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Areta, JL, Jeukendrup, AE, Van Genechten, L, Langan-Evans, C, Pedlar, CR, Rodas, G, Sale, Craig and Walsh, NP (2025) Limited Empirical Support for Relative Energy Deficiency in Sport (REDs) Syndrome. Sports Medicine. ISSN 0112-1642

DOI: https://doi.org/10.1007/s40279-025-02220-7

Publisher: Springer Verlag

Version: Accepted Version

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# Limited Empirical Support for Relative Energy Deficiency in Sport (REDs) Syndrome

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## Declarations

Conflicts: The authors report no conflicts of interest directly relevant to the content of this article.

Funding: No funding was received for the preparation or publication of this letter.

Author contributions statement: All authors were involved in the conception, drafting and final approval of this work and agree to be accountable for all aspects of this work.

We would like to thank Mountjoy et al. for their interest in our recent paper titled "Does Relative Energy Deficiency in Sport (REDs) syndrome exist?" [1]. We share the common interest of supporting the health and performance of the athlete.

In their letter, Mountjoy et al. conclude "we - the IOC consensus co-authors - know that *REDs exists*", a statement that is not compatible with the scientific process [2]. Science is a process where empirical evidence is obtained to test hypotheses. We believe its important to challenge dogmas and encourage rigorous scientific processes. Our intention was to critically discuss the REDs concept and the limited empirical evidence available to support the model. The REDs model describes how low energy availability (LEA), which is impossible to measure accurately in the field, causes a wide range of deleterious health and performance outcomes. We contend that the REDs model is too calorie-centric, and the name and definition of the model only acknowledges one cause, 'LEA'. REDs symptoms are likely of multi-factorial origin (Figure 1). Focusing upon one possible cause leads to bias, which can preclude researchers and practitioners from unveiling the true aetiology of the presented symptoms.



**Figure 1**. Comparison of the current REDs model that centers around LEA as the only cause of symptoms (Left: with permission [3]) and the more holistic approach we presented in our paper [1].

Mountjoy et al. challenge our criticism that few studies demonstrate causality between LEA and the symptoms reported in the REDs model. They state that "*a large totality of cross-sectional data can eventually be shown to be causative*", citing examples of smoking causing lung cancer and repetitive head impacts causing chronic traumatic encephalopathy [2]. These are false analogies, however, because they have clear objective, identifiable and quantifiable single causes (*i.e.*, smoking and head impacts), and equally clear objective, identifiable and quantifiable to the argument that LEA causes REDs, because: first, LEA is not an objective, identifiable, quantifiable parameter in practice; second, there are no clear objective, identifiable and clinical outcomes directly related to LEA *only* and third, the constellation of non-specific symptoms reported in the REDs model are unlikely to be the consequence of *just* LEA. The likely multi-factorial aetiology of REDs symptoms aligns with an allostatic load model and the consequence of allostatic overload [1,4] (Figure 2) [1]. This was the reason for us proposing the Athlete Health and Readiness Checklist (AHaRC: Figure 3).



**Figure 2**. Common symptoms and clinical conditions in athletes that are similar to REDs may be caused by many factors independent of —or in combination with— LEA. Eight categories of factors that can contribute to these symptoms are shown (in no order preference). In many situations several factors, potentially from several categories, may play a role in the development of REDs symptoms in athletes. Many different types of challenges can independently or in combination increase allostatic load and over time this can cause wear and tear on the body and ultimately result in symptoms and pathology. The common pathways are the HPA axis and central nervous system (CNS). The brain plays a central role and psychiatric disorders, trauma, and abuse, as well as major life events, play an important role by modifying neuro-endocrine reactivity to stress. Life/environmental factors that can cause stress related to relationships, competition or self-image, to name just a few. There are also many important behavioural factors, most notably for athletes, including their training, their nutrition and sleep. Lingering infections can also affect allostatic load but could also have direct effects on a number of symptoms. This is the case for several other factors as well; for example, iron

deficiencies or other nutritional deficiencies can have direct effects, causing REDs symptoms.

Mountjoy et al. criticise the AHaRC (Figure 3) for not going through a validation process like the REDs *Clinical Assessment Tool-Version 2* (CAT2), consisting of internal expert voting and clinical cross-agreement validation. The AHaRC is not a tool that requires validation, since it is not diagnostic, rather it is a screening checklist to signpost practitioners to appropriate tools and relevant professional consultations. Unlike the REDs CAT2, it is not embedded in a model created *ad hoc*, and it is not a tool attempting to define a binary outcome in the same way as the REDs CAT2 (*i.e.*, REDs present/not present). The AHaRC is supported by a series of recommendations, consensus statements and questionnaires from experts of each area.



Athlete Health and Readiness Checklist

**Figure 3**. Athlete Health and Readiness Checklist (AHaRC) providing a multidimensional decision tree to maintain athletes' health and performance. The AHaRC will act as a guide for practitioners working with athletes, to implement regular checks, identifying possible tools and the most relevant professionals to consult. There are eight categories (no order of preference), all important to check. Some need frequent checks (daily or weekly)

others more periodically (suggested frequency: D = daily, W = weekly, M = monthly, AH = ad hoc, OI = on indication). The list here is not exhaustive but should be a good starting point for those responsible for athlete health. For each component in the checklist, the recommended tools and possible actions are supported by expert/consensus recommendations. Profile of mood states (POMS); recovery stress questionnaire for athletes (RESTQ-S), and daily analyses of life demands of athletes (DALDA). (1) training/exercise [5–7], (2) life/environmental [8], (3) mental health [9], (4) disordered eating/eating disorders [9–11], (5) nutrition [12], (6) sleep [13], (7) infection/illness [14], and (8) undiagnosed clinical condition [15,16].

Mountjoy et al. conclude by stating "we - the IOC consensus co-authors - know that REDs exists." Simply 'knowing' that something is true is a personal belief. Hunches, observations and beliefs may be good triggers to initiate research, and apply the scientific method, but not to draw conclusions. Science is about systematically testing falsifiable hypotheses. We shall be reminded that the plural of anecdote is not scientific evidence, and that the main reason why we apply the scientific method is to overcome the limitations in the power of observation of individuals, which is biased. A theory or hypothesis is falsifiable if it can be logically contradicted by an empirical test. The REDs model is somewhat immune to falsification because isolating the effects of LEA from other potential causes is experimentally challenging. Therefore, we may never definitively answer the question, "does REDs syndrome exist?". From a practical point of view, it is not necessary to isolate LEA as a cause because all potential areas of health and performance improvement should be identified and tackled to provide the best possible care to symptomatic athletes.

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