Psychological profile of trail runners associated with running-related injuries: A prospective study

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Abstract

Background: Trail running has increased in popularity due to the benefits of physical activity in nature. However, trail running has an inherent risk of running-related injuries (RRI). It is known that athletes with certain psychological traits have a greater tendency to suffer injuries, however, this is unknown in trail runners. The main objective of this study was to identify trail runners' psychological profiles and to compare the proportion of RRI across these profiles.

Hypothesis: Trail runners with psychological profiles of high stress, precompetitive anxiety, mental fatigue, competitiveness and poor sleep quality are at increased risk of RRI.

***Study design*:** Prospective cohort study.

Level of evidence: Level 2.

Methods: A Gaussian mixture model cluster analysis was performed on 202 trail runners (55.5% males; aged 38.7 [33.4-46.2] years) with psychological stress, cognitive and somatic anxiety, self-confidence, mental fatigue, sleep quality and competitiveness measured four

weeks before participating in a race. The proportion of RRI during the race was recorded and compared across clusters.

***Results*:** Overall RRI proportion during competition was 11.3% (n=24). The most common RRI were muscle (41.7%) and tendon/bursa injuries (16.7%), primarily affecting the knee (33.3%) and lower leg (20.8%). Five psychological profiles were identified. Cluster 1 (competitive runners with moderate psychological stress and mental fatigue, low sleep quality and anxiety, and high self-confidence) had a higher RRI proportion than Cluster 3 (similar traits but lower psychological stress, mental fatigue, and higher self-confidence; 21.2% vs 3.2%; p=0.02).

Conclusions: Certain psychological profiles in trail runners were associated with higher RRI risk.

Clinical relevance: The medical team or trail running coaches should monitor runners with psychological profiles with higher psychological stress, mental fatigue and cognitive anxiety, as well as lower self-confidence and sleep quality, in order to design strategies to reduce their risk of RRI.

Keywords: trail running, clustering, risk, injuries.

Introduction

According to the International Trail Running Association (ITRA), a trail running race is *a pedestrian competition open to everyone, which takes place in a natural environment, with the minimum possible of paved roads (20% maximum). The course can range from a few kilometres for short distances all the way to 80 kilometres and beyond for ultra-trail races* [19]. This discipline is increasingly popular worldwide due to its accessibility and the interest in performing physical activity in the middle of nature, seeking physical, psychological and social benefits [18,47]. An estimated 20 million runners worldwide participate in trail running competitions, with a 15% increase in the last decade [41].

Like any physical activity, trail running has an intrinsic risk of injury [52]. The reported incidence in trail runners varies between 0.7-61.2 injuries per 1000 hours of practice and 5.9-95.4 injuries per 1000 runners, while the prevalence ranges from 1.3% to 90% [52]. These injuries can lead to significant consequences for the runner, such as training modifications, performance impairment [14], high treatment costs [21], persistent symptoms [9], and even abandonment of the activity [33]. For this reason, injury prevention is a fundamental objective of the sports health team [7]. In order to generate injury prevention strategies, an important step is to know the risk factors [31].

Risk factors for running-related injuries (RRI) are generally described as multiple, addressing physical, sociocultural and psychological dimensions, which interact as a complex system. [6,54]. There is ample evidence analyzing the relationship of physical and sociocultural factors with sports injuries [32,48,55]. For example, neglecting warm-up, lacking a specialized running plan, sustaining a previous injury or runners involved in physical labor have been reported as factors associated with RRI in trail runners [29,50,51]. However, understanding of the risk factors is still incomplete [55].

In recent decades, the emphasis shifted to the analysis of the psychological dimension, attempting to provide a more comprehensive approach to the aetiology of sports injuries [45,48]. Thus, multiple factors related to sports injuries have been analyzed. For example, psychological stress has been discussed extensively, based primarily on the model of stress and sports injuries developed by Williams & Andersen [2,56]. High levels of mental fatigue or high pre-competitive anxiety have also been found to increase the risk of injury in competitive athletes or in sports where they must make fast decisions. [35,39] This could be explained by the fact that these conditions generate alterations in attention or concentration, exposing athletes to failures that could lead to a sports injury [27,36,37].

The association between risk factors and a RRI (e.g., running experience, no specialized running plan, neglecting warm-up, etc.) has often been studied using univariate analyses, presenting a limited view of this association [6,51]. The multifactorial nature and complexity of RRI demands the search for new analysis strategies. Thus, constructing profiles of the runners most prone to RRI could increase our understanding. Martin et al. (2021), in an exploratory study, generated psychological profiles of competitive athletes of a variety of sports (e.g., long-distance running, triathlon, weightlifting, basketball), determining that the profile given by the combination of high athletic identity, perfectionist concerns, negative life stress and poor relationship with the coach had a higher frequency of sports injuries than other profiles [30]. In this line, the clustering analysis should be highlighted. This is defined as a machine learning method used to identify patterns and group people similar in terms of risk factors without the method having prior knowledge of whether the subjects are suffering from an injury or not [43]. Clustering analysis allows the generation of psychological profiles that can be compared according to the proportion of RRI. However, to the best of our knowledge, no publications analyze the relationship between psychological profiles and RRI in trail runners.

Consequently, this study aims to identify trail runners´ psychological profiles and compare the proportion of RRI in each. Secondary objectives were i) to determine the frequency of RRI during a competition; ii) to describe the characteristics of running-related injuries, and iii) to describe and compare the demographic and sports characteristics between trail runners who presented a RRI and those who did not. Our hypothesis was trail runners with psychological profiles of high stress, precompetitive anxiety, mental fatigue, competitiveness and poor sleep quality are at increased risk of RRI.

Material and methods

Study design

This prospective cohort study was approved by the Scientific Ethical Committee of the Valdivia Health Service (No. 410/2022). This article is reported according to STROBE-SIIS guidelines [4].

Participants

The target population included trail runners in southern Chile. Runners registered for the Huilo-Huilo Trail 2022, Pucón Trail 2023 and/or Torrencial Trail 2023 races were invited to participate. Inclusion criteria were: 1) 18 years or older, 2) participate in one of the three trail races mentioned above, and c) an active e-mail address. Exclusion criteria were determined as follows: 1) having a medical diagnosis of moderate or severe psychiatric pathology based on medication use.

Data collection

The procedure for obtaining the information consisted of four stages:

First stage: Runners registered for either of the three trail running races were invited to participate through an e-mail sent by the organization six to four weeks before each race. At this stage, a link to the QuestionPro® platform was attached, with the information about the

study and informed consent. The latter was accepted if the runner clicked the I consent button on the digital informed consent form.

*Second stage***:** Four weeks before each race, participants received an online survey to complete their demographic, sports characteristics, and psychological profiles.

*Third stage***:** Between 72 and 24 hours before each race, the participants received an online survey to complete their pre-competitive psychological profiles.

Fourth stage: Between days 7 and 14 after each race, the participants received an online survey to report any RRI that occurred during the race. The definition of RRI employed in this study relies upon the consequences observed one week post-injury. Consequently, we surveyed RRI seven days following the race.

Measurement instruments

Psychological profile

Psychological stress is defined as a *psychological response to internal or external stressors. Stress involves changes affecting nearly every system of the body, influencing how people feel and behave* [1]. Psychological stress prior to the event was evaluated through the Spanish version of the Perceived Stress Scale (PSS-10) [25]. The PSS-10 is a widely used scale for measuring the psychological stress response to a stressful situation during the past month. It consists of 10 items, scored on a 5-point Likert scale: never, almost never, occasionally, many times and always, giving a total score ranging from 0 to 40 points. The higher the score, the higher the perceived stress. PSS-10 has a good internal consistency (α=0.89) and has been widely used in athletes [12].

Pre-competitive anxiety is defined as *an impending emotional state characterized by feelings of apprehension, tension and nervousness, linked to elevated nervous system activity, generated by sporting competition* [38]. It was evaluated through the Competitive Sport Anxiety

Inventory (CSAI-2R) [10]. The CSAI-2R is composed of 17 items divided into three subscales. Each item is answered on a 4-point Likert scale ranging from 1 (not at all) to 4 (very much so). The cognitive anxiety subscale, described as the mental component caused by items such as fear of perceived social evaluation, fear of failure and loss of self-esteem, contains five items and a score ranging from 5 to 20 points. The somatic anxiety subscale reflects the perception of physiological responses such as increased heart rate, respiration and muscle tension, containing seven items and a score ranging from 7 to 28 points. The self-confidence subscale, defined as the degree of confidence that the subject believes he/she has about his/her chances of success in the competition, contains five items and a score ranging from 5 to 20 points. The higher the score, the greater the presence of the component. CSAI-2R has a good internal consistency (α=0.79-83) and has been widely used in athletes [3].

Mental fatigue is defined as *a* p*sychobiological state of tiredness caused by prolonged periods of performing demanding, cognitive-load-inducing activities, and it reduces efficiency in cognitive performance* [24]. Mental fatigue was measured using a visual analogue scale (VAS), where runners were asked to select a number between 0 and 100 that best indicated their state of mental fatigue, with 0 not at all fatigued and 100 extremely fatigued. This scale demonstrates high internal consistency (α = 0.94 - 0.96) [28] and has been previously used in runners [26].

Sleep quality is defined as *an individual's self-satisfaction with all aspects of the sleep experience* [34]. It was measured using a VAS, where runners were asked to select a number between 0 and 100 that best indicated their sleep quality, with 0 being very good and 100 very bad. The VAS has demonstrated good psychometric properties [58] and has been used in previous research in athletes [44] and several populations (e. g., people with cancer [22]).

Runners were classified according to their self-perceived level of competitiveness through a question with two alternatives: Recreational, defined as people who run regularly for fun and health; or Competitive, those who train to improve their sports performance.

Running-related injury

Defined as *running-related (training or competition) musculoskeletal pain in the lower limbs that causes a restriction on or stoppage of running (distance, speed, duration, or training) for at least 7 days or 3 consecutive scheduled training sessions, or that requires the runner to consult a physician or other health professional* [57]. The description of RRI characteristics was based on the recommendations of Strengthening the Reporting of Observational Studies in Epidemiology: Extension for Sports Injury and Illness Surveillance (STROBE-SIIS) [4]. This was assessed through a self-report questionnaire designed for this study, which included questions such as: i) Did your injury occur acutely or gradually?" ii) What was the anatomical location of this injury? iii) What was the injured tissue? iv) Did you receive physiotherapy treatment?

Demographic and sports characteristics

Information pertinent to the participants' basic data, including age, sex, and body mass index, was collected. Aspects related to sports practice included race distance, years of running experience and competing, running volume (kilometres per week) and whether they have a coach.

Statistical analysis

An exploratory data analysis was performed to detect missing, inconsistent or repeated data. Participants with missing data (5.6%; n=12) were eliminated from the study, due to lack of critical information to generate their psychological profile. Subsequently, the database was exported to the RStudio software (Posit Software PBC, 2023).

For the descriptive analysis of the participants according to demographic and sports characteristics, the distribution of quantitative variables was evaluated using the Kolmogorov-Smirnov test, which showed a non-normal distribution. Therefore, continuous variables were described using the median as a measure of central tendency and the interquartile range as a

measure of dispersion. The distribution of frequency and proportion described qualitative variables. Participants who presented a RRI and those who did not were compared through the Mann-Whitney test for continuous variables and Chi-square in the case of qualitative variables.

Based on the STROBE-SIIS recommendations, a detailed description of RRI, according to onset, anatomical location, tissue and treatment, was made for the total population, and comparisons were made by sex using the Chi-square test.

Before the construction of clusters, the Hopkins statistic was applied to all variables, which gives an idea of the tendency of natural grouping of the data. Values close to 0.5 indicate no grouping, and values close to 1 indicate strong grouping. Clustering intends to find clusters of points in a data set that share some common characteristics. For the construction of the clusters, the psychological profile evaluated four weeks before the competition was used, since they allow us to describe a psychological trait independent of the race condition [8,46]. The Gaussian Mixture Model is a machine-learning method used to determine the probability that each data point belongs to a given cluster [13]. This algorithm was used because of its robustness in identifying variables of different scales, covariance in the data, and flexibility in identifying clusters of different shapes. The silhouette coefficient was used to determine the optimal number of clusters. The silhouette was calculated for various clusters, ranging from 1 to 20, and the number yielding the highest silhouette value was selected as the appropriate number of clusters. For the obtained clusters, a descriptive statistical analysis was performed for each, reporting the mean and standard deviation of each group. Subsequently, differences between clusters for quantitative variables were analyzed with the Kruskal-Wallis test (nonparametric ANOVA), adjusted by the Benjamini-Hochberg procedure, controlling for false discovery rate (FDR), to identify statistically significant differences in demographic factors, sports characteristics, psychological profiles, and pre-competitive psychological profiles. The categorical variables were analyzed with a Chi-square test. Corrected residuals (z-values) were

calculated and considered statistically significant if their absolute value exceeded ±1.96, provided the Chi-square test was significant [5]. A p-value of <0.05 was considered statistically significant.

Results

Of the 2579 trail runners who participated in the three races, 202 (7.8%) completed all stages of data collection. Determining the psychological profile, the Gaussian Mixture Model and silhouette analysis yielded five clusters. Table 1 describes the characteristics of the psychological profile used in the clustering process.

Cluster characteristics

*Cluster 1. Competitive runners and poor sleepers***:** This cluster is characterized by a higher proportion of runners who describe themselves as competitive, with a psychological profile of moderate psychological stress and mental fatigue, low sleep quality, cognitive and somatic anxiety, and high self-confidence.

Cluster 2. Fatigued competitive runners: This cluster is characterized by a higher proportion of runners who describe themselves as competitive, with a psychological profile of moderate psychological stress and sleep quality, low cognitive and somatic anxiety, and high self-confidence and mental fatigue.

Cluster 3. Relaxed competitive runners and poor sleepers: This cluster is characterized by a higher proportion of self-described competitive runners, with a psychological profile of low sleep quality, psychological stress, mental fatigue, cognitive and somatic anxiety, and high self-confidence.

*Cluster 4. Recreational, relaxed runners and poor sleepers***:** This cluster is characterized by a higher proportion of runners who describe themselves as recreational, with a psychological profile of low sleep quality, psychological stress, mental fatigue, cognitive and somatic anxiety, and high self-confidence.

Table 1. Characteristics of the psychological profile used in the clustering process.

	Cluster 1 n=52 (25.7%)	Cluster 2 n=41 (20.3%)	Cluster 3 n=31 (15.4%)	Cluster 4 n=43 (21.3%)	Cluster 5 n=35 (17.3%)
Psychological stress four weeks prior (PSS-10) [a]	14.6 (5.2)	17.5 (5.8)	10.5 (4.1)	8.5 (4.8)	16.3 (6.0)
Cognitive anxiety four weeks prior (CSAI-2R) [a]	8.4 (2.8)	8.9 (3.0)	7.3 (2.1)	7.0 (2.0)	8. 9 (2.4)
Somatic anxiety four weeks prior (CSAI-2R) [a]	10.4 (2.9)	11.8 (3.5)	9.9 (2.1)	8.6 (2.0)	11.5 (4.3)
Self-confidence four weeks prior (CSAI-2R) [a]	15.1 (2.9)	15.0 (3.0)	17.9 (1.8)	17.5 (2.4)	15.5 (3.4)
Mental fatigue four weeks prior (VAS) [a]	33.7 (9.2)	69.6 (12.2)	12.9 (6.7)	9.7 (6.2)	33.7 (14.5)
Sleep quality four weeks prior (VAS) [a]	78.1 (8.4)	63.1 (15.6)	67.6 (5.5)	88.6 (7.4)	43.7 (13.3)
Competitiveness					
Recreational [b]	16 (30.8)	17 (41.5)	12 (38.7)	23 (53.5)	13 (37.2)

[a] Data are shown in mean (standard deviation).

[b] Data are shown in frequency and proportion.

n=number; PSS-10= Perceived Stress Scale; CSAI-2R= Competitive Sport Anxiety Inventory; VAS = Visual Analogue Scale.

Table 2: Descriptive statistics for each cluster.

	Cluster 1 n=52 (25.7%)	Cluster 2 n=41 (20.3%)	Cluster 3 n=31 (15.4%)	Cluster 4 n=43 (21.3%)	Cluster 5 n=35 (17.3%)
Running-related injury [a]	11 (21.2)	6 (14.6)	1 (3.2)	3 (6.9)	3 (8.6)
Sex					
Female [a]	23 (44.2)	22 (53.7)	9 (29.0)	16 (37.2)	20 (57.1)
Age (years) [b]	39.2 (9.2)	37.4 (6.9)	42.4 (8.2)	42.9 (9.0)	38.6 (8.6)
Body mass index (kg/m2) [b]	23.9 (2.2)	24.1 (2.4)	24.9 (3.0)	24.0 (2.5)	23.8 (2.8)
Running experience (years) [b]	5.6 (5.3)	6.7 (6.7)	7.2 (5.8)	7.7 (7.0)	6.7 (9.2)
Competing experience competing (years) [b]	3.6 (3.4)	4.1 (3.7)	4.0 (3.2)	5.2 (5.9)	3.1 (2.6)
Weekly training (km) [b]	33.3 (16.7)	34.9 (20.2)	40.0 (27.3)	43.6 (28.3)	32.1 (19.1)
Has a coach [a]	50.0	61.0	38.7	58.1	48.6
Psychological stress two days prior (PSS-10) [b]	15.4 (6.3)	16.8 (5.7)	11.1 (5.6)	9.4 (5.4)	16.1 (7.0)
Cognitive anxiety two days prior (CSAI-2R) [b]	9.5 (3.8)	9.0 (3. 5)	7.4 (2.1)	6.8 (1.7)	9.0 (2.3)
Somatic anxiety two days prior (CSAI-2R) [b]	11.5 (4.2)	12.3 (4.3)	10.6 (2.7)	9.2 (1.8)	11.8 (3.0)
Self-confidence two days prior (CSAI-2R) [b]	15.1 (3.4)	14.8 (2.7)	18.1 (2.3)	17.9 (3.0)	15.6 (3.1)
Mental fatigue two days prior (VAS) [b]	41.5 (22.9)	48.1 (22.8)	28.7 (21.3)	22.3 (19.9)	42.1 (25.2)
Sleep quality two days prior (VAS) [b]	69.4 (20.2)	68.1 (16.1)	70.5 (15.7)	84.7 (12.3)	58.7 (22.1)
Psychological stress change (PSS-10) [b]	0.9 (5.7)	-0.8 (4.4)	0.6 (5.5)	0.9 (4.6)	-0.1 (4.6)
Cognitive anxiety change (CSAI-2R) [b]	1.0 (2.7)	0.1 (2.6)	0.1 (2.8)	-0.2 (1.9)	0.1 (2.1)
Somatic anxiety change (CSAI-2R) [b]	1.0 (3.7)	0.6 (3.8)	0.7 (3.3)	0.6 (2.1)	0.3 (3.8)
Self-confidence change (CSAI-2R) [b]	0.0 (2.8)	-0.2 (2.4)	0.2 (2.8)	0.4 (2.5)	0.1 (2.2)
Mental fatigue change (VAS) [b]	7.8 (23.2)	-21.5 (22.6)	15.7 (21.0)	12.5 (20.0)	8.4 (24.9)
Sleep quality change (VAS) [b]	-8.6 (19.7)	5.0 (16.2)	2.9 (15.5)	-3.9 (13.8)	15.0 (26.3)

[a] Data are shown in frequency and proportion.

[b] Data are shown in mean (standard deviation).

n=number; Y=yes; N=no; F=Female; M=Male; kg=kilograms; m=meter; km=kilometers; PSS-10= Perceived Stress Scale; CSAI-2R= Competitive Sport Anxiety Inventory; VAS = Visual Analogue Scale.

Cluster 5: Competitive runners and self-confident: This cluster is characterized by a higher proportion of runners who describe themselves as competitive, with a psychological profile of moderate psychological stress, sleep quality and mental fatigue, low cognitive and somatic anxiety, and high self-confidence.

Table 2 describes the variables not used in the clustering process according to each of the five clusters. A Chi-square test showed differences in injury proportion between Cluster 1 and 3 (n=11; 21.2% vs n=1; 3.2%; p=0.02), proportions other cluster showed no differences.

The differential characteristics of Cluster 1 to Cluster 3 are that they presented four weeks prior: higher psychological stress (14.6±5.2 vs 10.5±4.1; p=0.02), lower self-confidence (15.1±2.9 vs 17.9±1.8; p=<0.01), higher mental fatigue (33.7±9.2 vs 12.9±6.7; p<0.01), lower sleep quality (78.1±8.4 vs 67.6±5. 5; p<0.01), and two days prior higher psychological stress (15.4±6.3 vs 11.1±5.6; p<0.01), higher cognitive anxiety (9.5±3.8 vs 7.4±2.1; p=0.05), lower self-confidence (15.1±3.4 vs 18.1±2.3; p<0.01), greater mental fatigue (41.5±22.9 vs 28.7±21.3; p=0.04) and greater change in sleep quality (-8.6±19.7 vs 2.9±15.5; p=0.02).

Twenty-four (11.9%) participants sustained a RRI during the competition. Regarding the characteristics of RRI in trail runners, we found a similar proportion in their onset (sudden 57.2% vs gradual 45.8%), with the most frequent anatomical location the knee (33.3%) and the most common tissue type being muscle (41. 7%) injuries. The majority of trail runners required physiotherapy treatment. Table 3 shows the characteristics of RRI and their distribution by sex.

There were no significant differences between the injured and non-injured groups, according to their demographic and sports characteristics. There is a trend towards a higher proportion of injuries among competitive runners. Table 4 details the demographic and sports characteristics.

Table 3. Characteristics of RRI in trail runners by sex.

	Total n=24	Male n=12 (50%)	Female n=12 (50%)	p-value
Onset				0.682
Sudden	13 (54.2)	7 (53.9)	6 (46.1)	
Gradual	11 (45.8)	5 (45.5)	6 (54.5)	
Anatomical location				0.258
Hip/groin	3 (12.5)	3 (100)	0 (0)	
Thigh	3 (12.5)	0 (0)	3 (100)	
Knee	8 (33.3)	4 (50)	4 (50)	
Lower leg	5 (20.8)	3 (60)	2 (40)	
Ankle	3 (12.5)	1 (33.3)	2 (66.7)	
Foot	2 (8.33)	1 (50)	1 (50)	
Tissue				0.272
Muscle	10 (41.7)	6 (60)	4 (40)	
Tendon/bursa	4 (16.7)	1 (25)	3 (75)	
Nervous	1 (4.2)	0 (0)	1 (100)	
Bone	1 (4.2)	0 (0)	1 (100)	
Cartilage	3 (12.5)	3 (100)	0 (0)	
Ligament	3 (12.5)	1 (33.3)	2 (66.7)	
Skin	1 (4.2)	1 (100)	0 (0)	
Fascia	1 (4.2)	0 (0)	1 (100)	
Physiotherapy treatment				0.064
No	3 (12.5)	3 (100)	0 (0)	
Yes	21 (87.5)	9 (42.9)	12 (57.1)	

Data are shown in frequency and proportion (%).

Table 4. Demographic and sports characteristics of trail runners.

	Total n=202	Uninjured n=178 (88.1%)	Injured n=24 (11.9%)	p-value
Sex [a]				0.567
Female	90 (44.6)	78 (86.7)	12 (13.3)	
Male	112 (55.4)	100 (89.3)	12 (10.7)	
Age (years) [b]	38.7 [33.4-46.2]	38.3 [33.7-46.0]	39.8 [32.1-49.5]	0.777
Body mass index (kg/m^2) [b]	24.0 [22.5-25.7]	24.1 [22.6-25.9]	23.3 [21.6-24.7]	0.107
Race distance (km)[a]				0.386
≤10	12 (5.9)	12 (100)	0 (0)	
11-21	91 (45.1)	82 (90.1)	9 (9.9)	
22-42	64 (31.7)	54 (84.4)	10 (15.6)	
43-60	21 (10.4)	19 (90.5)	2 (9.5)	
100	14 (6.9)	11 (78.6)	3 (21.4)	
Running experience (years) [b]	5 [2 -10]	5 [2-10]	5 [2-10]	0.927
Experience competing (years) [b]	2.75 [1-6]	2 [1-5.3]	3.5 [1-7.5]	0.381
Weekly training (km) [b]	30 [20-50]	30 [20-50]	40 [30-50]	0.111
Competitiveness [a]				0.052
Recreational	121 (59.9)	111 (91.7)	10 (8.3)	
Competitive	81 (40.1)	67 (82.7)	14 (17.3)	
Has a coach [a]				0.819
Yes	105 (52.0)	92 (87.6)	13 (12.4)	
No	97 (48.0)	86 (88.7)	11 (11.3)	

[a] Data are shown in frequency and proportion (%); Chi-square.

[b] Data are shown in median [interquartile ranges]; Mann Whitney test.

kg=kilograms; m=meter; km=kilometers.

Discussion

The main goal of our study was to identify trail runners' psychological profiles and compare the proportion of RRI in each. Our study population could be divided into five clusters considering the psychological variables measured 4 weeks prior to the competition, finding significant differences in the proportion of RRI among two of them (Cluster 1 vs 3). The proportion of RRI during competition was 11.9%, with the knee and muscle being the most frequently injured anatomical location and tissue. No differences were found in the demographic and sports characteristics between trail runners who presented a RRI and those who did not.

Our results show that Cluster 1 had a significantly higher proportion of RRI than Cluster 3. When we compared these two Clusters, we found that participants in Cluster 1 presented a psychological profile with higher psychological stress and mental fatigue, as well as lower self-confidence and sleep quality four weeks prior to the competition. In addition, when facing competition, participants in Cluster 1 had higher psychological stress, cognitive anxiety and mental fatigue, as well as lower self-awareness than their peers in Cluster 3. Williams and Andersen [2,56] suggested in their classic model of psychological stress and sports injuries, a decrease in neurocognitive and perceptual processes (e.g., closure of peripheral vision), increased reaction times and decreased attention to relevant tasks related to increased psychological stress, which would lead to an increased risk of injury for the athlete. According to this model, the risk of injury is influenced by the magnitude of the athlete's psychological stress, as the athlete appreciates potentially stressful situations such as, for example, competition. Our results show that Cluster 1 tended to increase their psychological stress, cognitive anxiety, somatic anxiety and mental fatigue, as well as a decrease in their self-confidence and sleep quality in the two days prior to competition. Other studies have found a significant increase in pre-competitive anxiety [8,46], which has been associated with an increase

in mental and physical fatigue [46]. However, other clusters showed higher levels of psychological stress, somatic anxiety, mental fatigue and poorer sleep quality, with no significant difference in their proportion of RRI (Cluster 2: 14.6%). This suggests that psychological factors alone do not fully explain injury risk and that they form a complex system in which the interaction of a group of factors (clusters/profiles) may expose a runner to an increased risk of injury [6,30].

The proportion of RRI during competition was within the range reported in other studies (0.59-67%) [11,15–17,23,29,40,49,52]. However, it should be taken into account that this wide range of prevalence is because these studies used different definitions and ways of recording injuries. Further, different types of competitions (single-stage/multi-stage), distances and environments formed part of these studies and may have affected the proportion of injuries. Therefore, these characteristics should be taken into account when comparing with our results. Proportion of RRI by onset was similar to that found in most studies, with knee-lower leg and muscle-tendon injuries also being the most frequent [16,53]. The demographic and sports characteristics between uninjured and injured trail runners showed no significant differences. Only a trend was shown that self-described competitive runners had a higher frequency of RRI than recreational runners. Other studies have found relationships between some factors such as age, race distance, running experience and competitiveness, however these studies have different definitions of RRI and most of them are cross-sectional or retrospective, so they do not allow a good comparison with our study [51].

To our knowledge, this is the first prospective study in trail runners that associates a psychological profile with RRI. Studies have generally focused on associating physical or training variables [51], or making associations in cross-sectional studies [20]. The generation of psychological profiles with a higher association to RRI allows complementing these studies, being able to generate a more detailed characterization of trail runners who may have a higher risk of suffering from RRI [6,51,54].

A limitation of our study is the use of self-reporting of injuries, as they are associated with some bias and validity problems. However, this type of self-reporting has shown good consistency with reports of medical diagnoses, supporting their use in epidemiological studies of injuries associated with musculoskeletal disorders [42]. In addition, we used the consensus definition of RRI proposed by Yamato [57], which will allow us to compare our studies with others. Nevertheless, this definition was intended for road runners and included only lower limb injuries. A trail runner is exposed to changing weather and terrain conditions, which could lead to activity-related injuries in other anatomical areas, e.g. as a result of a fall. This is why generating new consensus specific to trail runners is necessary. Despite including several strategies to improve the response rate (i.e., short and focused survey, use of clear and concise language, use of e-mail to facilitate accessibility, sending reminders, etc.), the response rate of our study was low (7.8%), which limits the possibility of extrapolating our results and should be considered when interpreting our results. This may have occurred because all of our research was conducted online, so participants may have felt little commitment to their participation or continuity in the study. An alternative to solve this problem could be using face-to-face interviews, but the prospective nature of our study did not allow it. Finally, there is a need to develop studies incorporating new variables (e.g. physiological, biomechanical or training-related) and larger sample sizes to define the profiles of the most exposed trail runners.

Conclusion

This study provides preliminary information to identify psychological profiles of trail runners who may be more prone to RRI. Trail runners with psychological profiles with higher psychological stress, mental fatigue and cognitive anxiety, as well as lower self-confidence and sleep quality four weeks before a competition, are associated with a higher risk of RRI in competition (level 2 study quality). Therefore, the medical team and coaches should consider them to generate injury prevention strategies.

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