THE IMPORTANCE OF NUTRITIONAL CONSIDERATION FOR ATHLETE LONG-TERM DEVELOPMENT: UNIQUE CONCERNS FOR THE WEIGHT-CLASS STUDENT-ATHLETE

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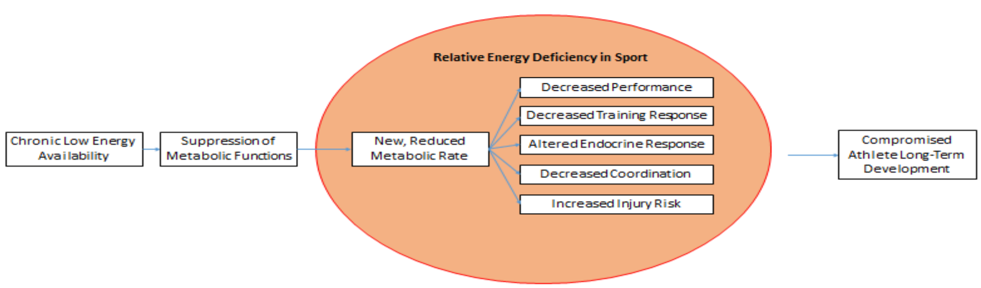
INTRODUCTION: The ultimate goal of training within the context of sports is to improve performance. These improvements develop as a result of an interplay between skill development and physiological adaptations, notably through metabolic responses in the form of protein synthesis. As such, nutrition is a significant modifier of an athlete's ability train, improve, and perform. Therefore, the coach and college athlete should be aware of potential nutritional impediments to athletic performance and long-term development. Because of the direct link between dietary practices and body weight, nutritional considerations are important to the weight-class athlete. Specifically, poor dietary practices aimed at maintaining or achieving a desired short-term body weight may impact the long-term development of the athlete. Noteworthy are the negative consequences of low energy availability (EA).

The purpose of this brief review describe low EA and its potential impact on both the short and long-term training process, highlight the possible nutritional impediments to student-athletes, and offer a practical nutritional consideration for the long-term development of a weight-class student-athlete.

Energy Intake, Balance, Deficiency, and Availability

Adequate energy intake (EI) is an essential component to the athlete's diet, yet there exists much complexity and nuance with this fundamental concept. The caloric value of a food item reflects that item's dietary energy, and EI is the summation of the caloric values of all food items consumed (Mountjoy et al., 2014). An athlete is said to be in a state of energy balance (EB) when total EI matches total energy expenditure (TEE) (Mountjoy et al., 2014). When EI is less than TEE, the athlete is in a state of energy deficit. When EB is achieved, body mass remains unchanged, while a deficit and positive balance will result in a reduction or increase in body mass, respectively (Mountjoy et al., 2014). Nonetheless, maintaining EB is not always indicative of the absence of a *relative* energy deficit (Mountjoy et al., 2014). Specifically, the athlete may be in a state of relative energy deficiency, despite maintaining overall EB with no alterations to body mass (Mountjoy et al., 2014). In such a condition, the athlete's metabolic rate has reduced as a result of suppressed physiological functioning. Relative Energy Deficiency in Sports (RED-S) is the term used to describe the impaired physiological functioning specific to athletes caused by relative energy deficiency, which includes but is not limited to downregulation of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health. The underlying etiology of RED-S is low EA (Mountjoy et al., 2014). Figure 1 shows the relationship between low EA, RED-S, and downregulation of the training process.

Figure 1. A conceptual framework on the relationship between low EA and RED-S



EA is the amount of energy remaining to support total metabolic needs after the energy expenditure for a specific task has been subtracted. In sports, the specific task energy expenditure is training/competition. Although similar, both EB and EA are conceptually different, where EB is an output and EA is an input (Loucks et al., 2011). That is, because EI that is used to fuel the physical demands of training is no longer available to the body, EA is the total net energy put into the body. Low EA is the scenario where an athlete's dietary energy consumption is not enough to properly support the remaining metabolic needs associated with recovery, basic health and function, and daily physical activity. Low EA may reduce the metabolic rate to normalize to a lower level (Stubbs et al., 2004) by suppressing physiological processes (Mountjoy et al., 2014). Therefore, achieving dietary EB based on direct or estimated TEE or by changes in body mass may not reflect the true metabolic state of an athlete, especially those with chronic low EA.

Recommendations have been established to determine adequate EA (Loucks et al., 2011). Energy availability is expressed in a relative manner of dietary energy (kcal) per kilogram of fat free mass (FFM). Adequate EA to maintain body mass in a healthy, non-relative energy deficient athlete is around 45 kcal/kg FFM/Day. The minimum EA for an athlete to lose weight without compromising physiological functioning is around 30 kcal/kg FFM/Day. Table 1 provides an example of EA calculations for a 70 kg athlete with a standard training energy expenditure of 500 kcal.

Table 1. Total energy intake ranges based on energy availability and standardized for physical activity for a 70 kg athlete with 15% body fat

	Low Energy Availability	**Acceptable Reduced Energy Availably for Body Composition Changes**	**Energy Availability for Maintenance**	**Energy Availability for Body Mass Increase**
Energy Category	**< 30 kcal/kg FFM/Day**	**30 to < 45 kcal/kg FFM/Day**	**45 kcal/kg FFM/Day**	**> 45 kcal/kg FFM/Day**
Energy Availability (Kcal)	< 1785	1785 - < 2677	2677	> 3385
Training Energy Expenditure (Kcal)	500	500	500	500
Total Energy Intake (Kcal)	< 2285	2285 - < 3177	3177	> 3177

Energy Availably and the Training Process

The practical implications of low EA and RED-S are substantial. The central issue surrounding RED-S is that the athlete's current physiological state is below the inherent potential. Complicating this issue further is that the athlete has habituated to this current physiological state, so this suppressed state may not be recognized, and viewed as normal or healthy. In such conditions, a new and reduced homeostatic set point has been established. As many of the recovery/adaptation responses to the training process are the result of protein synthesis, this energy-consuming process is fundamentally in opposition to the suppression of metabolic processes in RED-S. Such an antagonistic relationship is likely to impede the training process.

Low EA is attributable to many unwanted physiological developments as a result of RED-S. Most of the research on low EA has focused on the Female Athlete Triad (Triad), which may be categorized as a subset under RED-S (Mountjoy et al., 2014). Nonetheless, as low EA is the cause of RED-S, similar physiological pathways may disrupted in both sexes, but differ in the final symptoms and consequences (Mountjoy et al., 2015). Such variations can complicate the identification of RED-S. Underlying many of the maladaptations in RED-S from low EA include hormonal and substrate alterations, including insulin, cortisol, growth hormone, insulin-like growth factor-I, 3,3,5-triodothyronine, grehlin, leptin, glucose, fatty acids, and ketones (Mountjoy et al., 2014). Such alterations can independently or collectively impact an athlete's ability to train and adapt to training. This negative impact on the training process likely influences both the individual training session and the long-term training process.

Phase potentiation is a theoretical training model that capitalizes on the effects of one training block, which potentiates a later block due to delayed gains in performance (Stone et al., 1982). Thus, the concentrated stimulus of emphasized training results in a specific adaptation that comes to fruition as a later period. One is left to hypothesize how RED-S may act as a negative potentiation stimulus to the training response. For example, weight-class athletes often undergo periods of rapid weight loss through extreme diet restriction and dehydration to attain a weight-class goal (Sundot-Borgen & Garthe, 2011). This period of a concentrated low EA stimulus, too, may have delayed ramifications and ultimately influence the training block after competition. More research is needed to examine this potential for a systematic, negative potentiation effect of low EA on training adaptation.

Impediments to Implementing Nutrition Best-Practices in Student-Athletes

As evident in the EA example of a 70 kg athlete, maintaining proper EA with a modest amount of physical activity still requires a substantial caloric intake. Further, consuming that amount of energy in a manner that supports sports nutrition guidelines on quantity, timing, frequency, meal composition, and food variety, all around the time restraints imposed by school and training demands is a complex task. Additional questions arise as to the availability of food items through school dining or the ability of the athlete to cook and prepare meals. Unfortunately, research does not indicate that most student-athletes have the knowledge, skills, or support to perform such a task independently.

Research has found that as low as 9% of collegiate student-athletes have adequate knowledge of basic sports nutrition, and as a whole, have the least knowledge on weight management and eating disorders (Torres-McGehee et al., 2012). Similarly, nutrition knowledge among collegiate coaches tends to be low. Adequate knowledge of basic sports nutrition has been reported as low as 5% (Botsis & Holden, 2015) to 40% (Torres-McGehee et al., 2012) among coaches. Regarding weight management, coaches have reported to place a greater importance on total weight over body composition for sport performance (Rockwell et al., 2001). Such findings are concerning, given that nearly half of student-athletes in a recent investigation report referring to their coach for nutrition guidance (Torres-McGehee et al., 2012). Based on these findings and the importance of body weight and composition to weight-class sports, it is unlikely that many collegiate weight-class athletes have the skills or support structure to develop optimally from a nutritional perspective.

PRACTICAL APPLICATION: Given the detrimental effects of low EA and the relationship between body mass and nutrition, a nutritional perspective for long-term development is warranted for collegiate weight-class athletes. Specifically, assigning a weight-class to an incoming athlete is based on the assumption that the athlete has no suppressed physiological functions from RED-S and their weight is maintained by adequate EA. If the athlete has not followed a well-structured, best-practice nutrition plan, it is unknown if the athlete's potential development is compromised by a relative energy deficiency and if the given weight-class is appropriate for the athlete. For example, if an athlete weighs 71 kg and plans to compete in the 69 kg class but has attempted to keep body mass artificially low through energy restriction, the metabolic habituation to the lower energy state would offer little to no room to reduce caloric further before entering or worsening the low EA state.

Therefore, coaches of weight-class sports should also view the athlete's development from a nutrition and weight-management perspective. In a four-year collegiate scenario, the first two years could serve as the bases for establishing a sound developmental foundation. In this period, the athlete would work with a qualified nutrition professional to establish a well-constructed nutrition program and would also be educated about sports nutrition and general nutrition related skills. The goal of this period is to establish a healthy baseline for the athlete where EB and EA are gradually aligned around 45 kcal/kg FFM/day. The emphasis in this period is on physiological and skill development to establish an optimal weight class. Doing so should allow the athlete to recover and adapt more ideally to training. In the second two years, the focus shifts to optimizing performance within a weight class. With the baseline diet set around 45 kcal/kg FFM/day, the athlete now has acceptable ranges to alter the diet to obtain more ideal body composition within a weight class.

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