Does ketone ester supplementation really blunt overreaching symptoms during endurance training overload?

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In a recent paper in *The Journal of Physiology*, Poffé et al. (2019) concluded that "ketone ester intake is a potent nutritional strategy to prevent the development of non-functional overreaching". I argue that such a conclusion cannot be proposed from the data that is presented in the paper.

Poffé et al. (2019) recruited eighteen male subjects who completed a 3-week overload-training cycling programme and a 1-week recovery period. Subjects completed 28 training sessions and received either a ketone ester drink (KE group; n = 9), or an isocalaric placebo (control group; n = 9) following training as well as 30 min before sleep. Before, during (days 7 and 14) and after the training period, as well as during the recovery phase (3 and 7 days), the subjects completed a 30 min time trial and a 90 s cycling sprint. Furthermore, on day 18 of the training period, subjects completed a 30 min time trial after a 90 min cycling preload. Poffé et al. (2019) make elaborate remarks throughout the paper to suggest that ketone ester intake is a potent nutritional strategy that is effective in preventing the development of non-functional overreaching (NFOR) and in preventing symptoms of overtraining. However, there is no attempt at any point in the paper to individually classify the subjects as being overreached (either functional or non-functional) or overtrained based on their change in cycling performance and resultant recovery timeline, a classification that is typically employed in human studies (Halson *et al.*, 2002; Coutts *et al.*, 2007; Le Meur *et al.*, 2013; Aubry *et al.*, 2014; Bellinger *et al.*, 2019) and consistent with the consensus statement defining overreaching and overtraining (Meeusen *et al.*, 2013).

Based on the definitions used by Halson and Jeukendrup (2004), and the joint consensus statement of the European College of Sport Science and American College of Sports Medicine (Meeusen *et al.*, 2013), functional overreaching (FOR) results in a short-term decrement in performance capacity, with or without related physiological and psychological signs and symptoms of overtraining, in which restoration of performance capacity may take several days

to weeks. If the balance between training stress and recovery is further disrupted, NFOR may develop, which is an extreme state of overreaching, leading to a decrease in performance that will not resume for several weeks or months (Meeusen *et al.*, 2013).

In the study of Poffé et al. (2019), there was no decrement in 30 min time trial performance, and 90 s sprint cycling performance was impaired to the same magnitude in both the KE and control group in response to the overload-training period, which returned to a value no different from pre-training after 3 days of recovery. From this standpoint it could be suggested that both the KE and control group became FOR. However, it must be noted that subjects should only be classified on an individual basis, and there is no attempt to do this throughout the paper. Indeed, it is possible for athletes to respond positively to a period of intensified training, whilst others experience decrements in performance and, therefore, it is critical that individual performance data is presented. On day 18 of the training period, mean power output during the 30 min time trial that was preceded by a 90 min cycling preload was 15% higher in the KE group compared to the control group (Poffé *et al.*, 2019). However, given that this time trial was only performed once throughout the entire study period, it is impossible to determine whether there was a performance decrement as a result of the overload-training programme or whether the between group differences were already evident prior to the training period. Despite the authors (Poffé *et al.*, 2019) making efforts to pair-match the subjects based on other performance measurements before the commencement of the study, the conclusions that can be drawn from the 15% between group difference in this time trial are limited.

While the authors might argue that disturbances in selected cardiovascular, hormonal and perceptual symptoms were different between KE and control groups, it should be noted that these disturbances do not necessarily differentiate between states of overreaching. Indeed, while NFOR is thought to exhibit the first signs and symptoms of prolonged maladaptation such as psychological disturbance (decreased vigour, increased fatigue) and hormonal

disturbances, these symptoms may also be present in athletes that are classified as FOR (Meeusen *et al.*, 2013). As such, changes in performance and recovery time remain as two of the only methods to partition the two stages of overreaching. Indeed, FOR is characterized by a short-term decrement in performance capacity, in which restoration (Halson *et al.*, 2002; Aubry *et al.*, 2014), and sometimes super-compensation (Coutts *et al.*, 2007; Le Meur *et al.*, 2013; Bellinger *et al.*, 2019), may occur following an appropriate period of recovery (~1–3 wk). Conversely, a state of NFOR will need weeks or months to recover (Meeusen *et al.*, 2013). Given that the only performance marker (90 s sprint cycling performance) that was impaired in response to the overload-training programme restored after only 3 days of recovery, it could be suggested that subjects in both the KE and control groups were not NFOR. However, without presenting the individual responses this remains unclear. As such, the claim that ketone ester intake can prevent NFOR is unfounded. Furthermore, Poffé et al (2019) state that "we provide preliminary observations to indicate that growth differentiation factor 15 may be an adequate hormonal marker for the development of over-reaching/overtraining", but without studying the individual responses in respect to whether subjects were classified as being overreached, this conclusion is also unfounded.

Given the elaborate statements throughout the paper by Poffé et al. (2019). exclaiming that ketone ester intake is effective in preventing the development of NFOR and in preventing symptoms of overtraining, it may be that the enthusiastic media attention and news articles that were highlighted by Korevaar et al. (2019) regarding this paper manifested from the overly optimistic and unfounded concluding remarks from Poffé et al (2019).

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