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# Overtraining Syndrome Symptoms and Diagnosis in Athletes: Where Is the Research? A Systematic Review

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**Context:** To understand overtraining syndrome (OTS), it is important to detail the physiological and psychological changes that occur in athletes. **Objectives:** To systematically establish and detail the physiological and psychological changes that occur as a result of OTS in athletes. **Methods:** Databases were searched for studies that were (1) original investigations; (2) English, full-text articles; (3) published in peer-reviewed journals; (4) investigations into adult humans and provided (5) objective evidence that detailed changes in performance from prior to the onset of OTS diagnosis and that performance was suppressed for more than 4 weeks and (6) objective evidence of psychological symptoms. **Results:** Zero studies provided objective evidence of detailed changes in performance from prior to the onset of OTS diagnosis and demonstrated suppressed performance for more than 4 weeks accompanied by changes in psychological symptoms. **Conclusions:** All studies failed to provide evidence of changes in performance and mood from “healthy” to an overtrained state with evidence of prolonged suppression of performance. While OTS may be observed in the field, little data is available describing how physiological and psychological symptoms manifest. This stems from vague terminology, difficulties in monitoring for prolonged periods of time, and the need for prospective testing. Real-world settings may facilitate the collection of such data, but the ideal testing battery that can easily be conducted on a regular basis does not yet exist. Consequently, it must be concluded that an evidence base of sufficient scientific quality for understanding OTS in athletes is lacking.

**Keywords:** OTS, physiological, psychological, recovery

Overtraining syndrome (OTS) is a condition associated with a long-term imbalance between training and recovery.<sup>1</sup> First reported in the scientific literature in the 1930s,<sup>2</sup> it is characterized by performance decrements, fatigue, and mood disturbances and has been proposed to affect between 20% and 60% of athletes throughout their careers.<sup>3-6</sup> Compared to functional and nonfunctional overreaching, OTS is the most severe condition and reflects a chronic accumulation of training and nontraining stressors that can take months to years to fully recover from.<sup>7</sup> However, the pathophysiology of this condition is still poorly understood, with the evaluation of a range of psychological, biochemical, immune, neural, and neuroendocrine measures commonly assessed with little success.<sup>8-11</sup> Additionally, inconsistencies in the terminology and diagnosis of OTS has likely contributed to the poor understanding of this phenomenon, and information regarding the effects of true OTS in elite populations is exceedingly limited.

OTS is defined as “a sports-specific decrease in performance together with disturbances in mood state. Underperformance persists despite a period of recovery lasting weeks or months.”<sup>12</sup> Because of this ambiguous definition, OTS is a vague concept. While often considered a more extreme version of overreaching, consensus definitions imply that the main difference between OTS and overreaching is the amount of time needed for performance restoration.<sup>7</sup> However, difficulty lies in the subtle difference that might exist between nonfunctionally overreached athletes and those experiencing OTS. Additionally, the inclusion of mood or psychological changes has not always been used in definitions.<sup>7,12</sup>

It is difficult to comprehend that such severe fatigue that causes prolonged, yet transient performance decrement would not induce some form of psychological signs or symptoms. Thus, the vague terminology and uncertainty that stems from existing definitions makes identifying literature that provides objective evidence on OTS difficult.

Due to the severe and complex nature of OTS,<sup>13</sup> understanding, diagnosing, and treating the syndrome has been difficult. Very little published data in elite athletes is available and, despite being less extreme, and potentially having similar functional outcomes, inferences from athletes who are experiencing overreaching are commonly used to insinuate outcomes of OTS. This lack of information may be due to the difficulties associated with OTS research, including the inability to ethically induce a state of overtraining, the need for consistent monitoring prior to and during the overtraining state to validate a performance decrement, and the likely multifaceted nature of the syndrome.<sup>14</sup> Despite this, it is commonly discussed throughout the sports science literature and the general sports community, and a concerted effort has been made to understand the mechanisms and associated symptoms.

Considering the proposed severe consequences and substantial literature on OTS, it is important to understand its effects on athletic performance, physiological changes, and psychological signs and symptoms. Furthermore, to better understand the etiology of the syndrome, it is prudent to detail the physiological changes and psychological symptoms that occur when an athlete becomes overtrained. Therefore, the aim of this systematic review was to establish and detail the objectively demonstrated physiological and psychological changes that occur as a result of OTS in athletes.

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## Methods

### Search Strategy

Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines for systematic reviews,<sup>15</sup> the academic databases SPORTDiscus, Web of Science, Scopus, and MEDLINE were systematically searched in June and December of 2021 to identify English-language peer-reviewed original research studies that investigated OTS as defined by Urhausen and Kindermann.<sup>12</sup> Due to differences in database design, studies were identified by searching “abstracts, titles, and key words” in Scopus; “All Text” in SPORTDiscus and MEDLINE; and “All Fields” in Web of Science. Additionally, the following Boolean search string was used: (overtrain\* OR over-train\* OR overreach OR staleness) AND (underperformance OR under performance OR underrecovery OR under-recovery OR “under recovery”) (full search strategy for each database can be found in [Supplementary Material 1](#) [available online]). Medical Subject Headings were not used when searching the MEDLINE database and the protocol was not peer reviewed prior to submission. All search results were extracted and imported into a reference manager (EndNote 20, Thomson Reuters, Philadelphia, PA). A systematic review protocol that includes the review question, search strategy, exclusion criteria, and risk of bias assessment was registered on September 2, 2021, with the Open Science Framework ([osf.io/45zwp](https://osf.io/45zwp)).

### Selection Criteria

All duplicate studies were removed, and the titles and abstracts of all remaining studies were independently screened for relevance by 2 authors (J.W. and S.L.H.). Studies that were deemed beyond the scope of the review were removed. Disagreements were resolved through discussion or via a third researcher (I.M.). The full text of the remaining studies were then assessed for eligibility. To be eligible for inclusion, studies were required to (1) be original research investigations; (2) be full-text articles written in English; (3) be published in a peer-reviewed academic journal; (4) be an investigation into adult humans; (5) provide objective evidence that details changes in performance from prior to the onset of OTS diagnosis (ie, “healthy”), and that performance was suppressed for more than 4 weeks; and (6) provide objective evidence (eg, validated questionnaire) of psychological symptoms of maladaptation. If it was deemed that a study did not meet the inclusion criteria, it was excluded from the analysis. The reference lists of all full-text screened studies were manually searched for any studies that were not retrieved in the initial search. If any studies were identified through this manual search strategy it was subjected to the same assessment as previously described. Outcomes that were recorded were any objectively demonstrated physical and psychological change that occur as a result of OTS. Finally, it should be noted that 4 weeks of performance suppression was deemed necessary as periods shorter than this are commonly used to facilitate the realization of physical capacities during, for example, normal overreaching-tapering or altitude training strategies in athletes. Additionally, due to the severe and chronic nature of OTS, the requirement of both physical performance suppression and psychological changes were considered appropriate.

### Assessment of Reporting Quality

The reporting quality of the research was assessed using a modified version of the Downs and Black checklist.<sup>16</sup> This method is valid

for assessing the methodological reporting quality of observational study designs and has previously been used by systematic reviews pertaining to sport science.<sup>17,18</sup> Study quality was assessed against 9 items, scored on a scale from “0” (unable to determine, or no) to “1” (yes). In total, a score of “9” was indicative of the highest study quality.

## Results

### Identification of Studies

The systematic search retrieved a total of 768 studies with a further 10 manuscripts found through screening of reference lists. One hundred and sixty-one of these were removed as duplicates. The titles and abstracts of the remaining 768 studies were screened, with 42 manuscripts being retrieved for full-text screening. However, zero studies were identified that met the inclusion criteria. Because of this, questions 12 to 15 of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines could not be completed. The identification process is outlined in Figure 1.

### Research Reporting Quality

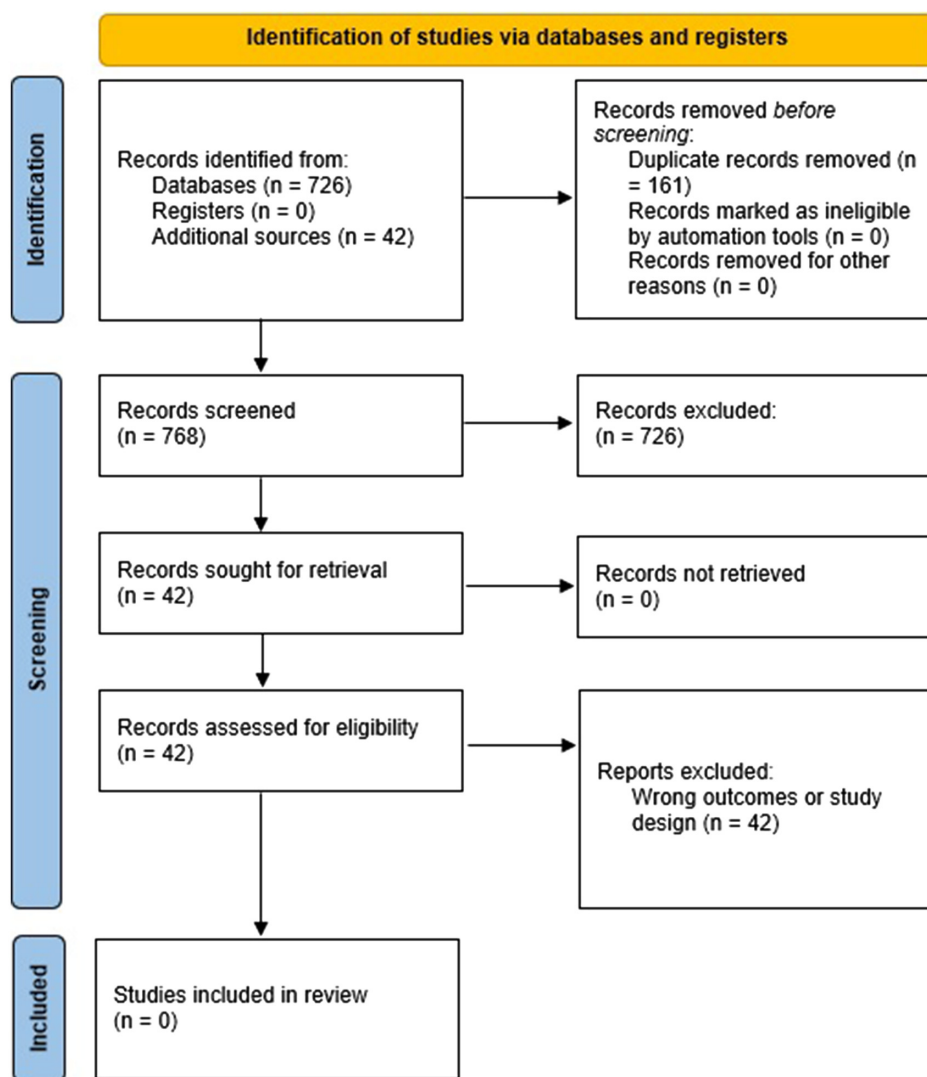
As no studies met the inclusion criteria, the methodological reporting quality could not be reported.

### Study Characteristics

No studies met the inclusion criteria of this review; this was largely attributed to no study providing objective evidence of performance changes from a “healthy” state combined with evidence of suppression of performance that lasted 4 weeks or longer. It should be noted that several studies<sup>8–10,14,19–29</sup> did state that performance had declined; however, evidence of the magnitude or the length of decline was not provided. Furthermore, studies occasionally stated that psychological changes had occurred, but this was not corroborated with objective evidence (eg, a validated scale).<sup>30</sup> Therefore, as no study provided actual evidence of objective changes in physical performance and psychological states, as required by the definition of purportedly overtrained athletes, we were unable to describe the physical and psychological changes that occur with OTS.

## Discussion

The aim of this systematic review was to establish and detail the physiological and psychological changes that occur as a result of OTS in athletes. From the search of the literature, no studies met the criteria and definition of OTS, with all studies failing to provide evidence of changes in physical capacity from a “healthy” to an overtrained state with chronic (ie,  $\geq 4$  wk) suppression of performance. This suggests that, while OTS may be a severe condition that can negatively affect athletes, for practitioners and researchers, there is little data available that describes how physical and psychological qualities manifest (Figure 2). These issues likely stem from the vague terminology that has traditionally been used to define OTS, the difficulties of providing objective evidence of performance across prolonged periods of time, and the prospective nature of testing that would be required for diagnosis. It should be noted that while this review cannot provide evidence of sufficient quality regarding changes in performance and mood state associated with OTS, it is plausible practitioners and researchers have indeed observed OTS but have been unable to document these



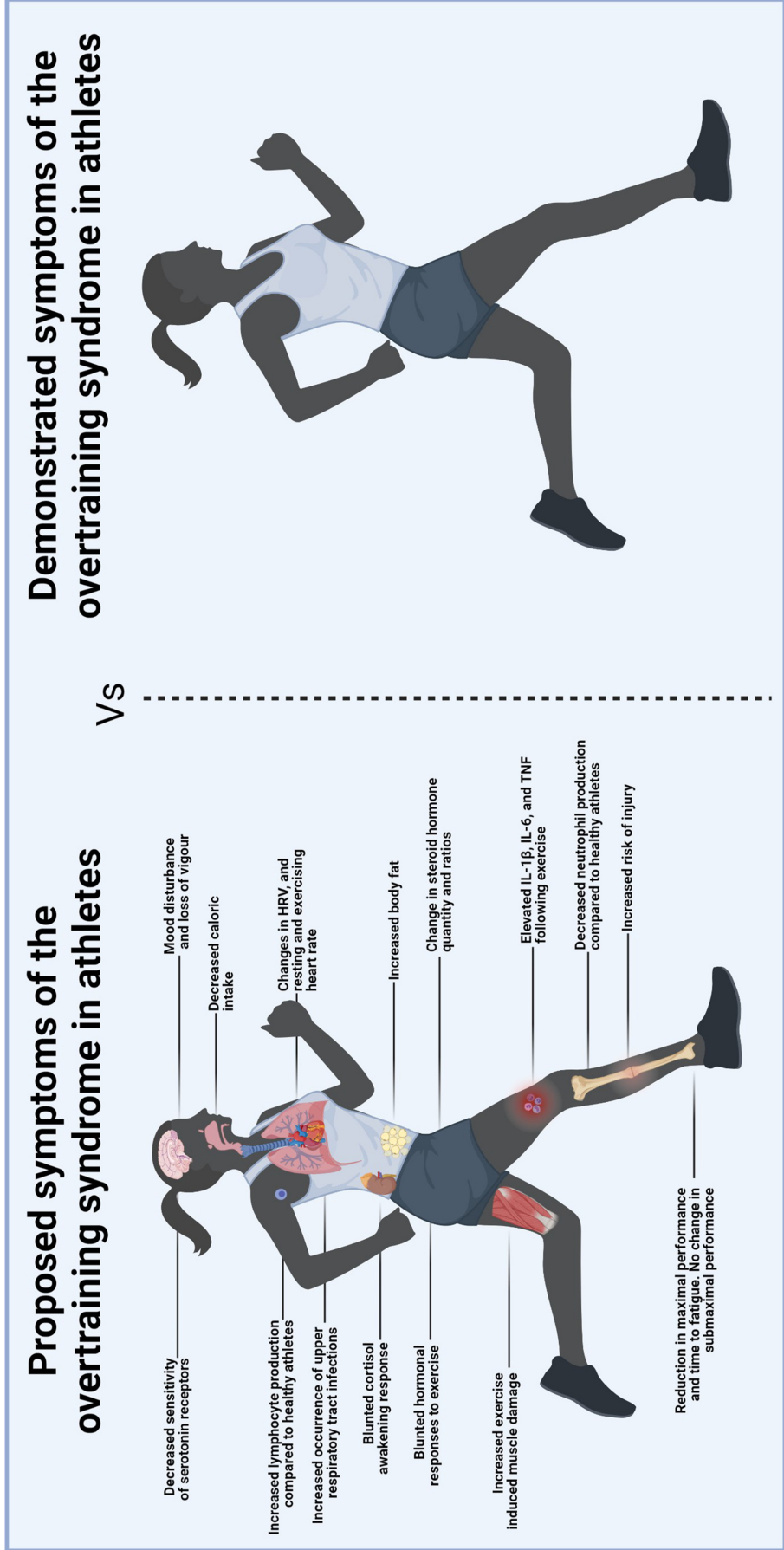
**Figure 1** — Flow diagram of search strategy for eligible studies.

changes. Therefore, it is our recommendation researchers and practitioners resist the urge to state that OTS has occurred, or infer similar outcomes, when short-term suppression of performance is observed.

A range of factors may be limiting our understanding of OTS. For example, due to the vague definition and timelines associated with the syndrome, it is difficult to clearly ascertain the requirements and earliest time point at which it can be diagnosed. The current definition states that “several weeks” of performance suppression is required. Despite this, it is known that fatigue is often transient in nature and common tapering strategies last 2 to 4 weeks,<sup>32</sup> while other strategies often used by athletes, such as altitude training, may suppress performance prior to supercompensation well beyond the time frame associated with OTS.<sup>33</sup> Furthermore, it is hard to fathom that severe training and limited recovery that causes a transient substantial performance decrement would not induce negative psychological signs or symptoms. However, decreases in mood/psychological state are not always a mandatory inclusion for diagnosis of OTS.<sup>7</sup> Finally, since OTS is not only associated with the mismanagement of training load but also external variables,<sup>34</sup> “overtraining” by name is a misnomer.

Biopsychosocial and other factors such as existence of an underlying medical disorder, insufficient caloric intake, reduced sleep quality and/or quantity, and poor mental health likely play a considerable role in its development and should also be considered.<sup>22</sup> This has been discussed with the term “unexplained underperformance syndrome” being suggested to be more appropriate terminology than “overtraining.”<sup>34</sup> Due to these issues, the literature to date has considerable inconsistencies in the terminology and diagnosis of OTS, which has likely contributed to the poor understanding of this phenomenon.

The lack of information pertaining to OTS is likely an outcome of the difficulties associated with capturing the necessary data. With unexplained decrement in performance being one of the criteria for diagnosis of OTS, several studies have simply stated that performance has declined when an athlete perceives they are not performing as well as normal.<sup>19,21</sup> Alternatively, in sports in which performance is difficult to quantify (eg, wrestling), performance has been subjectively assessed by coaches.<sup>35</sup> However, these methods inherently invite bias and do not objectively assess change in one of the most important considerations in the definition of OTS. Further complicating the topic, psychological



**Figure 2** — Proposed and demonstrated symptoms of overtraining syndrome. Information retrieved from references 8-11, 13, 14, 23-25, and 31. HRV indicates heart-rate variability; IL, interleukin; TNF, tumor necrosis factor.

symptoms have regularly been reported but this has often been done without rigor.<sup>30</sup> Within the literature, athletes have been requested to recall whether a single psychological characteristic has been altered during their training history. Disregarding issues surrounding whether an athlete can accurately recall the length and severity of changes in mood, the ability of a single question to assess psychological change must be questioned. Considering these concerns, efforts must be made to find valid and reliable objective methods of quantifying changes in performance and psychological state that can feasibly assess OTS in a practical setting.

Within the scientific literature, 15 studies have stated or indicated that objective methods were used to identify suppression in performance (>2 wk) and psychological symptoms.<sup>8–10,14,19–29</sup> However, these studies did not provide baseline performance testing data of the athletes included and objective changes in performance were not detailed. Furthermore, it should be noted that 12 of these 15 studies analyzed data from the same cohort of athletes. This indicates that only 4 different cohorts of athletes are available that have provided objective assessment of performance and psychological state, with two of these having only one participant each. While it is praiseworthy that these authors attempted to objectively assess these outcomes and the inherent difficulties are duly acknowledged, without the provision of data prior to their diagnosis, practitioners and researchers alike are still unable to truly understand how OTS manifests.

With the chronic and severe nature of OTS, it could be argued that elite-level athletes, who complete substantial training loads, may be at the greatest risk. However, similar to other research in elite athletes, this inherently brings difficulties. For instance, the severe nature of OTS coupled with the scarcity of *truly* elite populations reduces the likelihood of obtaining data in these populations. Furthermore, with the growing emphasis on sport science in elite sport, the mismanagement of fitness and fatigue in elite athletes may be increasingly rare. Thus, the feasibility of this type of research in these populations is remarkably difficult. As practitioners or researchers would not purposely induce OTS in a group of athletes, it is therefore more likely that individual case studies from prospective cohorts will be the only feasible method of attaining an accurate understanding of the expression of OTS in elite populations. Finally, it should be noted that we recognize that previous quality research has been conducted in the areas of intensified training, overreaching, and potential mechanisms in suspected overtrained athletes that has resulted in an enhanced understanding of fatigue responses and potential fatigue monitoring tools in the field. However, the challenges in conducting research that meets the strict criteria necessary for the diagnosis of OTS, has resulted in a lack of research data that can be translated to truly elite athletes.

With the diverse range of physical demands that are placed upon athletes from different sports, signs and symptoms of OTS distinct to different forms of exercise may be prevalent.<sup>7,31</sup> In overreached athletes, excessive resistance training volumes and intensities have been shown to induce different fatigue profiles when compared to endurance training.<sup>36</sup> Additionally, separate physical characteristics (eg, strength vs power) have varying sensitivity to fatigue.<sup>37</sup> Therefore, depending upon the athlete, their sport, and the physical performance test monitored, the onset of OTS may occur at differing time points. Furthermore, while the cause of OTS is commonly acknowledged as multifaceted, it is plausible that athletes that incur different demands also experience different symptoms. Therefore, investigating OTS as a homogenous outcome that affects all athletes in the same

manner, and attempting to quantify the symptoms of athletes from a range of athletic endeavors is likely overly simplistic.

To appropriately monitor and quantify the signs and symptoms associated with OTS, there are several considerations that can contribute to an accurate reporting of this syndrome. First, there is a need to establish a baseline in a valid and reliable test that assesses a relevant physical quality. This is required to verify that a change in performance has occurred. Second, regular testing must occur to establish if performance has declined. However, if a state of OTS has been reached, physically testing an athlete during this time may be undesirable and exacerbate the fatigue and psychological burden of the athlete. Third, it must be clearly established that decreases in performance are not an acute response to previous bouts of training. Research into tapering and peaking indicates that performance supercompensation can take up to 4 weeks following the reduction of training volume and that the timing of supercompensation can differ between athletes despite identical training loads.<sup>38</sup> Fourth, any changes in performance must be outside that of the regular variation associated with the test selected. Fifth, regular testing throughout the purported overtraining period may be needed to ascertain the duration of the performance suppression and to confirm that OTS has occurred. For the understanding and accurate reporting of OTS, these considerations are necessary but can be exceedingly difficult in practice.

## Practical Applications

A considerable number of issues associated with OTS stem from the misidentification or lack of verification of the syndrome. To date, no studies have provided information regarding baseline physical qualities, evidence of change, and verification of chronic (ie,  $\geq 4$  wk) suppression of performance. Consequently, to improve understanding, several recommendations can be made that may help practitioners and researchers. Future research is strongly recommended to complete a 3-step testing verification process that involves: (1) testing athletes when they are healthy, (2) testing again at the initial point of suspected OTS, and (3) testing at least 4 weeks postinitial suspicion. Additionally, tests that are selected should be relevant to the athlete and changes in performance must be outside the usual variation of the test used. Furthermore, valid objective assessment of the athlete's psychological state is required and should be assessed at the second or third testing occasion to verify symptoms of psychological maladaptation.

When designing studies to assess OTS in athletes, there are a range of ethical and practical considerations. While purposely inducing a state of OTS in any individual is unethical, in athletes, it would also be exceedingly impractical. Therefore, while possible, an accurate understanding of OTS will unlikely be achieved through controlled trials. Nevertheless, observational data from a range of real-world settings may enable assessment of this syndrome. For example, training camps or institutes of sport frequently house athletes for extended periods of time with testing often completed. However, follow-up time points to verify diagnosis may be difficult considering the associated issues with data collection and the unknown changes that occur with OTS, but these may also provide some of the best opportunities to collect data on elite athletes.

## Conclusions

The multitude of publications on OTS and its severe consequences for athletes is in direct contrast with the limited availability of

objective data and diagnostic tools that align with the definition of OTS. It should be remembered that the key difference between functional overreaching, nonfunctional overreaching, and OTS is the amount of time needed for performance restoration and/or performance supercompensation. Therefore, the diagnosis of OTS can only be made retrospectively and may be less common than reported throughout the literature. While measurements of selected physiological markers may seem appealing, due to the multifaceted nature of OTS, they may rarely be useful in diagnosis. Additionally, their volatility, and the lack of standardized definitions and procedures that have been used throughout the literature, reduce our understanding of their mechanistic properties. Therefore, from a critical review of the existing literature, it must be concluded that an evidence base of sufficient scientific quality for the understanding of OTS in athletes is simply lacking.

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