



The association between screening questions of anxiety and depression symptoms among endurance athletes

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ABSTRACT

Anxiety is an important transdiagnostic factor for depression. Our purpose was to investigate the association between anxiety and depression symptoms among endurance runners. We used a cross-sectional, cross-country, web-based research design. A web survey was used to gather information about the runners' general profile (age, sex, civil status, main sport, performance level, sports-specific characteristics, and training characteristics), anxiety symptoms (Generalized Anxiety Disorder-7), and depression symptoms (Patient Health Questionnaire-9). Network analysis was performed using the software JASP (Version 19). We sampled a total of 382 endurance men athletes, competing in ultramarathon ($n = 226$), marathon ($n = 89$), half-marathon ($n = 55$) or others. ANX_Q4 and DEPRESS_Q8 showed the highest strength and expected influence, indicating that are key bridge between anxiety and depressive symptoms and the rest of the network. Interventions that target relaxation capacity, body awareness, and recovery regulation could potentially attenuate the activation of both anxiety and depressive symptoms simultaneously.

1. Introduction

Mental health issues, including anxiety and depression, are considered important public health problems (Santomauro et al., 2021) given the economic burden associated with it. Anxiety refers to uncomfortable or upsetting thoughts and is usually accompanied by agitation, feelings of tension, and activation of the autonomic nervous system ("Physical Activity Guidelines Advisory Committee report, 2008. To the Secretary of Health and Human Services. Part A: executive summary," 2009). Depression includes a mood disorder with prolonged periods of low mood and a lack of interest and/or pleasure in normal activities most of the time (*Diagnostic and statistical manual of mental disorders: DSM-5™, 5th ed.*, 2013).

Physical exercise has a protective role in reducing anxiety and depression symptoms (Smith & Merwin, 2021). A previous review reported that specifically running load (such as volume and intensity), as

well as interventions using running can improve mood and mental health (Oswald et al., 2020). Despite the benefits of endurance activities, higher training loads (frequency, volume, intensity), combined with the competitive nature of the sport can also increase the risk of anxiety and depression (Niering et al., 2024; Scheer et al., 2025; Thuany et al., 2023). A recent systematic review showed that the prevalence of anxiety and depression ranges from 12.8 % to 18.4 % among ultramarathoners (Castaldelli-Maia et al., 2019), and suggests that future research focus on better understanding the factors associated with these mental health issues.

A previous study investigating the risk for screening for major depression showed that age, previous self-reported history of depression, more frequent weekly workouts, and weeks lost to injury present an association with depression symptoms (Scheer et al., 2025). However, conflicting evidence exists with another study not showing an association between training variables and depression among ultra-

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runners (Niering et al., 2024). Despite the importance of better understanding the association between these factors, most studies focussing on mental health among athletes have traditionally examined anxiety and depression as independent conditions, focusing on their risk factors (Niering et al., 2024; Scheer et al., 2025; Thuany et al., 2023). Despite these studies provides important insights for clinical practice, in recent years, researchers change the strategies used to analyze these issues, using the network theory (Borsboom, 2017).

The network theory considers the aetiology of mental health problems as a dynamic process, where symptoms interact within a network, potentially triggering or exacerbating one another (Borsboom, 2017). In this sense, anxiety and depression symptoms can be interconnected, forming a complex interaction, rather than existing as isolated conditions. Understanding these connections is important to identifying key symptoms that drive this network, and to develop targeted interventions, aiming to reduce the risk of developing harmful issues. The purpose of this study is to understand the association between anxiety and depression symptoms among endurance runners.

2. Method

2.1. Ethical aspects

The 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; 28/02/2023). The research was conducted following the Declaration of Helsinki (World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects, 2013). All of the participants were informed about the purpose of the project. Since this is a web-based project, for informed consent, all participants must click on the option that indicates "I have read and agree to participate in the research". No personal information (e.g., name, address, phone number) was requested for participation in this study.

2.2. Design, sample, and eligibility criteria

We used a cross-sectional, cross-country, web-based research design. We sampled adults who previously participated in endurance running events, defined as those who previously completed a race with at least the distance of a half-marathon (21.1 km), in the 24 months before data collection, or those who are currently training for an ultramarathon (Scheer et al., 2020). We excluded athletes competing in other endurance activities than running, such as triathlon, cycling, cross-country skiing, among others.

2.3. Instrument and data collection procedures

We used a web survey for data collection and followed the Checklist for Reporting Results of Internet E-Surveys (Gunther Eysenbach, 2004). After providing informed consent to participate in this study, participants were invited to answer questions regarding their general profile (age, sex, civil status, main sport, performance level, sports-specific characteristics, and training characteristics) and mental health issues. For the evaluation of the mental health issue, we used the Generalized Anxiety Disorder-7 (GAD-7) questionnaire to assess the presence of anxiety symptoms (Spitzer et al., 2006), and the Patient Health Questionnaire-9 (PHQ-9) to assess the presence of depression symptoms (Kroenke et al., 2001).

2.4. Generalized anxiety disorder 7 (GAD-7)

The GAD-7 comprises seven items measuring worry and anxiety symptoms over the last two weeks (ANX_Q1: Feeling nervous, anxious, or on edge; ANX_Q2: Not being able to stop or control worrying;

ANX_Q3: Worrying too much about different things; ANX_Q4: Trouble relaxing; ANX_Q5: Being so restless that it is hard to sit still; ANX_Q6: Becoming easily annoyed or irritable; ANX_Q7: Feeling afraid, as if something awful might happen). Each item is scored on a four-point Likert scale (0–3) with total scores ranging from 0 to 21, which can be categorized as "0–4: minimal anxiety", "5–9: mild anxiety", "10–14: moderate anxiety" and "15–21: severe anxiety" with higher scores reflecting greater anxiety severity (Spitzer et al., 2006).

2.5. Patient health questionnaire 9 (PHQ-9)

The PHQ-9 consists of nine items measuring depressive symptoms corresponding to the diagnostic criteria for major depressive disorder (DEPRESS_Q1: Little interest or pleasure in doing things; DEPRESS_Q2: Feeling down, depressed, or hopeless; DEPRESS_Q3: Trouble falling or staying asleep, or sleeping too much; DEPRESS_Q4: Feeling tired or having little energy; DEPRESS_Q5: Poor appetite or overeating; DEPRESS_Q6: Feeling bad about yourself or that you are a failure or have let yourself or your family down; DEPRESS_Q7: Trouble concentrating on things, such as reading the newspaper or watching television; DEPRESS_Q8: Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual; DEPRESS_Q9: Thoughts that you would be better off dead, or of hurting yourself). Each item is scored on a four-point Likert scale (0–3) with scores ranging from 0 to 27, being classified as "1-4: minimal depression", "5-9: mild depression", "10-14: moderate depression", "15-19: moderately severe depression", and "20-27: severe depression". Scores above 10 are considered major depression (Kroenke et al., 2001).

2.6. Advertising the survey

A no-randomized sampling strategy was used, since the Google Forms platform was used to send the instrument as a link. Given the lack of information regarding the potential participants, no a priori sample size estimation was performed. Participants (athletes) were informed about the study, and online recruitment was performed through social media, race organizer websites, running clubs, and the Ultra Sports Science Foundations website. Information about the study was provided in writing to participants and in case of interest in participating in the study, the survey link (for further explanation/informed consent before being allowed to enter the questionnaire) was sent. Informative posts about the research, including contact information for the principal researchers, were shared on social media. The instrument was open for data collection from March to September 2023, and no email list was used. Participants did not receive any incentives for participation and spent on average 20 min to complete the questionnaire. Regarding the items, no randomization was performed, but some questions were specific for women or men. The respondents were able to review and change their answers before submitting them, and the answers were automatically captured.

2.7. Statistical analysis

Descriptive statistics are presented as mean (standard deviation) for continuous variables and frequency (n, %) for categorical variables. Symptom associations were examined using network analysis. Given the ordinal nature of the questionnaire items, we estimated a sparse Gaussian Graphical Model (GGM) based on polychoric correlations. Networks were inferred using the graphical least absolute shrinkage and selection operator (graphical LASSO) with model selection performed via the Extended Bayesian Information Criterion (EBIC) and the tuning parameter γ set to 0.25 (range 0–0.50). Edges in the network represent regularized partial correlations (i.e., conditional dependencies); edge thickness is proportional to the absolute weight, with blue indicating positive connections, while red indicates a negative. The

Fruchterman–Reingold algorithm was used to position nodes so that strongly associated variables are placed closer together. To determine the centrality statistics of the variables we considered the: (1) betweenness (centrality between the parts), estimated from the number of times that a node is part of the shortest path among all the other pairs of nodes connected to the network; (2) closeness, which is determined from the inverse of the distances from one node to all others; (3) strength; and (4) expected influence, shows the most influential variables in the network. Network stability was estimated based on a 1000-resample bootstrap. The software Jasp (version 19) was used for data analysis.

3. Results

A total of 382 endurance men athletes answered the online survey. The mean age was 43.2 (10.4) years, average workout hours per week of 8.2 (5.0) hours and ~15 years of experience. Most of the athletes are competing in ultramarathon (n = 226), marathon (n = 89), half-marathon (n = 55) or others (n = 12). Fig. 1 presents the frequency of participation by country. Most of the participants came from France (n = 147) and Argentina (n = 134).

Fig. 2 presents the network plot illustrating the connections between anxiety and depression symptoms. Two distinct clusters can be observed, corresponding to each disorder. Most associations within each cluster are positive (blue lines), whereas negative connections appear between the two disorders, suggesting partial symptom differentiation. To identify the most influential nodes within the system, Table 1 displays the centrality measures. Among all nodes, “ANX_Q4” showed the highest strength (1.288) and expected influence (2.426), indicating that this symptom plays a central role by maintaining strong and numerous connections with other anxiety symptoms. Its high expected influence also suggests that changes in this symptom may propagate broadly throughout the anxiety network. Similarly, “DEPRESS_Q8” presented elevated strength (2.123) and betweenness (2.862), indicating that it acts as a key bridge between depressive symptoms and the rest of the network. In contrast, more peripheral nodes such as “ANX_Q3” and “DEPRESS_Q3” exhibited low strength and expected influence, suggesting that their activation or remission would have limited effects on the overall system.

The stability of the network is shown in Supplementary Fig. 1. The sample and bootstrap means are not superimposed, and the confidence

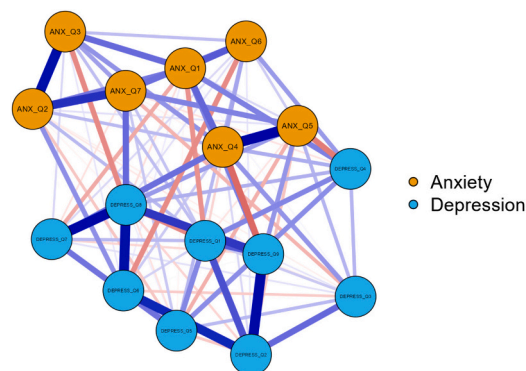


Fig. 2. Network plot for the connection between Anxiety and Depression symptoms.

intervals show considerable variability in some connections and node centralities. This indicates that the overall network is fairly stable, but some specific relationships should be interpreted with caution, as they may be less reliable (supplementary material).

4. Discussion

Adopting a theoretical framework that conceptualizes mental health as a complex system of interacting symptoms, this study aimed to examine the interrelationship between anxiety and depression symptoms among endurance athletes. The network analysis revealed that symptoms were organized into two distinct but interconnected clusters, reflecting the close comorbidity between these two disorders. Our main findings revealed that 1) “trouble in relaxing” emerged as the most influential variable within the system, suggesting it can be associated with both depression and anxiety levels among endurance athletes; 2) “ANX_Q4” and “DEPRESS_Q8” are potential targets for interventions aimed at disrupting maladaptive symptom interactions.

A previous study that investigated the prevalence of depression among endurance runners, identified different high-risk factors, such as individual characteristics (age, and sex), training load (weekly training volume and intensity), and injuries (Scheer et al., 2025). Despite mental health issues among athletes having multifactorial origin, most of the research has been conducted adopting a linear approach, which means

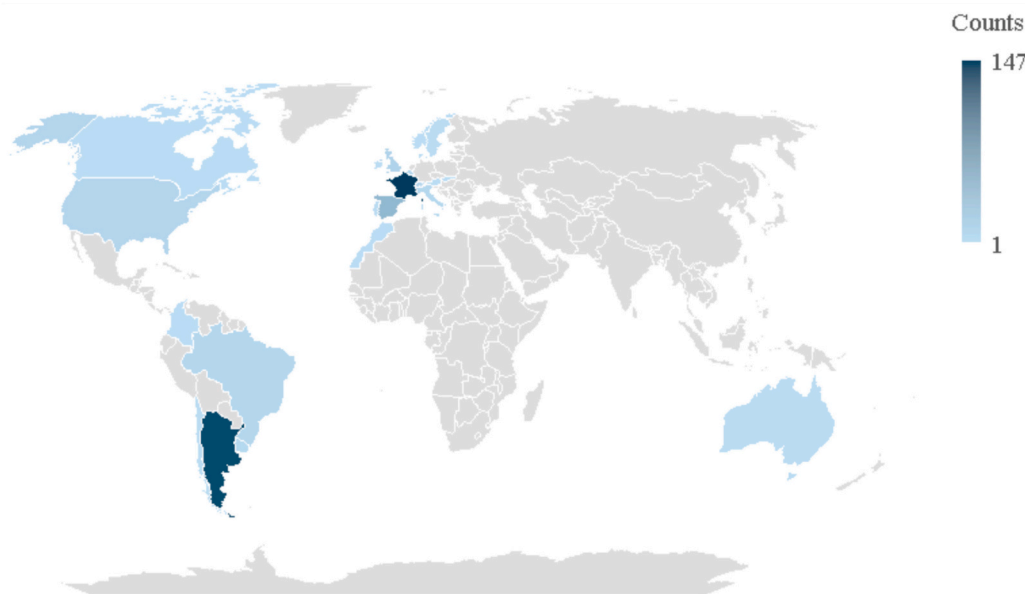


Fig. 1. Countries of the participants.

Table 1
Results of the centrality measures.

Variable	Betweenness	Closeness	Strength	Expected influence
ANX_Q1	0.371	0.707	0.983	-0.180
ANX_Q2	-0.652	-0.700	-0.405	0.926
ANX_Q3	-0.857	-0.843	-0.646	0.125
ANX_Q4	0.371	0.981	1.288	2.426
ANX_Q5	-0.447	-0.009	0.356	-1.465
ANX_Q6	-0.857	-0.891	-0.729	-0.182
ANX_Q7	0.166	0.039	-0.073	-0.074
DEPRESS_Q1	-0.447	0.040	1.157	0.099
DEPRESS_Q2	0.371	0.418	-0.253	0.499
DEPRESS_Q3	-1.061	-1.775	-1.758	-1.467
DEPRESS_Q4	-0.857	-0.850	-1.094	-0.877
DEPRESS_Q5	-0.652	-1.216	-0.593	-1.111
DEPRESS_Q6	1.394	0.979	0.122	0.807
DEPRESS_Q7	0.166	0.008	-0.696	-0.542
DEPRESS_Q8	2.826	1.880	2.132	0.784
DEPRESS_Q9	0.166	1.232	0.209	0.231

ANX_Q1: Feeling nervous, anxious, or on edge; ANX_Q2: Not being able to stop or control worrying; ANX_Q3: Worrying too much about different things; ANX_Q4: Trouble relaxing; ANX_Q5: Being so restless that it is hard to sit still; ANX_Q6: Becoming easily annoyed or irritable; ANX_Q7: Feeling afraid, as if something awful might happen; DEPRESS_Q1: Little interest or pleasure in doing things; DEPRESS_Q2: Feeling down, depressed, or hopeless; DEPRESS_Q3: Trouble falling or staying asleep, or sleeping too much; DEPRESS_Q4: Feeling tired or having little energy; DEPRESS_Q5: Poor appetite or overeating; DEPRESS_Q6: Feeling bad about yourself or that you are a failure or have let yourself or your family down; DEPRESS_Q7: Trouble concentrating on things, such as reading the newspaper or watching television; DEPRESS_Q8: Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual; DEPRESS_Q9: Thoughts that you would be better off dead, or of hurting yourself.

they do not consider the multifactorial nature of the phenomenon and the diverse mutual relationship that can be observed between a plethora of variables (Borsboom, 2017; Scheer et al., 2025; Thuany et al., 2023). Instead, these studies mainly focus on simplistic explanations, trying to understand a given outcome (“y”) as the direct result of a given behaviour (“x”). Supporting the need to investigate anxiety and depression as closely related, a previous study, involving student athletes, showed anxiety as an important transdiagnostic factor for depression (DeWolfe et al., n.d.). This finding highlights the need to investigate the phenomenon by considering the interactions between these disorders and employing complex systems as a theoretical framework. From this perspective, as can be seen in Fig. 1, symptoms are considered nodes, while the lines connecting nodes represent the interaction between symptoms (Borsboom, 2017).

Within this network, *trouble relaxing* (“ANX_Q4”) emerged as the most central and influential symptom, showing high values of strength and expected influence. This finding suggests that difficulties in physiological or cognitive relaxation may play a pivotal role in sustaining both anxiety and depressive symptomatology among endurance athletes. From a theoretical standpoint, *trouble relaxing* can be seen as a regulatory deficit, reflecting heightened arousal and persistent cognitive activation. In endurance athletes—who are frequently exposed to different source of stress (Braschler et al., 2025)—this symptom may act as a gateway through which somatic tension spills over into emotional distress, reinforcing both anxious and depressive pathways.

Given that anxiety and depression are issues commonly reported among athletes, identifying variables that contribute to their expression can be an important avenue during the development of targeted interventions to minimise the likelihood of the emergence of these problems (Niering et al., 2024; Scheer et al., 2025). Furthermore, a closer examination of the network structure reveals more than just the direct relationships between some variables in the occurrence of anxiety and depression symptoms. It is also possible to observe a highly interconnected network, where all variables can influence, directly or

indirectly, the expression of the traits. For instance, the activation of a single symptom (even those located on the periphery of the network) can increase or decrease the likelihood of activating another symptom which, in turn, can contribute to the emergence of the studied traits to varying degrees (Borsboom, 2017).

In this sense, we identified that psychomotor agitation or retardation (“DEPRESS_Q8”), also displayed strong connections within the depressive cluster and some links toward anxiety symptoms. This pattern suggests that psychomotor alterations may serve as a bridge between the two disorders, capturing the shared physiological component of hyper- or hypoactivation. Similar findings have been reported in previous studies, which demonstrate a bidirectional association between anxiety and depression (Jansson-Fröjmark & Lindblom, 2008; Wilson et al., 2020).

Our study has key limitations to consider when interpreting the results. Firstly, our data collection process is subject to biases. The use of a non-randomized approach and sharing the survey on social media may have influenced the participation of runners interested in the topic. This is also supported by the network stability results, which indicate higher variability in the analyzed data and suggest caution in generalizing the findings. Also, memory bias and social desirability could influence the answers, as well as potential misunderstandings related to language barriers. Another potential limitation refers to the used of screening tools instead of clinical assessments, which potentially overestimate or underestimate the prevalence of anxiety and depression. However, both screening tools has been used in sports context (Anderson et al., 2023; Keenan et al., 2023; Tran, 2020).

Despite this, surveys are widely used in the context of running research and provide important insights regarding several behaviours. Second, although age, sex, and competitive level are recognized as important factors related to the prevalence of mental health issues, given the smaller sample size we decided to not analyze the data stratified by these variables. Despite these limitations, this is the first study to investigate mental health issues among ultra-endurance runners, through a network science analysis.

These results provide important information for stakeholders working with runners as they show that anxiety and depression are multifactorial traits, closely interconnected, and no single strategy exists for addressing them effectively. From a practical point of view, interventions that target relaxation capacity, body awareness, and recovery regulation could potentially attenuate the activation of both anxiety and depressive symptoms simultaneously (Asselmann et al., 2024). In addition, strategies must be focused on considering a holistic approach, incorporating diverse sources of symptoms, and involving a multi-professional team. The aim should not only focus on the identification of trigger points that allow breaking the cascade of symptoms, but also on preventing their emergence whenever possible.

5. Conclusion

Anxiety and depression in endurance athletes should not be considered as isolated constructs, but as dynamically interacting networks of symptoms. In our study, the symptom “trouble in relaxing” emerged as the most central variable, showing strong associations with both anxiety and depression in endurance and ultra-endurance runners. This finding highlights the importance of considering the multifactorial nature of these traits, rather than focusing on single symptoms in isolation.

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CRediT authorship contribution statement

Mabliny Thuany: Writing – original draft. **Carel Viljoen:** Writing – review & editing. **Thayse Natacha Gomes:** Writing – review & editing. **David Valero:** Formal analysis. **Thomas Rosemann:** Writing – review & editing. **Katja Weiss:** Writing – review & editing. **Beat Knechtle:**

Writing – review & editing. **Volker Scheer**: Writing – review & editing, Conceptualization.

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Declaration of competing interest

VS is a founding member of Ultra Sports Science Foundation and grant recipient. The authors declare no conflict of interest.

Data availability

Data will be made available on request.

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