Mental health in ultra-endurance runners: a systematic review

Running head: Mental health issues in ultra-endurance runners

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Abstract

Background: Among ultra-endurance runners (UER), the mental, behavioral and physical demands of training/competition can result in maladaptive outcomes. Mental health issues are common in athletes and can impact psychology, physical health, and performance.

Purpose: To synthesize information regarding the incidence/prevalence and associated factors of mental health issues among UER.

Methods: Systematic searches were performed in PubMed, SPORTDiscus, Scopus, Cochrane databases, CINAHL, Web of Science, and Medline Ovid using key terms related to UER (e.g., trail running, road running) and psychological pathologies (e.g., exercise addiction, depression). Inclusion criteria considered original articles published in peer-reviewed journals in English, using qualitative or quantitative approaches. We considered papers reporting incidence/prevalence and associated factors with mental health outcomes in UER of both sexes, all ages, and levels of competition (e.g., elite, non-professional runners). The Joanna Briggs Institute - Analytical cross-sectional studies critical appraisal tool was used for quality assessment.

Results: A total of 282 studies were identified and 11 studies were included in the final selection. A total of 3670 UER were included in the studies. The prevalence of mental health issues among UER ranged between 32.0%-62.5% for eating disorders, from 11.5% to 18.2% for exercise addiction, 18.6% for depressive symptoms, and 24.5% for sleep disturbance. Exercise addiction was not related to weekly volume, but a strong relationship with exercise in an unstructured space, age, and body mass index was shown.

Conclusion: Mental health issues among UER are common, especially eating disorders, exercise addiction, sleep disturbances, and depressive symptoms. Further high-quality

studies are needed to examine underlying factors and find preventative strategies to protect UER.

Registration: The protocol of this systematic review was registered at the PROSPERO - CRD42022338743

Key points:

- The last decade showed an increase in interest in mental health in ultra-endurance runners.
- Common mental health issues among UER are eating disorders and exercise addiction.
- Race distance within ultra-endurance running is not a risk factor for mental health issues.

1. Background

Mental health disorders involve clinical conditions that change a person's thinking, behavior, and emotions [1]. These disorders are associated with distress and/or disabilities in social, occupational, and other activities [1]. Mental health disorders affect approximately 13% of the general population [2] and are one of the leading economic burdens (medical costs) worldwide, including symptoms such as anxiety, depression, substance use, among others [3]. These mental health issues are complex and multifactorial and can be challenging to manage, with protective factors including social support, social network, working conditions, and physical activity working in synergy [4].

Physical activity has a prophylactic and therapeutic capacity to diminish depression and anxiety [5, 6]. Furthermore, physical activity can also prevent and reduce insomnia symptoms [7, 8]. A dose-response relationship highlighted a decline of about 33% in the risk of psychological distress in groups involved in sports practice more than four times a week [9]. However, the relationship between physical activity and mental health follows a U-shaped curve, with higher levels of physical activity having damaging effects on mental health [10].

Among the general population, those involved in prolonged and strenuous exercise, with higher physiological demands, may be at increased risk of mental health issues [3]. Ultra-endurance runners (UER) are runners competing in ultra-endurance events (>42.195 km or >6 hours of running), either in a single day or stage or in multi-day or multi-stage events [11]. The number of UER has increased over the last 20 years worldwide [12, 13], including participants of different competitive levels (i.e., elite athletes, amateur, recreational runners), both sexes, and different age groups [14]. The long-term health issues of the UER were previously discussed in the context of the implications in the cardiovascular system, renal functions, and musculoskeletal injuries, respiratory response[15]. However, little information is currently available regarding mental health issues among UER.

Despite the evidence about the protective role of endurance running against chronic illness [16], as well as the psychological benefits associated with the practice [17], different mental health disorders were observed among sub-groups of runners [18, 19]. Previous findings showed that elite UER present a higher prevalence of addictive behavior, compared to non-sport-oriented subjects and university athletes [20]. In addition, among cross-country and trail runners a high frequency of eating disorders and exercise addiction were reported [21, 22], since body weight management is a recurrent

practice among athletes competing in weight-sensitive sports [23], and a high training volume is pointed as closely related to performance [24, 25]. In this sense, the mental demands, behavioral changes (e.g., nutritional habits, training periodization), and physical demands related to competition can result in maladaptive outcomes [15].

Defining mental health in the sports context is a challenging task. Athletes' training demands and pressure can lead to unpleasant thoughts and emotions as a consequence of the sport/competition environment. In this context, Henriksen et al [26] highlighted the relevance to distinguish between clinical health disorders, subclinical mental ill health, the human condition, and the athlete condition. Some researchers have proposed new and dynamic definitions for mental health (not only in the context of sports), meaning that the condition may change according to the context. For example, the single continuum models state the idea that human-beings can "*move bidirectionally along a single mental health-mental disorder continuum*". In this case, athletes would move back and forth alongside this continuum, which doesn't necessarily relate to a risk of developing clinically relevant concerns or mental disorders in need of treatment [27]. Further, the dual-continuum model points out that mental health comprises a continuum of both mental illness and mental health, and the symptoms of each are independent, ranging from high to low [27-29]. The assessment of both dimensions must be performed simultaneously, and the "*absence of mental health does not imply the presence of mental illness, and the presence of mental illness, does not imply the absence of mental health*" [30], and this is of relevance for the general population and athletes.

Since UER can face different long-term health risks [15, 31] and substantial vulnerabilities to developing mental health illness [32], understanding the prevalence and factors associated with mental health disorders in this population is of importance. Currently, little is known about the extent of mental health issues in UER. To our

knowledge, no systematic review has been published on mental health issues in UER. The purposes of this systematic review, focusing on UER, are to present information regarding the incidence/prevalence of mental health issues, and to report on factors associated with mental health issues.

2. Methods

2.1 Protocol and Registration

This systematic review was conducted accordingly to the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [33], and the protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO – CRD42022338743).

2.2 Database and search strategy

The search strategy was developed by the lead author (MT) in collaboration with the co-authors of this review (VS, CV). The following seven key databases, relevant to our research question, were searched: PubMed, SPORTDiscus, Scopus, Cochrane databases, CINAHL, Web of Science, and Medline Ovid. Two sets of keywords were used, which were combined by the use of the Boolean operator AND: set 1 included the different terminologies for ultra-endurance running, which were combined with the OR operator (*"trail run*", "sky run*", "fell run*", "off-road run*", "mountain run*", "ultra run*", "ultramarathon*", "ultra trail*", "ultra endurance"*); based on the International Olympic Committee Consensus statement [34], the Set 2 included the different terminologies for mental health, which were combined with the OR operator *("mental health", "mental disorder*", "depress*", "suicide*", "anxiety", "sleep disorder*", "sleep problem*", "addiction*",* "*eating disorder**", "*substance abuse*",

"*alcohol abuse*", "*drugs abuse*", "*gambling**", "*post-traumatic stress disorder**", "*attention deficit hyperactivity disorder**", "*bipolar*", "*schizophrenia*"). The search was conducted and completed in August 2022. All records retrieved by the search query were imported into the Endnote X7 software (Thompson Reuters, Carlsbad, CA, USA), and duplicates were removed by the lead author (MT).

2.3 Study inclusion and exclusion criteria

Inclusion criteria considered original articles published in English, and published in peer-reviewed journals, using both qualitative and quantitative approaches. In addition, we considered papers reporting the incidence/prevalence and/or factors associated with mental health outcomes in UER. UER were defined as athletes who have participated in at least one ultra-endurance event, with a running distance longer than the standard marathon distance (42.195 km), multi-day or multi-stage events [11]. This included road or off-road running events [11], athletes of both sexes, all ages, and all levels of participation (e.g., elite and non-professional). Exclusion criteria considered case reports and case series, as well as not having access to the full article. All studies published from inception to August 2022 were considered.

2.4 Study selection and data extraction strategy

Titles and abstracts of potentially relevant papers were screened, and those selected were screened independently in full text by two reviewers (MT, CV). To be included in the present review, eligible papers were confirmed by the two reviewers (MT, CV), and when discrepancies arose, they were solved by discussion between them or a third independent reviewer (VS).

2.5 Data extraction and study quality assessment

Data extraction was performed by two authors (MT, TNG) for all selected studies, considering: (1) authors; (2) year of publication; (3) study design; (4) sample

characteristics; (5) running/race characteristics; (6) variables assessed; (7) main results; and (8) mental health associated factors. The Joanna Briggs Institute – Analytical cross-sectional studies critical appraisal tool [35] was used for quality assessment **(Table 1).** A qualitative assessment was performed individually by two reviewers (MT, TNG), and discrepancies were resolved by consensus. The quality appraisal checklist comprised 8 criteria: (1) sample inclusions defined; (2) study subjects and settings described; (3) exposure measured in a valid and reliable way; (4) objective, standard measurement criteria for the condition used; (5) confounding factors identified; (6) strategies to deal with confounding factors stated, (7) outcomes measured in valid and reliable way; (8) appropriate statistical analysis used. Each criterion was scored as being "met= yes" or "not met= no" or "unclear" and in some instances as "not applicable".

3. Results

3.1 Literature Search

A total of 282 studies were identified. After excluding the duplicates, 137 studies were screened by their titles and abstracts. A total of 42 studies were deemed relevant for full-textual assessment. Eleven studies fulfilled the eligibility criteria and were included in this review. The PRISMA flowchart is presented in **Figure 1**.

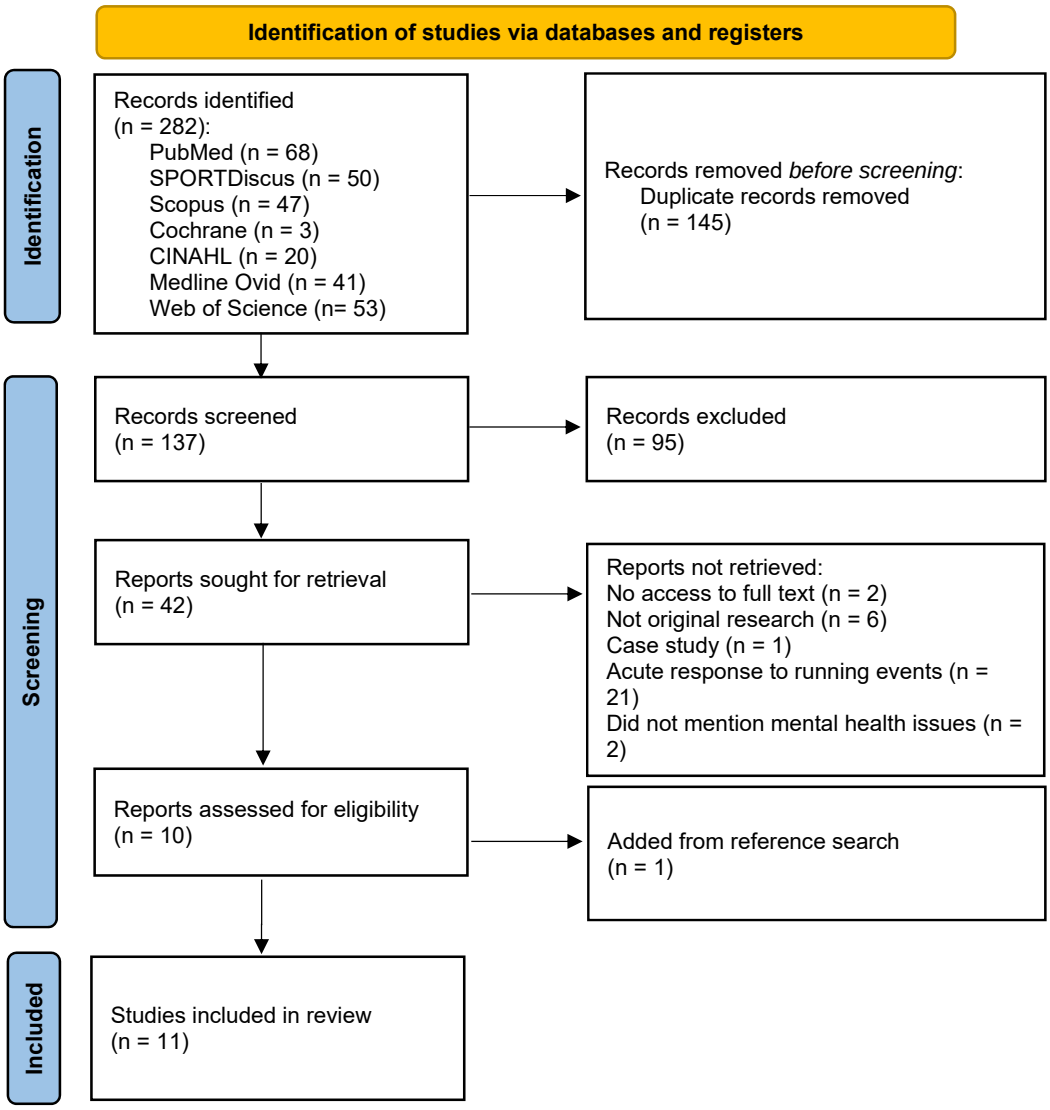

Figure 1. PRISMA flow diagram of the screening process

3.2 Quality assessment

Table 1 presents the methodological quality assessment. The concordance rate between the authors was 89.77%. Inclusion criteria and sample characteristics were reported appropriately in most of the studies. However, most of the studies did not present information about the use of standardized criteria for measurement (Q4), identification, and overcoming confounding factors (Q5 and Q6), meaning they were classified as "not applied" for these evaluation questions.

Table 1. Methodological quality assessment results

	Studies	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
[39]	Belinchón-de-Miguel et al (2021)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[36]	Buck et al (2018)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[38]	Folscher et al (2015)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[37]	Høeg et al (2021)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[40]	Hoffman and Krouse (2018)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[41]	Martin et al (2018)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[42]	Roebuck et al (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
[43]	Scheer et al (2020)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[20]	Szabo et al (2013)	No	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[45]	Wirnitzer et al (2022)	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes
[44]	Allegre et al (2007)	Unclear	Yes	Yes	N/A	N/A	N/A	Yes	Yes

Legend: Q1 Were the criteria for inclusion in the sample clearly defined?; Q2 Were the study subjects and the setting described in detail?; Q3 Was the exposure measured validly and reliably?; Q4 Were objective, standard criteria used for measurement of the condition?; Q5 Were confounding factors identified?; Q6 Were strategies to deal with confounding factors stated?; Q7 Were the outcomes measured validly and reliably?; Q8 Was appropriate statistical analysis used?. N/A (Not applicable).

3.3 Sample and study characteristics

The studies' characteristics are presented in **Table 2**. Across the selected studies, data were collected from 3670 participants. Of these, 2033 (55.9%) were men, 1189 (32.7%) were women, and 448 (12.3%) did not report on the participants' sex. Few studies indicated where the retrieved studies were conducted (for example, in the USA, Spain, and South Africa) [20, 36-38]. The publication date range of the included studies is from 2013 to 2022. The studies that met the inclusion criteria used a quantitative approach, with the design of the studies being predominantly cross-sectional [36-42], with one study presenting a retrospective approach [43] and another presenting a prospective approach [44]. When the study design was not mentioned in the text, we defined it based on the study outlines. Therefore, studies using data from the race results were considered cross-sectional. Study samples ranged from 20 [42] to 1,349 subjects [40], sampling both men and women, while running characteristics includes off-road and road running races [39], both distance- [38, 40, 44] and time-limited events [37], or both

[36, 43]. Distance-limited events ranged between >42.192 km to 100 miles (≈161 km) [37] and multiday events [43].

3.4 Prevalence of mental health issues

The assessment of mental health issues included eating disorders [37, 38], exercise addiction/dependence [20, 36, 44], perceived stress [39], depressive symptoms [36], sleep disorders [41], general mental health [39, 45], or multiple (i.e., anxiety, depression, exercise addiction) [36, 43]. The prevalence of mental health issues varied between studies: 11.5% [43], 17% [20], and 18.2% for exercise addiction risk [36]; 12.8% [43], and 18.6% for depressive symptoms [36]; 32% for risk of eating disorders [38]; 62.5% for eating disorders in women and 44.5% for eating disorder among men [37]; 24.5% for sleep disturbance [41]; and 12.8% for anxiety [43]. For mental health score and perceived stress results ranged from 0.58 [45] to 17.1 (7.0) [39], respectively.

3.5 Factors associated with mental health

The main outcomes showed no association between psychological variables and runners' performance [39], higher pain tolerance and reduced pain-related anxiety, and pain-related escape and avoidance behaviours [42]. No association between weekly volume and exercise addiction in UER was observed, but an influence of exercise in an unstructured space, age, and BMI [44] was shown. No significant association between race distance and mental health was found [45]. Mental health-associated factors include eating disorders [38], and also the female triad (when female runners were studied) [37, 38]. Sleeping behaviours were investigated for both sexes, showing that more women athletes report sleep issues [41].

4 Discussion

This systematic review summarized information regarding the incidence/prevalence, and associated factors of mental health issues among UER. The main findings (**Figure 2**) showed that (a) the last 10 years showing an increase in research interest in this topic, (b) eating disorders, exercise addiction/dependence, perceived stress, depressive symptoms, sleep disorder, anxiety, and psychological health are the most studied mental health issues in UER; (c) the prevalence results ranged between 11.5% and 18.2% for exercise addiction, from 12.8% to 18.6% for depressive symptoms, and from 32% to 62.5% for eating disorders; while the prevalence of sleep disturbance and anxiety were 24.5% and 12.8%, respectively; (d) exercise addiction was strongly related to exercise in an unstructured space, age, and BMI; no significant association between race distance and mental health was shown.

Figure 2. Main take-home messages of the systematic review.
(UER: Ultra-endurance runners)

4.1 Mental health issues assessed and the prevalence in UER

In current literature, eating disorders, exercise addiction/dependence, perceived stress, depressive symptoms, sleep disorder, anxiety, and psychological health are investigated. Eating disorders among athletes are a recurrent topic [21, 46], and results differ according to the characteristics of the studied sample [22, 37, 46-48]. The higher interest in eating disorders among UER could be related to the evidence that running emphasizes leanness or low body weight as a performance-related factor [48]. Comparisons between elite athletes and the general population showed a higher prevalence of eating disorders among the elite group [49], while a higher prevalence of eating disorders was observed for female compared to male athletes [49].

Of the total studies included in our systematic review, only one study presented between-sexes differences. Eating disorder prevalence was higher in women compared to men (62.5% vs 44.5%) [37]. In addition, 61.1% of women and 29.2% of men were classified as moderate, and 5.6% of both sexes were classified as "at high" risk for the Triad Cumulative Risk Assessment – a tool used to assess the risk for "relative energy deficiency in sport" (RED-S) [50]. RED-S takes into account disordered eating patterns, menstrual dysfunction, low bone mineral density, low body weight, delayed age of menarche, and oligomenorrhea [37]. Future comparative studies are needed to better understand the sex differences for eating disorders in UER, especially considering holistic perspectives that moves beyond the athlete centered approach. For instance, an etiological model proposed by Petrie and Greenleaf [52] considered society and sports pressure as important predictors of eating disorders, while internationalization, body satisfaction, and negative affect were considered moderators [52].

Similarly, no differences between eating disorders among UER of different performance levels were shown. Except for those studies investigating elite athletes, most

of the studies did not report the performance level of their samples. This lack of detail can be related to the lack of a clear definition of runners' performance [51], as well as, the lack of clarity regarding the characteristics of different competitive levels. This lack of information impairs the generalization of the findings, as it becomes challenging to ascertain whether the findings can be applied for all UER, or specific groups. One study investigated the difference in the prevalence of eating disorders between UER and half-marathoners [53]. Results showed that women athletes competing in ultra-distances (56 km) presented a higher prevalence for women athlete triad comparatively to their half-marathoner peers. When the triad components were considered individually (i.e., eating disorders, menstrual dysfunction, bone stress injury), UER also presented a higher prevalence of eating disorders [53]. Since eating disorders can be related to endurance training [38], prospective designs need to be considered in order to provide a deeper understanding of cause-effect associations over time.

In elite athletes, especially those competing in weight-sensitive sports, eating disorders and exercise addiction are interconnected [22, 47]. This highlights the relevant role that exercise addiction presents in the psychopathology of eating disorders [21]. Exercise addiction was coined when studies started reporting on the harmful effects of exercise (physical, social, medical, and financial problems, anxiety and depression) [54]. From the reviewed studies, the exercise addiction prevalence ranged from 11.5% [43] to 18.2% [36]. Besides differences in study design (retrospective vs cross-sectional) [36, 43] both studies used the Exercise Addiction Inventory [54], and presented similar characteristics regarding the ultra-endurance distance for the studied samples (50 km, 50 miles). These results are similar to the previous literature, in which a prevalence range of 2.7% to 42% was shown for endurance competitive men runners [55], and a range from 8.7% [56] to 15.6% [57] was shown for athletes competing in different sports

disciplines. Athletes competing in Muay Thai, boxing, and volleyball presented a high risk of exercise dependency, while athletes competing in basketball and football had a lower risk of exercise dependency [57]. Similarly, athletes competing in resistance-based sports have a higher risk of exercise dependency [57]. In the general population, exercise addiction prevalence ranged from 5% to 8.1% for amateur competitive athletes and general exercisers (subjects who exercised in a non-sporting context) [18]. Results differ according to the tool used, and running background (i.e., experience, commitment level) [58, 59].

Two studies investigated depressive symptoms in UER, with the prevalence ranging from 12.8% [43] to 18.6% [36]. Running has been associated with physical and mental health benefits [60]. A recent scoping review reported that runners presented lower depression and anxiety, lower stress, and higher psychological well-being compared to non-runners [61]. A 12-week group-based running program showed positive outcomes for people presenting complex mood disorders with a decrease in depression, stress, and anxiety [62]. However, while running is protective against mental health issues, the pressure of the sport, and the high demand for UER are risks for negative outcomes [63]. Perceived stress, sleep disorder, pain, and anxiety were also investigated. Symptoms of anxiety/depression were shown for elite (33.6%) and former athletes (26.4%) [3], as well as a higher prevalence among women (26%) compared to men athletes (10.2%) [64]. Women athletes are most vulnerable to developing mental health issues, as previously shown, for different outcomes [65, 66], meaning that synergic work between coaches, organizations, and stakeholders is important to provide better practices to prevent these issues.

4.2 Risk factors for mental health issues

Studies that assessed risks associated with mental health, reported exercise addiction was not associated with sex [36, 44], running event distance [36], or weekly running volume [20]. Regarding sex, a previous systematic review that assessed sex differences using the 'Exercise Addiction Inventory' and 'Exercise Dependence Scale' showed that men reported more or similar exercise addiction scores than women [67]. Future studies should focus on better understanding sex differences, considering the association between the risk for exercise addiction, exercise intensity, and level of commitment (e.g., weekly mileage, attendance of competition). The non-association between event distance and mental health needs to be further investigated. A high risk for mental health symptoms is related to sports where training volume is pointed out as a predictor of performance [39, 68-70]. However, it may be useful to control for additional variables such as training load characteristics, the training surface, competition (trail, mountain, road), and internal vs external stressors, that can be associated with a higher physical and mental demand during training and competition.

Nevertheless, Allegre et al. [44] reported that exercise in an unstructured space (i.e., street, public space, and park, etc.), age, and BMI were strong predictors for exercise addiction in athletes competing in 100 km ultra-marathons. Previous evidence showed a higher association between training volume and exercise addiction in recreational athletes [54, 71], but the same was not observed among elite athletes. Elite athletes can manage high training volumes per week without experiencing addiction symptoms [47], since the addiction is characterized by the athlete`s relationship with exercise, and how it dominates their life [47]. Since age was negatively related to exercise addiction, results are in accordance with previous literature where young athletes presented a higher prevalence of exercise addiction compared to their older peers [47, 72]. On the other hand, athletes

competing in ultra-marathon events tend to be older than athletes competing in other sports disciplines [73], therefore, more studies are necessary to better understand this association. Similarly, BMI was negatively related to exercise addiction. Future studies need to consider the association between BMI and exercise addiction including the role of eating disorders, given that eating behaviours are related to weight and BMI [38]. The association between exercise in unstructured space and exercise addiction needs to be better explored in future studies. Characteristics related to the place of residence (urban or rural space), natural and built environment of the training place, and racing events (ground, duration of the event, place of competition) should be explored to present better evidence regarding the mechanisms that explain this association.

4.3 Strengths and limitations

Factors that impair the generalization of these findings include the lack of standardized tools to assess the variables of interest. Future possibilities include the use of the IOC assessment tools (Sport Mental Health Assessment Tool 1, and Sports Mental Health Recognition Tool 1) to identify risks for mental health symptoms and disorders among elite athletes [74]. Similarly, as the popularity of UER has increased among non-professional athletes over the last years [12], future studies need to consider establishing consensus regarding the instruments to be used during the assessment and monitoring of mental health issues among non-professional runners. Similarly, mental health issues should be considered a complex phenomenon, influenced and determined by several factors. In this sense, to address the limitations of the studies included in this review, future researchers need to explore confounding factors related to mental health issues and use a longitudinal design to identify changes during the competitive period. This will further provide insight into which UERs are more at-risk of experiencing symptoms of mental ill-health. The lack of consensus regarding the definition of UER can be related

to differences in the characteristics of the studied sample and, consequently, differences in the prevalence of mental health issues. This lack of clarity regarding the performance level of the runners impairs the comparison and a deep understanding of mental health issues that affect different sub-groups of UER (i.e., elite or non-professional).

In this sense, future studies need to present a clear explanation regarding the sample characteristics (i.e., age, sex, practice experience in years, training characteristics, competition level etc.) to facilitate the sports-based evidence. Finally, we only considered studies published in English, which does not cover all the scientific literature available. However, the results of the present systematic review can be used to inform UER, coaches, policymakers, and sports organizations about the potential risks of mental health associated with ultra-endurance running. This can help to develop guidelines that promote the mental health and well-being of UER, such as providing mental health support services for athletes and incorporating mental health education into training and competition programs. Even though this review focused on highlighting the mental issues among UERs, we acknowledge that running is associated with positive health and well-being benefits as well. Future studies should also consider investigating the mental health benefits to shine light on the risks vs benefits of UER participation.

5 Conclusions

Eating disorders, exercise addiction/dependence, perceived stress, depressive symptoms, sleep disorder, anxiety, and psychological health are the most studied mental health issues in UER. The prevalence of mental health issues varied widely, with exercise addiction and eating disorders presenting the highest prevalence. Future comparative studies are needed to better understand sex differences and positive outcomes associated with participation in Ultra-endurance running among non-professional athletes. It is

important to continue investigating mental health issues among UER to better understand the risk factors and develop interventions to promote the well-being of these athletes.

Declarations

Ethics Approval and Consent to Participate

Not applicable.

Consent for publication

Not applicable.

Availability of Data and Materials

Not applicable.

Competing Interests

Mabliny Thuany, Carel Viljoen, Thayse Natacha Gomes, Beat Knechtle, Volker Scheer declare no competing interests.

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Author Contributions

MT drafted the manuscript; MT, CV, TNG, BK, and VS helped draft the final version. All authors read and approved the final manuscript.

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Table 2. Summary of the studies included

Author (year)	Design	Sample characteristics	Race characteristics	Variables assessed	Main results (mean ± SD or %)	Associated factors/outcomes
Belinchon-de-Miguel et al. (2021) [39]	Cross-sectional	Total sample: 448 runners G1: <45km (37.9±7.3 y); G2: 45 – 90 km (39.2 ± 6.9 y); G3: >90 km (41.0±7.2 y)	Ultra-endurance mountain (Valls d'Aneu Ultratrail - 92 km-long); Emmona Ultratrail (130 km-long); Canfranc-Canfranc Ultraendurance Mountain Race (100 km-long); Great Trail of Peñalara, (114 km-long), Gruseg Trail (51 km-long); Extremadura Mountain Federation Circuit (Including races from 6 km to 72 Km)	Perceived stress General mental health	Perceived stress: G1: 17.1±7.0 G2: 14.7±6.8 G3: 17.3±6.8 General mental health: G1: 14.0±6.4 G2: 12.8±6.1 G3: 14.0±6.4	No differences were found in psychological variables between the groups. No association between psychological variables and performance.
Buck et al. (2018) [36]	Cross-sectional	Total sample: 98 runners (60.2% male; 39.0±8.9 y)	Ultramarathon (Bear Chase Trail Race - 50 km, 50 miles, 100 km)	Exercise addiction Depressive symptoms	Risk for exercise addiction: 18.2% Depressive symptoms: 18.6%	No significant relationship between overall exercise addiction risk and completion status, sex, and age exists. Mood modification and tolerance were not significantly related to the overall EAI (exercise addiction inventory) score. No differences existed between entrants in the 3 events (50k, 50 miles, and 100k) concerning EAI Scores.
Folscher et al. (2015) [38]	Cross-sectional	Total sample: 306 runners (39.4±7.9 y)	Comrades Marathon (89km)	Eating disorder	No eating disorder: 68% Subclinical eating disorder: 26.8% Clinical eating disorder: 5.2%	A higher score to triade risk correlates negatively with faster race performance. A higher disorder eating behaviour scores correlate positively with triade risk scores, weight, and BMI.
Hoeg et al. (2021) [37]	Cross-sectional	Total sample: 123 runners (83 males – 46.2 ± 10.3 y; 40 females – 41.8 ± 7.6 y)	Ultramarathon Western States Endurance Run (100 miles)	Eating disorder	Eating disorders among women: 62.5%; Eating disorders among men: 44.5%; Moderate-to-high athlete triad cumulative risk score among women: 66.7%; Moderate-to-high athlete triad cumulative risk score among men: 34.8%	No association between disordered eating risk score and low BMI or low bone mineral density.
Hoffman and Krouse (2018) [40]	Cross-sectional	Total sample: 1349 runners G1: "Yes"(47.3 y) G2: "No" (43.3 y)	Ultramarathon (≥50km)	Anxiety Depression Alcoholism Drug abuse	G1: Anxiety (9.9%); Depression (13.1%); Alcoholism (4.3%) G2: Anxiety (7.6%); Depression (12.8%); Alcoholism: (3.3%)	

Martin et al. (2018) [41]	Cross-sectional	Total sample: 636 runners (541 males; 95 females; 18 to >60 y)	Ultramarathon	Sleep disorder	Sleep disturbances: 24.5%	No association between sleep problems and age category, or time of day when training was performed. Relationship between sleep problem and sex (more women reporting sleep problems than men).
Roebuck et al. (2018) [42]	Cross-sectional	Total sample: 40 participants (20 ultrarunners - 9 males, 11 females; 42.5±7.8 y; 20 control - 9 males, 11 females; 40.2±8.5 y)	Ultramarathon (≥50km)	Pain catastrophizing (PSC) Pain-related anxiety (PASS) Pain vigilance and awareness (PVAQ) Pain resilience (PRS)	Ultra-runner PSC Rumination: 3.85 ± 2.56; Magnification: 1.95 ± 1.15; Helplessness: 3.75 ± 3.23. PVAQ: 29.25 ± 15.77. PASS Cognitive anxiety: 6.30 ± 4.28; Escape and avoidance behavior: 4.40 ± 2.56; Fearful thinking: 3.40 ± 3.08; Physiological anxiety: 3.40 ±2.76; PRS Behavioral perseverance: 33.85 ± 12.31; Cognitive/affective positivity: 25.85 ± 6.01 Control group PSC - Rumination: 5.55 ± 3.03; Magnification: 3.00 ± 2.08; Helplessness: 5.55 ± 4.43. PVAQ: 37.45 ± 13.67. PASS Cognitive anxiety: 10.05 ± 4.98; Escape and avoidance behavior: 10.20 ± 5.74; Fearful thinking: 6.40 ± 5.02; Physiological anxiety: 6.70 ± 5.27; PRS Behavioural perseverance: 29.15 ± 13.25; Cognitive/affective positivity: 24.25 ± 6.41	Ultrarunners showed more pain tolerance and reduced pain-related anxiety and pain-related escape and avoidance behaviors.
Scheer et al. (2020) [43]	Retrospective	Initial sample: 78 runners (before 19 y) Current sample: 48 runners (aged: 38.0 ± 12.0 years)	≥42.192km, ≥6h or multi-day/multi-stage	Psychological health	Anxiety:12.8% Depression:12.8% Exercise addiction: 11.5%	

Szabo et al. (2013) [20]	Cross-sectional	Total sample: 242 athletes (non-sport-oriented university athletes: 90; Sports science university athletes: 57; Elite ultra-marathoners: 95)	Ultramarathon	Exercise addiction	Exercise addiction for sports science athletes: 7%; Exercise addiction of non-sport science university athletes: 10% (8.8% of all university athletes); Exercise addiction of elite runners: 17%	*The volume of weekly exercise is not related to exercise addiction in ultrarunners.
Wirnitzer et al. (2022) [45]	Cross-sectional	Total sample: 245 endurance runners (104 males, 141 females; 39 ± 17 y); 65 marathoners or ultramarathoners (62% male, 38% female)	Ultramarathon	Stress perception	Stress perception 10 km: 44% Half-marathoners: 27% Marathoners/ultramarathoners: 42%	*Half-marathoners reported lower perception of pressure and stress compared to 10-km runners and marathoners/ultra-marathoners. *No significant association between race distance and mental health
Allegre et al. (2007) [44]	Prospective	Total sample: 95 runners (86 men; 9 women; 43.4±10.9 y)	Ultramarathon (100 km)	Exercise Dependence	Exercise dependence: 54.46±16.36 At-risk for exercise dependence: 3.2%; Non-dependent-symptomatic: 61.1% Nondependent-asymptomatic: 30.5%	*The strongest predictors of exercise dependence were exercise in the city in an unstructured space, age, and BMI. *Moderate amount of physical activity and a total time of physical activity predicted exercise dependence.

SD: Standard deviation; y: years; BMI: Body Mass Index; EAI: Exercise Addiction Inventory; G1: group 1; G2: group 2; G3: group 3; PSC: Pain Catastrophizing; PASS: Pain-Related Anxiety; PVAQ: Pain Vigilance and Awareness; PRS: Pain Resilience. Group "Yes" and "No" of the study for Hoffman and Krouse [40] were based on the question "If you were to learn, with absolute certainty, that ultramarathon running is bad for your health, would you stop your ultramarathon training and participation?"