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ORIGINAL RESEARCH

HealthyTrailsBR – The prevalence of running-related injuries and cramps, and the description of personal and running characteristics in Brazilian trail runners: a cross-sectional study

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Abstract
Background: Physical activity in natural environments, such as trail running, is a way to nurture physical and mental health. However, running has an inherent risk of musculoskeletal injuries.
Objectives: To investigate the prevalence of running-related injuries (RRI) and cramps, and to describe the personal and training characteristics of Brazilian trail runners.
Methods: A total of 1068 trail runners were included in this observational cross-sectional study. The participants had at least six months of trail running experience. The data were collected between April 2019 and February 2020 through an online and self-reported survey.
Results: The point prevalence of RRIs was 39.2 % (95 % credible interval [CrI]: 36.3, 42.1). The body region with the highest point prevalence was the knee. The 12-month period prevalence of RRIs was 69.2 % (95 %CrI: 66.4, 72.0). The body region with the highest 12-month period prevalence was the lower leg. 1- and 12-month period prevalence of cramps was 19.5 % (95 %CrI: 17.1, 21.9) and 36.0 % (95 %CrI: 33.0, 38.8), respectively. Triceps surae was the muscle most affected by cramps.
Conclusions: Two in 5 (40 %) trail runners reported being injured at the time of data collection, and about 2 of 3 reported previous RRIs in the last 12 months. The most prevalent injured body regions were the knee and the lower leg. One in 5 trail runners reported cramps in the last month, increasing to 36 % in the last 12 months. Knowing better the characteristics of the population and the burden of health conditions may inform better decisions regarding implementation actions toward trail running practice.

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Introduction

Since the mid-1990s, trail running has been attracting practitioners and is recognised as an athletics modality by World Athletics.[1] The International Trail Running Association (ITRA) defines trail running as "*a run in a natural environment (mountain, desert, forest) with a minimum of paved roads (must not exceed 20 % of the total route)*".[2] The distances and the unevenness (the difference in altitude between the start and the finish line) vary substantially within the sport.[3] In the United States, the number of trail runners grew from approximately 4.8 million in 2009 to 9.1 million in 2017.[4] The Brazilian Athletics Confederation (CBAt) officially regulated trail running in 2017.[5]

Associating physical activity and the natural environment, such as trail running, has been reported as a way to maintain physical and mental health.[6] Trail running is practiced in natural environments which involves variations in terrain. Therefore, the trail runner deals all the time with biomechanical adaptations during ascents and descents and irregular surfaces.[3,7] Thus, the practice of trail running has an inherent risk of developing injuries.

Some studies have shown the prevalence of running-related injuries (RRI) in trail runners.[8–10] For instance, the mean 2-week period prevalence of RRIs in Dutch trail runners was 22.4 % (95 % confidence interval [CI]: 20.9, 24.0).[11] The point prevalence of RRIs in trail runners was 1.3 % in a study conducted in South Africa.[12] Researchers analysed data from five seasons (between 2015 and 2019) of 20–42 km trail running races and reported 1.6 RRIs per 1000 h of running.[13] Previous history of RRIs and/or cramps is associated with an increased risk of developing such health conditions during trail running events, which could lead to withdrawing of the trail runner from the race.[2]

Knowledge about the injuries affecting sports and society helps in the development of risk control and prevention strategies. For example, a group of researchers measured the burden of RRIs, including the prevalence (i.e., 22.4 % [95 % CI: 20.9, 24.0]), in Dutch trail runners.[11] The knowledge gathered from this study served as a basis for the recommendation and rationale for the development of a specific RRI prevention programme tailored to this populations.[14,15]

The objectives of this study in Brazilian trail runners were: (1) to investigate the point prevalence of RRIs; (2) to describe the most common injured body regions; (3) to investigate the period prevalence of cramps; (4) to describe the most common body regions affected by cramps; (5) to describe the personal and training characteristics; and (6) to investigate the history of previous RRIs.

Methods

Participants and sample size

The sample was composed of Brazilian trail runners, aged 18 or over, and with at least six months of trail running experience. Calls for participation in the study was disseminated through social media (i.e., Facebook, Instagram, Twitter, and WhatsApp) with messages explaining the aims of the study, and with the link to access the online questionnaire. The recruitment was also done in trail running events (for all levels of trail runners), through the distribution of flyers containing a 'quick response' (QR) code and the link to the online questionnaire. The QR code and the link to the questionnaire directed the participant to the online informed consent. Individuals who did not agree to participate in the study were not included in the study.

The *a priori* sample size estimation was based on previous studies that investigated the prevalence of RRIs in Dutch trail runners.[11] With a point prevalence reference value of 0.22 (22 %), with a margin of error of 0.03 (3 %), probability of type 1 error (α) of 0.05, probability of type 2 error (β) of 0.2 (ie, power of 0.8 or 80 %), a sample of at least 733 participants was suggested for the primary outcome of this study, that is, determining the point prevalence of RRIs.[11]

Study design and data collection

This was an observational cross-sectional study conducted between April 2019 and February 2020 in Brazil. This study was approved by the Research Ethics Committee of Universidade Cidade de São Paulo (UNICID), Brazil (protocol CAAE: 00,455,018.0.0000.5377). Data collection was performed through an online questionnaire built on the Typeform® platform.

The questionnaire was built based on previous studies,[11,16] it was entirely self-reported, and it was composed of four parts. Part 1 queried information about personal data, such as age, sex, body mass, height, and educational level. Part 2 was composed of questions regarding training characteristics, such as number of training sessions per week, average weekly mileage, average time per kilometer, and practice of other sports. Part 3 was composed of questions regarding current presence of trail RRIs to determine the point prevalence of injuries at the time of data collection (i.e., at the very moment when the participant was answering the online questionnaire), the affected body regions that were self-reported through options derived from a previous study,[14] and consequences of RRIs injuries, such as training time loss and medical attention. We also asked about the occurrence of cramps in the last month to determine the 1-month period prevalence of cramps and the body regions affected by cramps in an open-ended question. Part 4 was composed of questions regarding the previous history of trail RRIs to determine the period prevalence in the last 12 months, the body region of such injuries, and the training time loss and/or medical attention related to previous RRIs. We also asked about the occurrence of cramps in the last 12 months to determine the 12-month period prevalence of cramps and the body regions affected by cramps in an open-ended question.

Definition of trail running-related injuries

When considering previous definitions of RRIs reported in the literature, and to facilitate comparisons among studies, the following definitions were used in this study: (A) based on a study of Dutch trail runners, RRI was defined as "any disturbance of the musculoskeletal system that the runner attributes to the practice of running (training or competition)"[11];

(B) the time loss definition was based on missing or reducing training for three consecutive training sessions or not training at all for one week; and (C) the medical attention definition was based on seeking consultation with medical professionals, physical therapists, or other health professionals.[11,17]

Data analysis

The data of this study were analysed and summarised with descriptive statistics. Continuous data with evidence of belonging to a Gaussian distribution were described using mean and standard deviation (SD). Continuous non-parametric and discrete data were described using the median and 25 % to 75 % interquartile range (IQR). The dichotomous and categorical data were summarised with proportions and frequency distributions (n), and they were normalised and reported in percentages (%). Bayesian inference was performed to provide evidence of the population distribution (i.e., posterior distribution) of the outcomes based on the data collected. The posterior distributions were summarised with means and 95 % Bayesian highest posterior density credible intervals (CrI).[18] All analyses were performed in R version 4.0.5.[19]

A Gaussian model with unknown variance was implemented for continuous data with evidence of belonging to a Gaussian distribution.[20] A Gaussian non-informative prior with mean=0 and variance=1e6 hyperparameters was used for means, and an inverse-Gamma with *shape*=1 and *scale*=1 hyperparameters was used for variance.[21] Gibbs sampling were applied to obtained the marginal posterior distributions for mean and variance components of the Gaussian models with unknown variances, and the results were summarised using five chains and 20,000 iterations after disregarding the initial 5000 iterations for each chain (i.e., 100,000 samples).[22]

A Gamma−Gamma model was implemented for continuous non-parametric and discrete data using a non-informative prior with hyperparameters α=1/3 and β=1/1e6.[23] A Beta-Binomial model was implemented for dichotomous and categorical data using a non-informative prior with hyperparameters α=1/3 and β=1/3.[24] For the Gamma−Gamma and the Beta−Binomial models, the posterior distributions were summarised by sampling 100,000 samples directly from the posterior distributions.

Results

A total of 2491 people accessed the online questionnaire with 1219 people (48.9 %) submitting responses. Only 2 people (0.2 %) did not consent to participate and, therefore, were not presented with the full questionnaire (i.e., parts 1 to 4). Forty-five people (3.7 %) were not eligible, because of less than six months of trail running experience. A total of 104 responses (8.9 %) were removed because they were duplicates.

In total, 1068 Brazilian trail runners were included in this study. The average time to complete the online questionnaire was 14:41 min (IQR: 8:31, 14:44). Table 1 describes the personal characteristics of the participants. The mean age of the participants was 39.5 (95 %CrI: 39.0, 40.0). A total of 34.6 % (95 %CrI: 31.7, 37.4; *n* = 369) were women and 65.4 % (95 %CrI: 62.6, 68.3; *n* = 699) were men. Most of the trail runners presented a normal body mass index (BMI) (i.e., 18.5≤BMI≤24.9: 71.5 %; 95 %CrI: 68.9, 74.3; *n* = 764). A total of 76.0 % (95 %CrI: 73.4, 78.5; *n* = 812) had a higher education degree.

Before starting to run on trails, 85.1 % (95 %CrI: 83.0, 87.2; *n* = 909) of the participants reported to running on roads. On average, Brazilian trail runners reported to run 1 time per week on trails (95 %CrI 0, 3); 54.3 % (95 %CrI: 51.3, 57.3; *n* = 580) of them reported to run between 2 and 4 h per week on trails; and 49.7 % (95 %CrI: 46.7, 52.7; *n* = 531) reported to run between 5 and 20 km per week on trails (Table 2).

Most of the participants reported trail running experience between 2 and 5 years (53.2 %; 95 %CrI: 50.3, 56.2; *n* = 568), and the preferred distance related to participating in running events was the half marathon (45.6 %; 95 %CrI: 42.6, 48.6; *n* = 487) (Table 3). A total of 58.5 % (95 %CrI: 55.6, 61.5; *n* = 625) of the participants classified themselves as being recreational runners (Table 3). The main motivations to run in general (on and off trails) reported by the participants were: 'feeling of well-being'; 'to have fun'; 'to enhance health'; and 'to enhance performance' (Table 3).

A total of 544 RRIs were reported by 419 injured trail runners. The point prevalence of RRIs was 39.2 % (95 %CrI: 36.3, 42.1; *n* = 419) (Table 4). About 75.2 % (95 %CrI: 71.1, 79.3; *n* = 315) of the injured trail runners reported training time loss or a reduction in training volume, while 80.0 % (95 %CrI: 76.0, 83.6; *n* = 335) required medical attention due to RRIs (Supplementary Online Material Table S1). Regarding the characteristics of the symptoms related to the current RRIs, pain (*n* = 363) was the main symptom, with a prevalence of 34.0 % (95 %CrI: 31.2, 36.9) and representing 86.6 % (95 %CrI: 83.2, 89.7) of the symptoms reported by injured trail runners (Supplementary Online Material Table S1).

The prevalence of cramps in the last month was 19.5 % (95 %CrI: 17.1, 21.9; *n* = 208) and the prevalence of previous cramps (last 12 months) was 36.0 % (95 %CrI: 33.0, 38.8; *n* = 384) (Table 5). The locations of cramps in the last month and in the last 12 months can be found in Table 5 (prevalences) and Supplementary Online Material Table S2 (distribution in injured trail runners).

Discussion

Most Brazilian trail runners were men (65.4 %; 95 %CrI: 62.6, 68.3; *n* = 699) and had trail running experience between 2 and 5 years (53.2 %, 95 %CrI: 50.3, 56.2; *n* = 568). Regarding exposure to trail running, participants reported running on average 1 time per week on trails (95 %CrI: 0, 3), 2 to 4 h/week (54.3 %; 95 %CrI: 51.3, 57.3; *n* = 580), and 5 to 20 km/week (49.7 %; 95 %CrI: 46.7, 52.7; *n* = 531). The overall point prevalence of injuries related to trail running was 39.2 % (95 %CrI: 36.3, 42.2; *n* = 419), with the knee being the most affected site with a point prevalence of 13.4 % (95 %CrI: 11.4, 15.4; *n* = 143).

The results of our study showed a point prevalence of trail RRIs of 39.2 % (95 %CrI: 36.3, 42.2). The estimate found in our study was higher than the findings of a prospective study in Dutch trail runners (22.4 %, 95 %CI: 20.9, 24.0).[11] A

Table 1 Personal characteristics of Brazilian trail runners.

	All $n = 1068$		Men $n = 699$		Women $n = 369$	
Characteristics	Estimate	(95 %CrI)	Estimate	(95 %CrI)	Estimate	(95 %CrI)
Age (years), mean (SD)	39.5 (8.3)	(39.0, 40.0)	39.3 (8.5)	(38.7, 40.0)	39.9 (7.9)	(39.1, 40.7)
Height (cm), mean (SD)	171.3 (9.2)	(170.8, 171.9)	175.9 (6.9)	(175.4, 176.4)	162.7 (6.3)	(162.0, 163.3)
Body mass (kg), mean (SD)	70.3 (12.5)	(69.5, 71.0)	75.7 (11.0)	(74.9, 76.5)	59.9 (7.9)	(59.1, 60.7)
BMI (kg/m^2), % (n)						
Underweight (<18.5)	0.7 (7)	(0.2, 1.2)	0.6 (4)	(0.1, 1.2)	0.8 (3)	(0.1, 1.9)
Normal weight (18.5 to 24.9)	71.5 (764)	(68.9, 74.3)	63.8 (446)	(60.2, 67.3)	86.2 (318)	(82.6, 89.6)
Overweight (25.0 to 29.9)	25.1 (268)	(22.5, 27.7)	32.0 (224)	(28.6, 35.5)	11.9 (44)	(8.8, 15.4)
Obesity (over 30.0)	2.7 (29)	(1.8, 3.7)	3.6 (25)	(2.3, 5.0)	1.1 (4)	(0.2, 2.3)
Educational Level, % (n)						
Incomplete primary education	0.2 (2)	(0.0, 0.5)	0.1 (1)	(0.0, 0.5)	0.3 (1)	(0.0, 1.0)
Complete primary education	0.7 (8)	(0.3, 1.3)	1.0 (7)	(0.3, 1.8)	0.3 (1)	(0.0, 1.0)
Incomplete high school	0.9 (10)	(0.4, 1.6)	1.1 (8)	(0.5, 2.0)	0.5 (2)	(0.0, 1.4)
Complete high school	9.5 (101)	(7.7, 11.2)	10.6 (74)	(8.4, 13.0)	7.3 (27)	(4.8, 10.1)
Incomplete bachelor's degree	12.6 (135)	(10.7, 14.7)	14.4 (101)	(11.9, 17.1)	9.2 (34)	(6.5, 12.4)
Bachelor's degree	34.2 (365)	(31.4, 37.1)	32.6 (228)	(29.3, 36.2)	37.1 (137)	(32.2, 42.0)
Postgraduate degree	33.7 (360)	(30.9, 36.5)	32.0 (224)	(28.6, 35.5)	36.9 (136)	(32.0, 41.8)
Master's degree	6.1 (65)	(4.7, 7.6)	6.3 (44)	(4.6, 8.2)	5.7 (21)	(3.6, 8.3)
Doctorate degree	2.1 (22)	(1.3, 3.0)	1.7 (12)	(0.9, 2.8)	2.7 (10)	(1.2, 4.5)
Brazilian State, % (n)						
São Paulo	40.6 (434)	(37.7, 43.6)	37.9 (265)	(34.3, 41.5)	45.8 (169)	(40.2, 50.9)
Minas Gerais	17.9 (191)	(15.6, 20.2)	19.2 (134)	(16.3, 22.1)	15.4 (57)	(11.9, 19.2)
Rio de Janeiro	8.9 (95)	(7.3, 10.7)	9.2 (64)	(7.1, 11.4)	8.4 (31)	(5.7, 11.4)
Santa Catarina	8.4 (90)	(6.8, 10.1)	9.0 (63)	(7.0, 11.2)	7.3 (27)	(4.8, 10.1)
Rio Grande do Sul	6.1 (65)	(4.7, 7.6)	5.9 (41)	(4.2, 7.7)	6.5 (24)	(4.2, 9.1)
Paraná	5.8 (62)	(4.5, 7.3)	5.7 (40)	(4.1, 7.5)	6.0 (22)	(3.7, 8.5)
Ceará	2.7 (29)	(1.8, 3.8)	3.0 (21)	(1.8, 4.3)	2.2 (8)	(0.9, 3.8)
Espírito Santo	1.9 (20)	(1.1, 2.7)	2.3 (16)	(1.3, 3.5)	1.1 (4)	(0.2, 2.3)
Distrito Federal	1.0 (11)	(0.5, 1.7)	0.9 (6)	(0.3, 1.6)	1.4 (5)	(0.4, 2.7)
Other	6.6 (71)	(5.2, 8.2)	7.0 (49)	(5.2, 9.0)	6.0 (22)	(3.7, 8.5)

[b]BMI, body mass index; CrI, Bayesian credible interval; SD, standard deviation.

possible explanation for this discrepancy is that the studies had a different design; while our study had a cross-sectional design, the Dutch study had a prospective longitudinal repeated-measurements design. Also, the point prevalence of trail RRIs in South Africa was 1.3 %.[12] In this South African study, runners answered the questionnaire two weeks before competitions, and according to the authors, this may explain the low point prevalence, because runners could be prevented from running the race if they reported health problems.[12] The prevalence of trail RRIs ranged from 1.3 % to 90 % in a systematic review.[9] This large variation may be a consequence of studies using different designs and definitions of injury, according to the authors.[9]

Regarding the anatomical region affected by RRIs, similar findings were reported in road running, with the knee being the most frequently affected site.[25] Trail running factors related to knee overload may partly explain these findings, such as uphill, downhill, uneven terrain, and change directions. In addition, during ultra-trail races (common type of competition in trail running), runners experience high levels of fatigue, as demonstrated in previous studies.[26] Fatigue can result in kinematics changes of the knee, contributing to joint overload.[27] In a systematic review on the epidemiology of injuries and diseases among trail runners, the foot was the most affected site of injuries.[2] This systematic review also presented data on dermatological lesions and gastrointestinal symptoms, common in trail running events.[2] The authors speculated that, perhaps, the foot was the most affected site of injuries because there were many blisters and skin lesions on the feet and, then, this finding may have been overestimated.[2] Our study focused only on the point prevalence of musculoskeletal injuries of the lower limb during training exposure, which might explain the discrepancy compared to the aforementioned review.

Brazilian trail runners reported cramps in the last month (having the time of data collection as reference) mainly in

Table 2 Running exposure of Brazilian trail runners.

Characteristics	Trail Running						Road Running					
	All		Men		Women		All		Men		Women	
	(95 %CrI)		(95 %CrI)		(95 %CrI)		(95 %CrI)		(95 %CrI)		(95 %CrI)	
Frequency (times/week)	1	(0, 3)	1	(0, 3)	1	(0, 3)	3	(1, 5)	3	(1, 5)	3	(1, 5)
Duration (hours/week)	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**
≤ 1 h	56	5.2 (4.0, 6.6)	41	5.9 (4.2, 7.7)	15	4.1 (2.2, 6.2)	331	31.0 (28.3, 33.8)	214	30.6 (27.2, 34.0)	117	31.7 (27.0, 36.4)
1 to 2 h	342	32.0 (29.2, 34.8)	230	32.9 (29.5, 36.4)	112	30.3 (25.7, 35.1)	552	51.7 (48.7, 54.6)	359	51.4 (47.7, 55.1)	193	52.3 (47.2, 57.3)
2 to 4 h	580	54.3 (51.3, 57.3)	375	53.7 (50.0, 57.3)	205	55.6 (50.6, 60.7)	68	6.4 (4.9, 7.8)	44	6.3 (4.6, 8.1)	24	6.5 (4.1, 9.1)
> 4 h	65	6.1 (4.7, 7.5)	43	6.2 (4.4, 8.0)	22	6.0 (3.7, 8.5)	6	0.6 (0.2, 1.0)	5	0.7 (0.2, 1.4)	1	0.3 (0.0, 1.0)
Not reportedb	25	2.3 (1.2, 3.3)	10	1.4 (0.6, 2.4)	15	4.1 (2.2, 6.1)	111	10.4 (8.6, 12.2)	77	11.0 (8.7, 13.3)	34	9.2 (6.5, 12.3)
Distance (km/week)	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**	n	**% (95 %CrI)**
5 to 20 km	531	49.7 (46.7, 52.7)	330	47.2 (43.6, 51.0)	201	54.5 (49.4, 59.6)	416	39.0 (36.1, 42.0)	250	35.8 (32.2, 39.3)	166	45.0 (39.9, 50.1)
20 to 30 km	335	31.4 (28.6, 34.2)	242	34.6 (31.1, 38.1)	93	25.2 (20.9, 29.7)	281	26.3 (23.7, 28.9)	186	26.6 (23.4, 29.9)	95	25.8 (21.4, 30.3)
30 to 50 km	96	9.0 (7.3, 10.8)	69	9.9 (7.7, 12.1)	27	7.3 (4.8, 10.0)	195	18.2 (16.0, 20.6)	139	19.9 (17.0, 22.9)	56	15.2 (11.6, 18.9)
> 50 km	32	3.0 (2.0, 4.1)	22	3.1 (1.9, 4.5)	10	2.7 (1.2, 4.5)	64	6.0 (4.6, 7.4)	50	7.2 (5.3, 9.1)	14	3.8 (2.0, 5.9)
Not reportedb	74	6.9 (5.4, 8.5)	36	5.2 (3.6, 6.8)	38	10.3 (7.3, 13.4)	112	10.5 (8.7, 12.3)	74	10.6 (8.4, 12.9)	38	10.3 (7.2, 13.4)

CrI, Bayesian credible interval.
[b]Some trail runners preferred not to report.

the triceps surae and quadriceps. Cramps are common medical conditions during ultramarathon trail races.[28] Athletes who experience excessive fatigue or cramps during races should seek medical attention for evaluation, avoiding the risk of musculoskeletal injuries.[28] Therefore, monitoring cramps in trail runners seems to be a fundamental aspect to compose the evaluation and the surveillance of the health, training, and performance of trail runners.

A nationwide study in Brazil with runners in general (i.e., not specifically trail or road runners) showed a higher proportion of male runners (71.4 %) compared to female runners (28.6 %), corroborating our results.[29] The authors of the nationwide study hypothesised that perhaps Brazilian women have a preference for other exercises than running, because the proportion of female exercisers, excluding runners, was actually reverse (i.e., higher proportion of female non-runner-exercisers [56.2 %] compared to male non-runner-exercisers [43.8 %]).[29] The proportion of women found in our study (34.5 %) was higher compared to a systematic review on trail running injury risk factors (15.8 %).[2] In our study, women reported that trail running promotes a greater sense of well-being and has a more pleasant environment when compared to road running.

Brazilian trail runners trained, on average, 3 times/week on road tracks (paved surfaces). This corroborates our *a priori* hypothesis that trail runners do not train only on trails, as reported by Hespanhol Junior et al.[11] However, a cross-sectional study investigating injuries in the 2019 *Skyrun* race reported that trail tracks was the most often training surface (76.5 % on trails followed by 55.8 % on tarred/paved surfaces).[12] The difference in these findings can be explained by the difficulty of access to trails by Brazilian runners who, usually, live in metropolitan areas. In addition, culturally in Brazil training on flat and paved terrains is adopted by most running coaches, and it is part of the preparation to run on trails.

Strengths and limitations of the study

To our knowledge, this was the first study to describe demographic, training, and RRIs in trail runners in Brazil. The study presented a significant sample size considering that the total population of trail runners in Brazil is smaller than the population of runners in general, which is estimated at 2.5 % of the Brazilian population (i.e., ≈5,300,000).[29] Considering that around 5 % of the general population of runners may be trail runners, the sample of this study (*n* = 1068) would represent around 0.4 % of the trail runner population in Brazil (i.e., ≈265,000).

A limitation of this study was the self-reported nature of the data collected, which may have increased the risk of bias related to the accuracy of the data. For example, the participants may have had difficulties in reporting the body region and the type of injury. Some data were collected asking retrospective questions (e.g., previous injuries), which may have increased the risk of recall bias.

Perspectives

This study may be used in practice and in science as a source of information regarding the characteristics of trail running practice in Brazil. This information may serve as a baseline

Table 3 Trail running characteristics of Brazilian trail runners.

	All (n = 1068)		Men (n = 699)		Women (n = 369)	
	n	% (95 %CrI)	n	% (95 %CrI)		% (95 %CrI)
Running coach	853	79.9 (77.4, 82.2)	524	75.0 (71.7, 78.1)	329	89.1 (85.9, 92.2)
Trail running experience						
6 months	44	4.1 (3.0, 5.4)	30	4.3 (2.9, 5.7)	14	3.8 (2.0, 5.8)
1 year	159	14.9 (12.7, 17.0)	95	13.6 (11.1, 16.2)	64	17.3 (13.6, 21.3)
2 to 5 years	568	53.2 (50.3, 56.2)	358	51.2 (47.5, 54.9)	210	56.9 (51.8, 61.9)
5 to 10 years	216	20.2 (17.9, 22.7)	155	22.2 (19.1, 25.3)	61	16.5 (12.8, 20.4)
> 10 years	81	7.6 (6.1, 9.2)	61	8.7 (6.7, 10.9)	20	5.4 (3.3, 7.7)
Self-classification						
Recreational	625	58.5 (55.6, 61.5)	408	58.4 (54.7, 62.0)	217	58.8 (53.8, 63.8)
Previous experience	152	14.2 (12.1, 16.4)	106	15.2 (12.5, 17.8)	46	12.5 (9.2, 15.9)
Novice	138	12.9 (10.9, 15.0)	76	10.9 (8.6, 13.2)	62	16.8 (13.1, 20.7)
Professional	124	11.6 (9.7, 13.6)	94	13.4 (11.0, 16.0)	30	8.1 (5.5, 11.0)
Elite	29	2.7 (1.8, 3.7)	15	2.1 (1.2, 3.3)	14	3.8 (2.0, 5.9)
Cross training	961	90 (88.2, 91.8)	612	87.5 (85.0, 89.9)	349	94.6 (92.1, 96.7)
Weight	670	62.7 (59.8, 65.6)	430	61.5 (57.8, 65.0)	240	65.0 (60.0, 69.7)
Functional	438	41.0 (38.1, 43.9)	273	39.0 (35.5, 42.7)	165	44.7 (39.7, 49.8)
Flexibility	175	16.4 (14.2, 18.7)	108	15.4 (12.8, 18.1)	67	18.1 (14.4, 22.2)
Pilates	129	12.1 (10.2, 14.1)	62	8.9 (6.9, 11.0)	67	18.1 (14.3, 22.1)
Walking	55	5.1 (3.9, 3.5)	33	4.7 (3.2, 6.4)	22	6.0 (3.7, 8.5)
CrossFit	37	3.5 (2.4, 4.6)	20	2.9 (1.7, 4.2)	17	4.6 (2.6, 6.9)
Other Sport	514	48.1 (45.1, 51.1)	377	53.9 (50.2, 57.6)	137	37.1 (32.2, 42.0)
Mountain biking	219	20.5 (18.2, 23.0)	182	26.0 (22.9, 29.4)	37	10.0 (7.1, 13.1)
Cycling	190	17.8 (15.6, 20.1)	139	19.9 (17.0, 22.8)	51	13.8 (10.5, 17.5)
Soccer	38	3.5 (2.5, 4.7)	38	5.4 (3.8, 7.1)	0	0.0 (0)
Martial arts	30	2.8 (1.9, 3.8)	22	3.1 (2.0, 4.5)	8	2.2 (0.9, 3.8)
Surf	22	2.0 (1.3, 2.9)	19	2.7 (1.6, 4.0)	3	0.8 (0.1, 1.9)
Indoor soccer	16	1.5 (0.8, 2.3)	15	2.1 (1.2, 3.3)	1	0.3 (0.0, 1.0)
Tennis	15	1.4 (0.8, 2.2)	14	2.0 (1.1, 3.1)	1	0.3 (0.0, 1.0)
Basketball	8	0.7 (0.3, 1.3)	8	1.1 (0.4, 2.0)	0	0.0 (0)
Volleyball	8	0.7 (0.3, 1.3)	8	1.1 (0.4, 2.0)	0	0.0 (0)

	All (n = 1068)		Men (n = 699)		Women (n = 369)	
	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)
Preferred event distance						
5 km	30	2.8 (1.9, 3.8)	18	2.6 (1.5, 3.8)	12	3.2 (1.6, 5.2)
10 to 12 km	241	22.6 (20.0, 25.0)	132	18.9 (16.1, 21.9)	109	29.5 (24.9, 34.3)
Half marathon (21.1 km)	487	45.6 (42.6, 48.6)	319	45.6 (41.9, 49.3)	168	45.5 (40.5, 50.6)
Marathon (42.2 km)	92	8.6 (7.0, 10.3)	74	10.6 (8.4, 13.0)	18	4.9 (2.8, 7.2)
Ultramarathon						
50 km	129	12.1 (10.1, 14.0)	89	12.7 (10.3, 15.2)	40	10.8 (7.8, 14.1)
80 km	31	2.9 (1.9, 3.9)	23	3.3 (2.1, 4.7)	8	2.2 (0.9, 3.8)
100 km	18	1.7 (1.0, 2.5)	14	2.0 (1.1, 3.1)	4	1.1 (0.2, 2.3)
161 km (100 miles)	9	0.8 (0.3, 1.4)	7	1.0 (0.3, 1.8)	2	0.5 (0.0, 1.4)
Not reported[b]	31	2.9 (1.9, 3.9)	23	3.3 (2.0, 4.7)	8	2.2 (0.9, 3.8)
Motivation to run in general[c]						
Feeling of well-being	612	57.3 (54.3, 60.2)	381	54.5 (50.8, 58.2)	231	62.6 (57.6, 67.5)
To have fun	490	45.9 (42.9, 48.8)	316	45.2 (41.5, 48.8)	174	47.1 (42.1, 52.2)
To enhance health	443	41.5 (38.5, 44.4)	295	42.2 (38.6, 45.9)	148	40.1 (35.2, 45.2)
To enhance performance	427	40.0 (37.0, 42.9)	284	40.6 (37.0, 44.3)	143	38.7 (33.8, 43.7)
To reduce stress	303	28.4 (25.7, 31.1)	187	26.7 (23.5, 30.1)	116	31.4 (26.8, 36.2)
Competition	286	26.8 (24.2, 29.4)	205	29.3 (26.0, 32.8)	81	21.9 (17.8, 26.2)
Socialization	266	24.9 (22.4, 27.5)	157	22.5 (19.5, 25.7)	109	29.5 (24.9, 34.2)
Prevention of diseases	197	18.4 (16.2, 20.8)	132	18.9 (16.0, 21.8)	65	17.6 (13.9, 21.6)
To meet people	178	16.7 (14.5, 19.0)	112	16.0 (13.4, 18.8)	66	17.9 (14.1, 21.8)
To lose weight	139	13.0 (11.01, 15.1)	71	10.1 (7.9, 12.4)	68	18.4 (14.6, 22.5)
Motivation for trail running[c]						
More pleasant environment	340	31.8 (29.1, 34.6)	235	33.6 (30.1, 37.2)	105	28.4 (23.9, 33.1)
Feeling of well-being	285	26.7 (24.0, 29.3)	163	23.3 (20.2, 26.5)	122	33.1 (28.3, 37.8)
To have fun	160	15.0 (12.9, 17.1)	107	15.3 (12.7, 18.0)	53	14.4 (10.9, 18.0)
Higher intensity	36	3.4 (2.3, 4.5)	27	3.9 (2.5, 5.4)	9	2.4 (1.1, 4.1)
Higher socialization	24	2.2 (1.4, 3.2)	14	2.0 (1.1, 3.1)	10	2.7 (1.3, 4.5)
Fewer injuries	22	2.0 (1.3, 2.9)	15	2.1 (1.2, 3.3)	7	1.9 (0.7, 3.4)
Less competitive	10	0.9 (0.4, 1.6)	7	1.0 (0.4, 1.8)	3	0.8 (0.1, 1.9)
Lower intensity	8	0.7 (0.3, 1.3)	5	0.7 (0.2, 1.4)	3	0.8 (0.1, 1.9)
More competitive	3	0.3 (0.0, 0.6)	3	0.4 (0.0, 1.0)	0	0.0 (0)
Not reported[b]	180	16.8 (14.7, 19.1)	123	17.6 (14.8, 20.4)	57	15.4 (11.9, 19.2)

CrI, Bayesian credible interval.

[b] Some trail runners preferred not to report.

[c] Multiple choice.

Table 4 RRI characteristics in Brazilian trail runners.

	Point prevalence						12-month period prevalence (previous injuries)					
	All *n* = 1068		Men *n* = 699		Women *n* = 369		All *n* = 1068		Men *n* = 699		Women *n* = 369	
	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)
Overall prevalence of RRI	419	39.2 (36.3, 42.1)	281	40.2 (36.6, 43.8)	138	37.4 (32.5, 42.3)	739	69.2 (66.4, 72.0)	481	68.8 (65.3, 72.2)	258	69.9 (65.1, 74.4)
Prevalence by body region												
Knee injuries	143	13.4 (11.4, 15.4)	90	12.9 (10.5, 15.4)	53	14.4 (10.8, 18.0)	292	27.3 (24.6, 30.0)	195	27.9 (24.6, 31.2)	97	26.3 (21.9, 30.8)
Lower leg injuries	118	11.0 (9.2, 13.0)	80	11.4 (0.9, 13.9)	38	10.3 (7.3, 13.4)	322	30.1 (27.4, 32.9)	215	30.8 (27.4, 34.2)	107	29.0 (24.4, 33.7)
Ankle injuries	110	10.3 (8.5, 12.1)	79	11.3 (9.0, 13.7)	31	8.4 (5.7, 11.3)	235	22.0 (19.6, 24.5)	157	22.5 (19.4, 25.6)	78	21.1 (17.0, 25.3)
Foot injuries	95	8.9 (7.2, 10.6)	64	9.2 (7.1, 11.3)	31	8.4 (5.7, 11.3)	212	19.9 (17.5, 22.2)	146	20.9 (17.9, 23.9)	66	17.9 (14.1, 21.8)
Hip injuries	78	7.3 (0.6, 8.9)	47	6.7 (5.0, 8.7)	31	8.4 (5.7, 11.3)	155	14.5 (12.4, 16.6)	88	12.6 (10.2, 15.1)	67	18.1 (14.3, 22.2)
Prevalence by symptoms												
Pain	363	34.0 (31.2, 36.9)	249	35.6 (32.1, 39.1)	114	30.9 (26.3, 35.7)	649	60.8 (57.9, 63.7)	427	61.1 (57.5, 64.6)	222	60.2 (55.3, 65.2)
Feeling of heaviness	15	1.4 (0.8, 2.1)	7	1.0 (0.4, 1.8)	8	2.2 (0.9, 3.8)	13	1.2 (0.6, 1.9)	8	1.1 (0.4, 2.0)	5	1.4 (0.4, 2.6)
Feeling of tiredness	13	1.2 (0.6, 1.9)	8	1.1 (0.4, 2.0)	5	1.4 (0.4, 2.7)	26	2.4 (1.6, 3.4)	17	2.4 (1.4, 3.6)	9	2.4 (1.1, 4.2)
Tingling	9	0.8 (0.3, 1.4)	7	1.0 (0.4, 1.8)	2	0.5 (0.0, 1.4)	7	0.7 (0.2, 1.2)	5	0.7 (0.2, 1.4)	2	0.5 (0.0, 1.4)
Numbness	2	0.2 (0.0, 0.5)	1	0.1 (0.0, 0.5)	1	0.3 (0.0, 1.0)	3	0.3 (0.0, 0.6)	1	0.1 (0.0, 0.5)	2	0.5 (0.0, 1.4)
Not reportedc	17	1.6 (0.9, 2.4)	9	1.3 (0.5, 2.2)	8	2.2 (0.9, 3.8)	41	3.8 (2.7, 5.0)	23	3.3 (2.1, 4.7)	18	4.9 (2.9, 7.2)
Prevalence based on time loss or reduction in running volume	315	29.5 (26.8, 32.2)	208	29.8 (26.4, 33.2)	107	29.0 (24.4, 33.6)	640	59.9 (57.0, 62.8)	412	58.9 (55.2, 62.5)	228	61.8 (56.8, 66.7)
Prevalence based on medical attention	335	31.4 (28.6, 34.1)	216	30.9 (27.5, 34.4)	119	32.2 (27.5, 37.0)	629	58.9 (55.9, 61.8)	393	56.2 (52.6, 60.0)	236	64.0 (59.1, 68.8)

CrI, Bayesian credible interval; RRI, running-related injury.
[c]Some trail runners preferred not to report.

Table 5 Prevalence and location of cramps.

	Last month						Last 12 months					
	All *n* = 1068		Men *n* = 699		Women *n* = 369		All *n* = 1068		Men *n* = 699		Women *n* = 369	
	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)	n	% (95 %CrI)
Overall prevalence of cramps	208	19.5 (17.1, 21.9)	142	20.3 (17.4, 23.3)	66	17.9 (14.0, 21.8)	384	36.0 (33.0, 38.8)	281	40.2 (36.7, 44.0)	103	27.9 (23.4, 32.5)
Prevalence by body region												
Triceps surae	105	9.8 (8.1, 11.7)	71	10.2 (8.0, 12.5)	34	9.2 (6.4, 12.3)	229	21.4 (19.0, 23.9)	164	23.5 (20.4, 26.7)	65	17.6 (13.9, 21.6)
Quadriceps	49	4.6 (3.4, 5.9)	39	5.6 (3.9, 7.3)	10	2.7 (1.3, 4.5)	112	10.5 (8.7, 12.3)	92	13.2 (10.7, 15.7)	20	5.4 (3.2, 7.8)
Hamstring	28	2.6 (1.7, 3.6)	19	2.7 (1.6, 4.0)	9	2.4 (1.0, 4.1)	53	5.0 (3.7, 6.3)	43	6.2 (4.5, 8.0)	10	2.7 (1.2, 4.5)
Foot	20	1.9 (1.1, 2.7)	9	1.3 (0.6, 2.2)	11	3.0 (1.4, 4.8)	36	3.4 (2.3, 4.5)	20	2.9 (1.7, 4.1)	16	4.3 (2.4, 6.5)
Adductor	17	1.6 (0.9, 2.4)	14	2.0 (1.1, 3.1)	3	0.8 (0.1, 1.9)	26	2.4 (1.6, 3.4)	20	2.9 (1.7, 4.2)	6	1.6 (0.5, 3.0)
Abdomen	2	0.2 (0.0, 0.5)	1	0.1 (0.0, 0.5)	1	0.3 (0.0, 1.0)	7	0.7 (0.2, 1.2)	4	0.6 (0.1, 1.2)	3	0.8 (0.1, 1.9)
Gluteus	2	0.2 (0.0, 0.5)	0	0.0 (0.0, 0.0)	2	0.5 (0.0, 0.1)	0	0.0 (0.0, 0.0)	0	0.0 (0.0, 0.0)	0	0.0 (0.0, 0.0)
Tibialis anterior	0	0.0 (0.0, 0.0)	0	0.0 (0.0, 0.0)	0	0.0 (0.0, 0.0)	3	0.3 (0.0, 0.6)	3	0.4 (0.0, 1.0)	0	0.0 (0.0, 0.0)

CrI, Bayesian credible interval.

for hypotheses generation and for supporting informed decision-making regarding trail running. Specifically for research, this study may support, stimulate, and justify the conduct of prospective studies with regards to monitoring health and practice characteristics over time, and their relationship with the benefits and drawbacks of trail running (e. g., the development of trail RRIs). Specifically for practice, this study may help physical therapists, other health professionals, coaches, and managers to understand the profile of trail runners in Brazil, informing better decisions and the implementation of actions related to trail running practice (e.g., training and competitions), and managing injuries related to this practice.

Conclusions

The point prevalence of RRIs in Brazilian trail runners was about 40 %. Almost 70 % of runners reported previous RRIs in the last 12 months. The last month period prevalence of cramps was about 20 %, while the 12-month period prevalence was 36 %. The triceps surae was the muscle most affected by cramps, representing more than 50 % and almost 60 % in the last month and in the last 12 months, respectively.

Transparency

The authors affirm that the manuscript is an honest, accurate, and transparent account of the study being reported. No important aspects of the study have been omitted. Any discrepancies from the study as planned have been explained.

Data sharing statement

Data are available upon reasonable request to LH (corresponding author). De-identified participant data might be available after the consent of all authors and the privacy policy of the Research Ethics Committee of the Universidade Cidade de São Paulo (UNICID).

Conflicts of interest

The authors declare no conflicts of interest.

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Supplementary materials

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References

1. World Athletics. Published online October 10, 2022. Accessed October 10, 2022. https://www.worldathletics.org/disciplines/trail-running/trail-running.
2. Viljoen C, Janse van Rensburg DCC, van Mechelen W, et al. Trail running injury risk factors: a living systematic review. *Br J Sports Med*. 2022;56(10):577–587.
3. Vernillo G, Giandolini M, Edwards WB, et al. Biomechanics and physiology of uphill and downhill running. *Sports Med*. 2017;47(4):615–629.
4. Statista. Participants in Trail Running U.S. 2006-2017. https://www.statista.com/statistics/191333/participants-in-trail-running-in-the-us-since-2006/.
5. Confederação Brasileira de Atletismo. Published online January 9, 2023. Accessed January 9, 2023. http://www.cbat.org.br/.
6. Vella SA, Aidman E, Teychenne M, et al. Optimising the effects of physical activity on mental health and wellbeing: a joint consensus statement from sports medicine Australia and the Australian Psychological Society. *J Sci Med Sport*. 2023. Published online.
7. Giandolini M, Horvais N, Rossi J, Millet GY, Morin JB, Samozino P. Effects of the foot strike pattern on muscle activity and neuromuscular fatigue in downhill trail running. *Scand J Med Sci Sports*. 2017;27(8):809–819.
8. Sanchez-Garcia LF, Penichet-Tomas A, Pueo B, Jimenez-Olmedo JM. Injury incidence and pattern in elite young male and female trail runners. *Appl Sci*. 2022;12(3).
9. 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.
10. Viljoen CT, Janse van Rensburg DC, Verhagen E, van Mechelen W, Korkie E, Epidemiology Botha T. Clinical characteristics, and risk factors for running-related Injuries among South African Trail Runners. *Int J Environ Res Public Health*. 2021;18(23).
11. LC Hespanhol Junior, van Mechelen W, Verhagen E. Health and economic burden of running-related injuries in Dutch trailrunners: a prospective cohort study. *Sports Med*. 2017;47(2):367–377.
12. 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 Off J Assoc Chart Physiother Sports Med*. 2020;47:120–126.
13. González-Lázaro J, Arribas-Cubero HF, Rodríguez-Marroyo JA. Muskuloskeletal injuries in mountain running races: a 5 seasons study. *Injury*. 2020. Published online October.
14. Hespanhol L, van Mechelen Willem, Verhagen Evert. Effectiveness of online tailored advice to prevent running-related injuries and promote preventive behaviour in Dutch trail runners: a pragmatic randomised controlled trial. *Br J Sports Med*. 2018;52(13):851.
15. Hespanhol L, Vallio CS, van Mechelen W, Verhagen E. Can we explain running-related injury preventive behavior? A path analysis. *Braz J Phys Ther*. 2021;25(5):601–609.
16. Lopes AD, Costa LOP, Saragiotto BT, Yamato TP, Adami F, Verhagen E. Musculoskeletal pain is prevalent among recreational runners who are about to compete: an observational study of 1049 runners. *J Physiother*. 2011;57(3):179–182.
17. Clarsen B, Bahr R. Matching the choice of injury/illness definition to study setting, purpose and design: one size does not fit all!. *Br J Sports Med*. 2014;48(7):510–512.
18. Hespanhol L, Vallio CS, Costa LM, Saragiotto BT. Understanding and interpreting confidence and credible intervals around effect estimates. *Braz J Phys Ther*. 2019;23(4):290–301.
19. R Core Team (2021). https://www.R-project.org/.
20. Lesaffre Emmanuel. The normal distribution with μ and $\sigma 2$ unknown. *Bayesian Biostatistics*. ABL; 2012:83–88.
21. Lesaffre Emmanuel. Choosing the prior distribution. *Bayesian Biostatistics*. ABL; 2012:104–138.
22. Lesaffre Emmanuel. The Gibbs sampler. *Bayesian Biostatistics*. ABL; 2012:140–153.
23. Fink D. A compendium of conjugate priors. *Tech Rep*. 1997. Published online January.
24. Kerman Jouni. Neutral noninformative and informative conjugate beta and gamma prior distributions. *Electron J Stat*. 2011;5(none):1450–1470.
25. Borel WP, Filho JE, Diz JBM, et al. Prevalence of injuries in brazilian recreational street runners: meta-analysis. *Rev Bras Med Esporte*. 2019;25(2):161–167.
26. Scheer BV, Al Murray A. Andalus ultra trail: an observation of medical interventions during a 219-km, 5-day ultramarathon stage race. *Clin J Sport Med*. 2011;21(5). https://journals.lww.com/cjsportsmed/Fulltext/2011/09000/Al_Andalus_Ultra_-Trail__An_Observation_of_Medical.11.aspx.
27. Willwacher S, Sanno M, Brüggemann GP. Fatigue matters: an intense 10 km run alters frontal and transverse plane joint kinematics in competitive and recreational adult runners. *Gait Posture*. 2020;76:277–283.
28. Vernillo G, Savoldelli A, La Torre A, Skafidas S, Bortolan L, Schena F. Injury and illness rates during ultratrail running. *Int J Sports Med*. 2016;37(7):565–569.
29. Oliveira GM, Lopes AD, Hespanhol L. Are there really many runners out there? Is the proportion of runners increasing over time? A population-based 12-year repeated cross-sectional study with 625,460 Brazilians. *J Sci Med Sport*. 2021;24(6):585–591.