Are endurance runners at higher risk of depression? Screening for depression and risk factors

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ABSTRACT

Depression is an important public health issue. In the general adult population, about 6.7 % are affected. Little data are available about endurance runners. We conducted a prospective survey study screening for depression using the Patient Health Questionnaire and investigating potential associated risk factors in endurance runners (≥ 21.1–42.2 km) and ultraendurance runners (≥ 42.2 km). Statistical analysis included descriptive statistics, predictive techniques, and regression analysis. A total of n = 601 runners participated (female n = 222 and male n = 379; mean age [SD]: 42.8 years [± 10.1]). Overall, 11.3% screened positive for major depression, particularly female runners compared to male runners (p = 0.002) and endurance runners compared to ultraendurance runners (p = 0.023). No significant differences were observed among performance levels (elite vs. nonelite). Mild depression was observed in 21.6% of runners. Factors associated with a higher risk for screening for major depression included age (p < 0.001), particularly runners under the age of 28 years, previous self-reported history of depression (p < 0.001), more frequent weekly workouts (4–5/wk; p = 0.021), weeks lost to injury (p = 0.022), and female sex (p = 0.025). A third of endurance and ultraendurance runners screened positive for depression, highlighting the importance of creating awareness for mental health issues and potential screening for athletes and providing access to appropriate support services and education.

Introduction

Mental health disorders affect approximately 13 % of the general population [1], with depression being the leading cause, affecting about 6.7 % of the general adult population [2]. One in five people experience a period of depression in their lifetimes [3]. The burden of mental health–related diseases is a major cause of disability worldwide and is associated with premature mortality [4].

Depressive disorders are characterised by depressive mood (e.g., sad, irritable, and empty) or loss of pleasure accompanied by other cognitive, behavioural, or neurovegetative symptoms that significantly affect the individual's ability to function [5]. Individuals with major depression experience key symptoms of depressed mood, with little or no interest or pleasure from daily activities on most days over at least a 2-week period. Major depression is further associated with physical (e.g., weight changes, changes in appetite, psychomotor agitation or retardation), psychological (e.g.,

feeling of worthlessness, suicidal thought, insomnia or hypersomnia), and cognitive (e.g., fatigue, inability to concentrate, or indecisiveness) symptoms [5, 6]. Individuals may experience depressive symptoms without formally meeting criteria for the diagnosis of major depressive disorder according to the Diagnostic and Statistical Manual of Mental Disorders classification or according to International Classification of Disease classification [5, 6]. Screening tools for depression are often used, such as the Patient Health Questionnaire-9 (PHQ-9), a brief, validated, self-administered instrument to measure the severity of depressive symptoms [7], which is considered the most reliable screening tool; however, responses should be validated by a clinician for the diagnosis of depression [3]. Scores range from 0 to 27, with scores of 5–9 being used to classify mild depression [7] and scores of ≥ 10 being used as a cut-off value to identify major depression [8].

Physical activity can have a positive effect on mental health and depression, reducing the severity of symptoms and preventing future exacerbations [9]. An inverse curvilinear association has been shown between physical activity and the risk of depression for adults meeting the physical activity recommendations of equivalent to 2.5 h/wk of brisk walking, compared to adults with no physical activity [10]. However, higher levels of physical activity can follow a **U**-shaped curve, demonstrating that too much physical activity may have damaging effects on mental health [11]. The dose–response association between the extreme physical activity and the risk of depression in adults is not clearly understood and there are little data available about endurance runners (ERs) and ultraendurance runners (UERs) [12, 13]. A recent scoping review looked at the relationship between running and mental health and observed a positive association with higher self-identity and efficacy and low levels of depression; however, they did not report on depression prevalence and specific distances covered, nor include UER [14]. Mental illness in ERs/UERs is an under-represented research topic, although it may be particularly prevalent in this population [15]. Considering this, our aim was to prospectively screen for depression in ERs/UERs and investigate potential associated risk factors for developing depressive symptoms, providing information and insights to athletes and stakeholders.

Materials and Methods

Ethical approval

This study was approved by the internal review board (Comite de etica de la investigacion con medicamentos (CEIm)) of the University Hospitals Torrevieja and Elche-Vinalopo, Elche, Spain (protocol number: VS1; 28/2/2023) and registered at ClinicalTrials.gov (registration number: NCT05768841). Research was conducted in accordance with the Declaration of Helsinki [16] and Ethical Standards in Sport and Exercise Science Research [17].

Sample and eligibility criteria

This is a multicentred, prospective online survey study. Participants had to be aged 18 years or older and previously participated in endurance or ultra-endurance running events. We defined ERs as athletes who previously completed at least the distance of a half marathon up to a marathon distance (21.1–42.195 km) and UERs as athletes who previously completed the distance in excess of a standard marathon distance (> 42.195 km) [18]. The performance level included self-classification of elite and non-elite ERs/UERs, with elite runners being professional, or collegiate, participating at the national level (e.g., national championships) or the international level (e.g., participating for a national team and Olympic/Paralympic) [19].

Study protocol

The electronic survey was available online between March and September 2023. Participation was voluntary and anonymous, with no personal identifiable information requested at any stage. The study was accessible online via a dedicated link from the Ultra Sports Science Foundation website (https://www.ultrasportsscience.org). This link was shared several times during survey availability through social media, participating race organisers, and running related platforms (e.g., Ultra Trail Mount Blanc [UTMB], UTMB World Series, Patagonia Run, Ribera Salud, local running platforms, etc.). Participants were recruited through these multiple announcements on social media sites and asked for voluntary participation and completion of the survey. There was no direct recruitment of potential participants (e.g., no individual E-mails were sent), making response rate calculations not possible.

Questionnaire

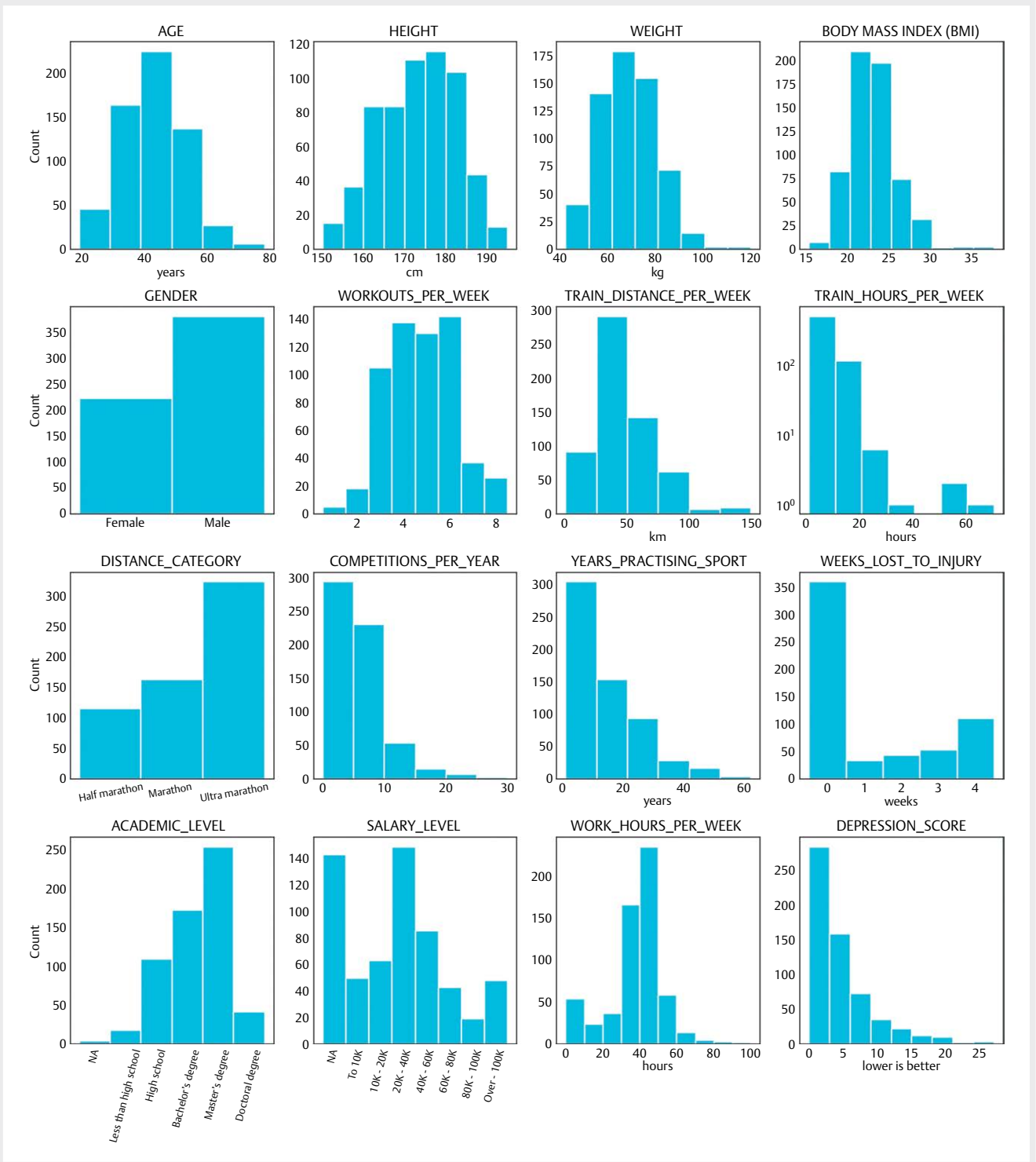
The questionnaire contained questions pertaining to self-reported data on biometrics, gender, the country of origin, social, psychological, medical, sporting, and training history. Depression was assessed via a specific mental health screening questionnaire (PHQ-9). The PHQ-9 is a brief, validated, self-administered instrument to measure the severity of depressive symptoms in the last 14 days, consisting of nine items [7] and has been identified as the most reliable screening tool for depression [3]. Each item is scored on a four-point Likert scale providing a range of depression severity from the composite score, with validated cut-off points (0–4 = none–minimal, 5–9 = mild, 10–14 = moderate, 15–19 = moderately severe, and 20–27 = severe) [7, 10] and scores of ≥ 10 as a cut-off to identify major depression [8]. Questionnaires were available in English, Spanish and French languages.

Statistical analysis

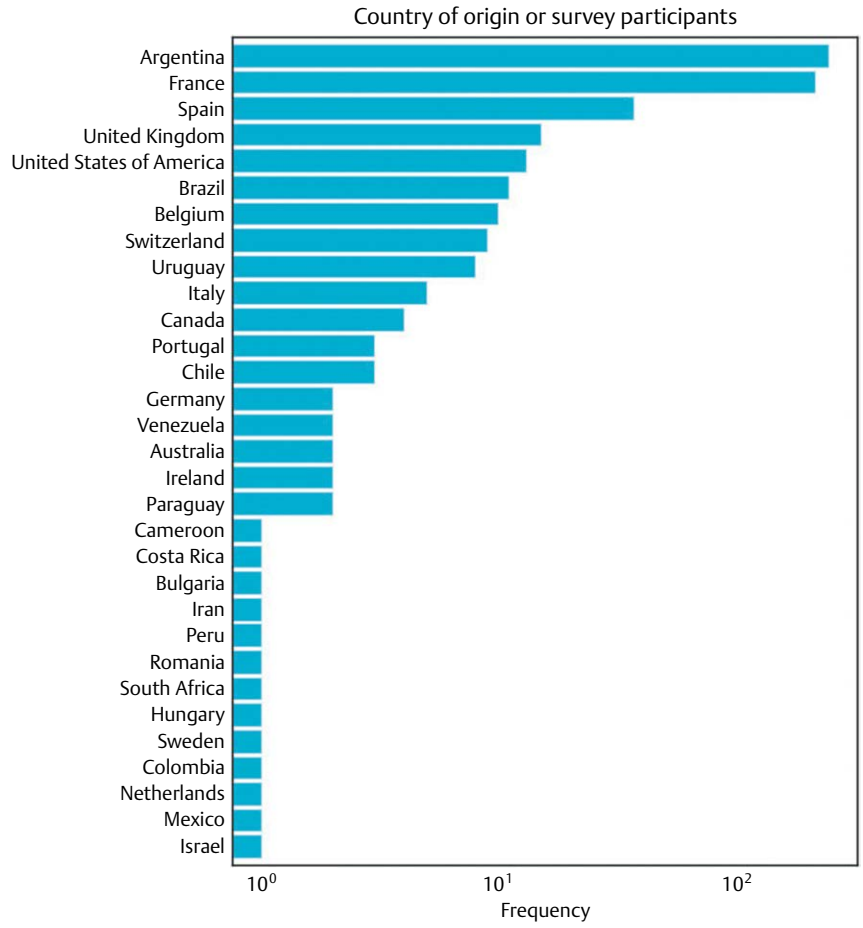
Descriptive statistics on depression were calculated by aggregating questionnaire response records by sex, distance category (half marathon, marathon, and ultramarathon) or performance level (elite and nonelite) and calculating the number of instances (frequency) in each case and the mean and standard deviation values when applicable. The distributions of the (numerical) main factors taken into consideration are explored via histograms. Statistical significance of the differences between groups of sex, distance category, and performance level on the depression score was assessed with the Kruskal–Wallis *H*-test. A machine learning classifier model, based on the CatBoost algorithm, was built with the major depression variable as target, and several variables as predictors (effects). The model was trained with the full qualifying sample, following which model interpretability tools such as SHapley Additive exPlanations (SHAP) and Partial Dependence Plots (PDP) were utilised to understand how each predictor influenced the model output

(the depression score). To assess which of these effects were statistically significant, we also built an ordinary least squares (OLS) multilinear regressor. Statistical significance was set at $p < 0.05$.

All analyses and calculations were done with a Jupyter notebook (Google Colab) and with Python.



▶ **Fig. 1** Graphical representation (histograms) from all participants' ($n = 601$ endurance runners) basic data (age, height, weight, body mass index (BMI), and gender), training characteristics (workouts per week, training distance per week, training hours per week, distance category, participation in numbers of competitions per year, years practicing the sport, and weeks lost training due to injury), social data (academic level, salary level, and work hours per week), and depression scores.



▶ **Fig. 2** The country of the origin of the survey participants ($n = 601$).

Results

Graphical representation from participants' basic data, training characteristics, social data, and depression score are shown in ▶ **Fig. 1**. Data included a total of $n = 601$ runners ($n = 222$ female and $n = 379$ male), with a mean age of 42.8 years (± 10.1) and a mean body mass index of 23.0 kg m^2 (± 2.8). Most participants originated from Europe (France, Spain, and UK), North (USA), and South America (Argentina and Brazil; see ▶ **Fig. 2**).

▶ **Table 1** shows the results of the depression screening from the PHQ-9 by depression severity (none, mild, and major depression), sex, distance category, and performance level. Overall, 11.3 % of runners screened positive for major depression and 21.6 % for mild depression. Female runners screened significantly higher for major depression compared to male runners ($p = 0.002$), as did ERs (in the half marathon distance category) compared to UERs ($p = 0.023$).

▶ **Fig. 3** shows the previous self-reported history of psychiatric conditions. Some individuals suffered from more than one condition in the past, mostly stress, anxiety, and sleeping disorder.

The SHAP aggregated value chart shown in ▶ **Fig. 4** allow us to interpret what our model has learnt about the major depression relative to the different risk factors. To assess which of these effects were statistically significant, the OLS multilinear regressors ($R^2 = 0.22$) was built, and it showed that age ($p < 0.001$), previous self-reported history of depression ($p < 0.001$), number of workouts per week ($p = 0.021$), weeks lost to injury ($p = 0.022$), and female sex ($n = 0.025$) were factors significantly associated with major depression.

▶ **Fig. 5** shows the PDP charts for some of the major depression risk factors, such as age, weeks lost to injury and number of workouts per week. Younger runners (under the age of 28 yr), runners with more time off injury, and more frequent weekly workouts (4–5/wk) are at increased risk for screening positive for major depression.

Discussion

The aim of the study was to provide screening data on depression in ERs/UERs and investigate potential factors associated with a higher risk for depression. A third of ERs/UERs screened positive for depression, particularly female runners and ERs compared to UERs. Factors associated with major depression included age, previous self-reported history of depression, more frequent weekly workouts, weeks lost to injury, and female sex.

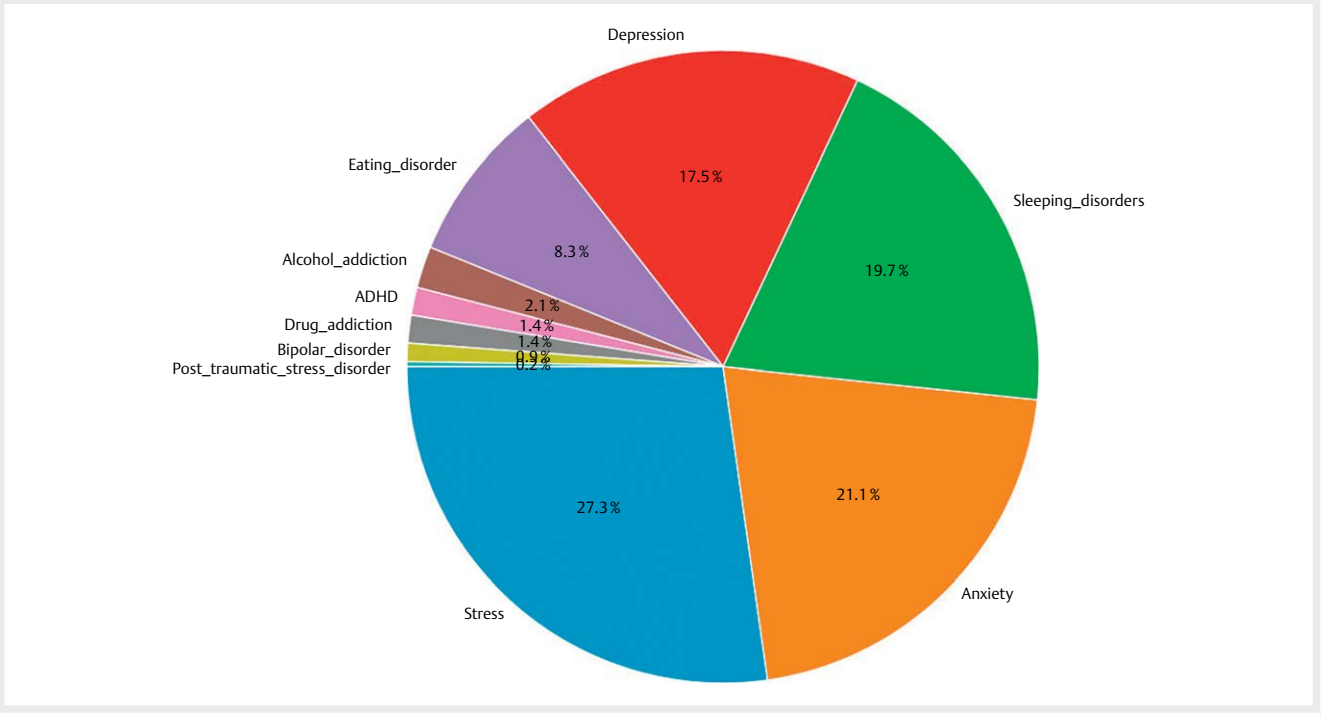
▶ **Table 1** Results of the depression screening from the PHQ-9 by sex, distance category, and performance level.

	Sample size (%)	Depression severity		
		None (%)	Mild (%)	Major (%)
All runners	601 (100)	403 (67.1)	130 (21.6)	68 (11.3)
Female	222 (36.9)	139 (62.6)	46 (20.7)	37 (16.7)*
Male	379 (63.1)	264 (69.7)	84 (22.2)	31 (8.2)
Half marathon	115 (19.1)	75 (65.2)	19 (16.5)	20 (17.4)**
Female	58 (50.4)	33 (56.9)	10 (17.2)	15 (25.9)
Male	57 (49.6)	42 (73.7)	9 (15.8)	6 (10.5)
Marathon	163 (27.1)	112 (68.7)	38 (23.3)	13 (8.0)
Female	74 (45.4)	48 (64.9)	18 (24.3)	8 (10.8)
Male	89 (54.6)	64 (71.9)	20 (22.5)	5 (5.6)
Ultramarathon	323 (53.7)	216 (66.9)	73 (22.6)	34 (10.5)
Female	90 (27.9)	58 (64.4)	18 (20.0)	14 (15.6)
Male	233 (72.1)	158 (67.8)	55 (23.6)	20 (8.6)
Subanalysis				
Elite	25 (4.2)	17 (68.0)	5 (20.0)	3 (12)
Nonelite	576 (95.8)	386 (67.0)	125 (21.7)	65 (11.3)

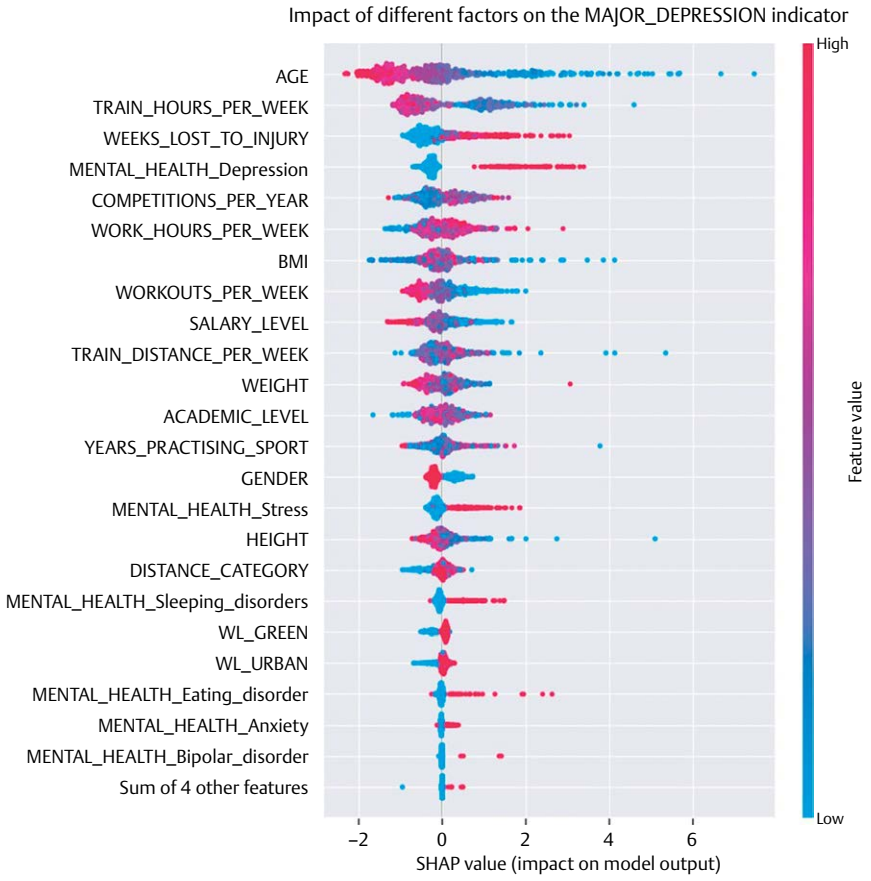
Abbreviation: PHQ-9, Patient Health Questionnaire-9.

The PHQ-9 defines a range of depression severities (0–4 = none, 5–9 = mild, and a cutoff value ≥ 10 for major depression). Female runners screened significantly higher for major depression than male runners ($p = 0.002$). The half marathon distance category screened significantly higher for major depression compared to marathon and ultramarathon distance category ($p = 0.023$). No significant differences were observed among performance levels.

*$p = 0.002$; **$p = 0.023$.



▶ **Fig. 3** Self-reported past medical history of psychiatric conditions ($n = 422$ conditions) in $n = 601$ runners.



▶ **Fig. 4** The SHAP aggregated values from the CatBoost regressor for different risk factors on the major depression. The SHAP values represent the impact of each factor on the major depression predictions. The variable age, for example, is the most important factor according to this model, with blue points (younger ages) accumulating on the right side of the reference output scale, making a positive contribution, and red points to the left making a negative contribution (so younger runners have a higher risk for major depression). Statistically significant factors associated with major depression were age ($p < 0.001$), previous self-reported history of depression ($p < 0.001$), number of workouts per week ($p = 0.021$), weeks lost to injury ($p = 0.022$), and female sex ($n = 0.025$). ADHD, attention deficit/hyperactivity disorder; BMI, body mass index; SHAP, SHapley Additive exPlanations.

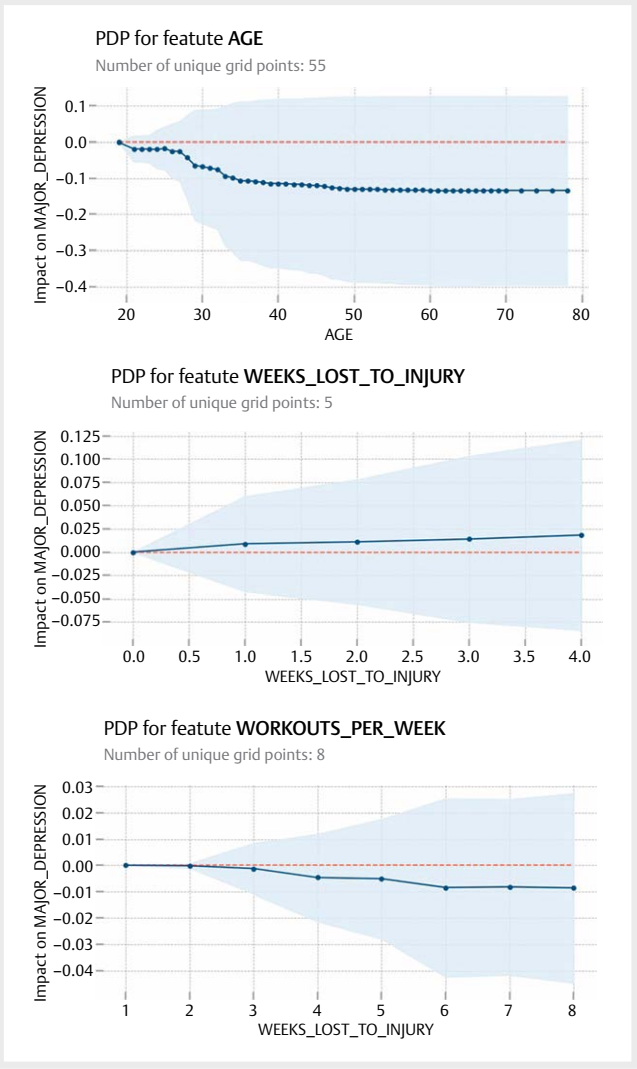
Prevalence of depression

Limited data are available on depression prevalence in ERs/UERs. A systematic review only identified two studies, with few participants and no investigation of potential risk factors [13, 20]. One study examined depressive symptoms during a single-day, multi-distance race (10–100 km) in Colorado, USA, via an online screening questionnaire ($n = 98$) and 18.6 % returned positive results for depressive symptoms [20]. A review on mental health disorders in ultraendurance sports (e.g., swimming, cycling, and triathlon) showed a similar paucity on depression prevalence. Only one study ($n = 33$) in triathlon (ironman distance) showed that 21 % of participants had depression and 12 % received treatment [21]. Although several studies postulate the beneficial effects of exercise on mental health and mood in runners and ERs, no data on depression prevalence are available for comparison [14, 22, 23].

It has been suggested that athletes experience a broadly comparable risk of depression relative to the general population. However, there may be subgroups that may experience higher rates of depression, especially athletes during their retirement phase, performance failure, or when suffering injuries [24], with rates of clinically diagnosed depression ranging from 4 to 34 % and depressive symptoms ranging between 4 and 68 % [6, 19, 24].

Our data showed that 11.3 % screened positive for major depression and 21.6 % for mild depression, higher than in the general population but comparable to some data in elite sports [6, 19, 24]. However, most of our participants were recreational runners and subgroup analysis between elite and recreational runners did not show any significant difference. Although there is a notion to compare UERs to elite athletes as training loads and time spent in training may be similar [15], there are other considerable differences in elite athletes e.g., professional and employment status, earnings, performance levels, etc.

Timing of depression screening may also be important as, in one study ($n = 50$) of elite swimmers, 68 % of athletes met criteria for a major depressive episode in a self-reported questionnaire just before an important competition, dropping to 34 % postcompetition [25]. Performance failure was significantly associated with depression and a diagnosis failure-based depression has been suggested [25].



▶ **Fig. 5** PDP interpretability of the CatBoost regression model. PDP charts for predictors age, workouts per week, and weeks lost to injury are shown, indicating that younger runners, runners with more time off injury, and more frequent workouts (4–5 per week) are at increased risk for major depression. PDP, partial dependence plots.

Risk factors for depression

Some specific risk factors in elite athletes may include the end of their professional career and entering into the retirement phase, performance failure, or when suffering injuries [24].

The role of sex is less clear, with inconsistent findings and individual sport athletes having higher rates [6, 19, 24]. In our cohort of runners, female sex was a significantly associated factor for major depression, as well as younger age, particularly among runners under the age of 28 years. Also, runners who lost time to injury, engaged in more frequent weekly workouts (4–5/week), or had a previous self-reported history of depression were associated factors for major depression.

Prevalence of depression and mental health issues in UER athletes are higher than those in the general population; however, it is not clear if this is causative, or if people with underlying depression, anxiety, and/or other mental health issues are drawn to sports, perceiving it as a way to "self-medicate" [12, 13]. There are reports that some ultra-endurance athletes participate in the sport to manage their existing symptoms related to post-traumatic stress disorder, attention-deficit/hyperactivity disorder, autism-spectrum disorder (ASD), and alcohol-use disorder [15]. Our data suggest that more ERs screen positive for major depression compared to UERs; however, the reason for this is not clear, but it may be an interesting topic for future research.

Runners have long described positive effects and improved mood with running ("runner's high") and the proposed pathways include acute neuroendocrine and inflammatory responses with activation of the endocannabinoid system and longer-term adaptations, including changes in the brain's neural architecture [26, 27].

There are some suggestions that athlete's depressive symptoms may be different from the general population when looking at the relationship between neurotransmitters and load considering exercise-induced neurohormonal imbalance resulting in depressive states among athletes [28]. Environment factors may also play a role with an association between physical activity and depression, e.g., the use of green space has been associated with a lower risk of depression [29] and it has been recommended to explore this in future studies [10]. We investigated the training environment in our cohort of runners but could not find any significant difference between training in green spaces or urban areas on the impact on depression scores.

Prevention of depression

Depression is often poorly recognised and there continues to be stigma and misunderstanding about the disorder, with little awareness and barrier of getting accurate diagnosis and effective treatment [2, 6]. Especially, in elite athletes, mental health issues may not be apparent as athletes continue with sport participation at high levels but may be suffering from mental health conditions [19]. Considering the high prevalence rates of depression among ER/UER screening and preventive measures are recommended to protect this athlete population.

Limitations

The PHQ-9 is a validated and recognised tool for screening depression [10], but it is recommended to verify the responses for a definitive diagnosis taking all other relevant information from the patient into account [3, 7]. Past psychological and medical history was self-reported and may include self-diagnosis or diagnosis from a registered health care provider. Our study relied on self-reported data gathered anonymously and therefore response rates and responses could not be verified independently, potentially leading to bias. For this study, we chose anonymity as data may be less contaminated, due to the sensitivity of some of the questions [30], but recognise that future studies should verify responses from participants; however, this may make larger scale studies potentially more challenging. Mental health issues are a complex interplay between various factors and variables that affect a persons' mood across a lifespan and endurance/ultra-endurance running may not be the only contributing factor, rather that people with underlying mental

health issues may be drawn to the sport, perceiving it as a way to "self-medicate" [13, 31]. Therefore, care should be taken to not generalise our findings to all endurance runners.

Conclusions

A third of endurance and ultraendurance runners screened positive for depression, with 11.3 % for major depression and 21.6 % for mild depression. Risk factors include age, female sex, time lost to injuries, number of workouts per week and previous self-reported history of depression. It highlights the importance of screening for depression and creating awareness among athletes, families, coaches, medical teams, and race organisers and providing access to appropriate support services and education.

Clinical Trial

Clinical Trial: Registration number (trial ID): NCT05768841, Trial registry: ClinicalTrials.gov (http://www.clinicaltrials.gov/), Type of Study: Prosepctive

Fundings

Ultra Sports Science Foundation | N/A

Conflict of Interest

The study was supported by a research grant from the Ultra Sports Science Foundation (https://www.ultrasportsscience.org).Disclosures: VS is founding member of the Ultra Sports Science Foundation.

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