L, Schwellnus M, Swanevelder S et al. Recent acute prerace systemic illness in runners increases the risk of not finishing the race: SAFER study V. *Br J Sports Med* 2017;51(17):1295-1300.
38. Gleeson M, Pyne DB. Respiratory inflammation and infections in high-performance athletes. *Immunol Cell Biol* 2016;94(2):124-131.
39. Chamorro-Viña C, Fernandez-del-Valle M, Tacón AM. Excessive exercise and immunity: the J-shaped curve, *The Active Female: Health Issues Throughout the Lifespan*, Springer, 2013. p. 357-372.
40. Craddock N, Buchholtz K, Burgess TL. Does a greater training load increase the risk of injury and illness in ultramarathon runners?: A prospective, descriptive, longitudinal design. *S Afr J Sports Med* 2020;32(1):v32i1a8559. doi:10.17159/2078-516X/2020/v32i1a8559.
41. Drew MK, Finch CF. The relationship between training load and injury, illness and soreness: a systematic and literature review. *Sports Med* 2016;46(6):861-883. doi:10.1007/s40279-015-0459-8.
42. Gabbett TJ. The training—injury prevention paradox: should athletes be training smarter and harder? *Br J Sports Med* 2016;50(5):273-280. doi:10.1136/bjsports-2015-095788.
43. Blume K, Körber N, Hoffmann D et al. Training load, immune status, and clinical outcomes in young athletes: a controlled, prospective, longitudinal study. *Front Physiol* 2018;9:120.
44. Pyne D, Gleeson M, McDonald W et al. Training strategies to maintain immunocompetence in athletes. *Int J Sports Med* 2000;21(Sup 1):51-60.
45. Nieman DC, Johanssen LM, Lee JW et al. Infectious episodes in runners before and after the Los Angeles Marathon. *J Sports Med Phys Fitness* 1990;30(3):316-328.
46. Franke TP, Backx FJ, Huisstede BM. Running themselves into the ground? Incidence, prevalence, and impact of injury and illness in runners preparing for a half or full marathon. *J Orthop Sports Phys Ther* 2019;49(7):518-528.
47. Garnett D, Bholah A, Olivier B et al. The epidemiology of injury and illness amongst athletes at the Indian Ocean Island Games, Mauritius, 2019. *SAJSM* 2021;33(1).
48. Jansen van Rensburg A, Janse van Rensburg DCC, Schwellnus MP et al. Days until return-to-play differ for sub-categories of acute respiratory tract illness in Super Rugby players: a cross-sectional study over 5 seasons (102,738 player-days). *JSAMS* 2021;24(12):1218-1223.
49. Schwellnus M, Derman W, Page T et al. Illness during the 2010 Super 14 Rugby Union tournament — a prospective study involving 22 676 player days. *Br J Sports Med* 2012;46(7):499-504. doi:10.1136/bjsports-2012-091046.
50. Jin X, Ren J, Li R et al. Global burden of upper respiratory infections in 204 countries and territories, from 1990 to 2019. *EClinicalMedicine* 2021;37.
51. Lapi F, Marconi E, Rossi A et al. The burden of recurrent respiratory tract infections in adult population: a population-based study in primary care. *Fam Pract* 2024;41(2):76-85.
52. Horgan BG, Drew MK, Halson SL et al. Impaired recovery is associated with increased injury and illness: a retrospective study of 536 female netball athletes. *Scand J Med Sci Sports* 2021;31(3):691-701.
53. Campa F, Toselli S, Mazzilli M et al. Assessment of body composition in athletes: a narrative review of available methods with special reference to quantitative and qualitative bioimpedance analysis. *Nutrients* 2021;13(5):1620.
54. Capili B, Anastasi JK. Cohort studies. *Am J Nurs* 2021;121(12):45-48. doi:10.1097/01.Naj.0000803196.49507.08.
55. Brydges CR. Effect size guidelines, sample size calculations, and statistical power in gerontology. *Innov Aging* 2019;3(4). doi:10.1093/geroni/igz036.