International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

ARTICLE TITLE	WHEN THE BODY DOES NOT GET FUEL. EFFECTS OF EXCESSIVE FOOD INTAKE RESTRICTIONS IN ATHLETES - A REVIEW
DOI	https://doi.org/10.31435/ijitss.4(48).2025.4343
RECEIVED	22 October 2025
ACCEPTED	17 December 2025
PUBLISHED	26 December 2025
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

WHEN THE BODY DOES NOT GET FUEL. EFFECTS OF EXCESSIVE FOOD INTAKE RESTRICTIONS IN ATHLETES - A REVIEW

Zuzanna Sawiec *(Corresponding Author, Email: zuzasaw@tlen.pl)*
Ludwik Rydygier Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0000-0002-3237-4029

Dominika Kondyjowska
Ludwik Rydygier Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0006-1458-9284

Natalia Bukała
University Clinical Hospital, Wrocław Medical University, Wrocław, Poland
ORCID ID: 0009-0009-1617-3487

Dorota Maria Komuńska
Stefan Żeromski Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0000-8919-0557

Ewa Antonowicz
Independent Public Health Care Center of the Ministry of Internal Affairs and Administration in Kraków, Kraków, Poland
ORCID ID: 0000-0002-6229-8389

Sylwia Tomasiczek
Stefan Żeromski Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0005-4214-8454

Weronika Tomasiczek
Gabriel Narutowicz Municipal Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0005-3466-0386

Marta Rogozińska
Stefan Żeromski Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0000-7445-1128

ABSTRACT

Background. With an increasing number of research, sports nutrition becomes an important topic both in professional and recreational athletes. In case of insufficient caloric supply, organism slowly shuts down expendable functions and that presents a health hazard. The first term trying to describe consequences of low energy availability (LEA) was Female Athlete Triad (eating disorder, menstrual disturbances and low bone density), later expanded to Relative Energy Deficiency in Sport (RED-S) which also includes fatigue, sleeping problems, hormonal imbalances, cardiovascular complications.
Aim. In this review we aimed to identify research of interest and sum up available information.
Material and methods. In order to identify research of interest, we used the following online databases: MEDLINE, CENTRAL and manually looked for applicable titles in references of identified publications.
Results. Identified researches showed that consequences of LEA are common which becomes a serious problem in sports medicine. The reasons for calorie restriction are connected to personal self-perception and discipline regulations. It is important to identify athletes at risk of complications and implement procedures aiming to improve their health while simultaneously understanding their motivation for sports success.
Conclusions. Although research on the topic is vast, it is still crucial to educate athletes and their ecosystem about risks and consequences of LEA.

KEYWORDS

Sports Nutrition, Relative Energy Deficiency in Sport, RED-S, Low Energy Availability, LEA, Female Athlete Triad, Eating Disorder, Athletes

CITATION

Zuzanna Sawiec, Dominika Kondyjowska, Natalia Bukała, Dorota Maria Komuńska, Ewa Antonowicz, Sylwia Tomasiczek, Weronika Tomasiczek, Marta Rogozińska. (2025). When the Body Does Not Get Fuel. Effects of Excessive Food Intake Restrictions in Athletes – A Review. *International Journal of Innovative Technologies in Social Science*. 4(48). doi: 10.31435/ijitss.4(48).2025.4343

Introduction

It is common knowledge that how and what we eat affects our well-being in many ways, most notably energy levels. Nevertheless, consumed nutrients can not only affect physical health, but also greatly impact mental well-being[1]. Maintaining a healthy balance necessitates supplying the body with adequate energy and essential nutrients to support physiological functions including but not limited to: cellular maintenance, growth, thermoregulation, reproduction, immunity, and movement[2]. In both amateur and professional athletes, the energy demand is naturally higher than in a sedentary or not regularly exercising person. Therefore focusing on both quantity and quality of meals is of utmost importance for reaching optimal performance. Considering different metabolic demands and type of exertion, performers of various disciplines require individual approach regarding macro and microelements intake[3]. Despite sport nutrition being a constantly developing and vast branch of science, in this review we decided to focus mainly on caloric intake. In order to identify research of interest, we used the following online databases: MEDLINE, CENTRAL and manually looked for applicable titles in references of identified publications.

The importance of diet

One of the theories trying to explain what determines health in individuals is one of Health Fields suggested by Marc Lalonde[4], a former Canadian Minister of Health. According to his views, environmental, genetic and health care factors are of importance. However, around 50% of well-being is influenced by personal lifestyle choices. This perspective can be extremely motivating since everyone starts with a different genetic load and one might not have total control over their environment. On the other hand, it is possible to have a great impact on one's health by eating nutritious and quality food, as well as engaging in regular physical activity. Various dietary patterns have been connected to decreasing the risk of illnesses such as Alzheimer's Disease[5] or cardiovascular diseases[6].

How much is enough

The easiest way of understanding calorie requirements is understanding that Total Energy Expenditure (TEE) is the sum of basal metabolic rate (BMR) and the Thermic Effect of Food (TEF) and the Thermic Effect of Activity (TEA). The latter comprises Exercise Energy Expenditure (EEE), Spontaneous Physical Activity and Non-exercise Activity Thermogenesis. It's crucial to assess EEE in athletes since if deducted from Energy Intakes, the result is what the organism is left with when it comes to maintaining its function - Energy Availability[7], which in general population has been assessed to be 45 kcal/kg of fat free body mass.

Relative Energy Deficiency in Sport

Concept of EA emerged from the context of the Female Athlete Triad (FAT). First position stand regarding FAT was published in 1977 by Task Force on Women's Issues of the American College of Sports Medicine[8]. It is defined as three interrelated yet distinct conditions: low energy availability with or without disordered eating, (2) menstrual dysfunction and (3) low bone mineral density. With more research and investigation on this topic, sport scientists included FAT in a broader group of symptoms constituting a Relative Energy Deficiency in Sport (RED-S)[9]. Updated definition of RED-S describes it as:

a syndrome of impaired physiological and/or psychological functioning experienced by female and male athletes that is caused by exposure to problematic (prolonged and/or severe) low energy availability. The detrimental outcomes include, but are not limited to, decreases in energy metabolism, reproductive function, musculoskeletal health, immunity, glycogen synthesis and cardiovascular and haematological health, which can all individually and synergistically lead to impaired well-being, increased injury risk and decreased sports performance. (Mountjoy et al, 2023)[10]

Above-metioned consequences show the importance of proper balance of energy intake and expenditure.

Why would athletes restrict food intake?

Although it might seem that negative body image is the most common reason for suboptimal calorie consumption, the review by Chapa et al. showed that female athletes were significantly more satisfied with their bodies when compared to nonathletes[11]. Simultaneously, levels of overall eating disorders patopsychology (sense of losing control while eating, drive for thinness and restricting food) were similar in both groups. It was shown that traits of disordered eating were influenced by sport type. Athletes participating in sports with weight categories (martial arts, rowing) or in which leanness is of value (e.g. gymnastics), were at higher risk of dissatisfaction with their body. Per contra, athletes engaging in strength related sports seemed to be much less impacted. Taking rowing as an example, lightweight rowers need a significant amount of lean body mass while not exceeding the weight threshold of 70 kg for men and 57 kg for women, weighing 2 hours before a race[12]. The very strict norms cause many sportsmen to maintain an unsustainably low body fat percentage while additionally implementing calorie and fluid deficit before the race, causing acute weight-loss to meet weight requirements[13]. Although this behaviour is known to be related to negative health consequences such as higher risk injury, lower performance, bone mass loss, hormonal imbalances and psychological problems, athletes still continue to lower energy availability as part of preparation for regatta[12].

Making the weight

Studies suggest that among lightweight rowers very few are naturally predisposed to this category, since average weight difference in body mass in and out of competing season is around 8%[14]. Main strategies for weight loss are calories and fluid restriction, increased exercise volume, active or passive sweat production and use of laxatives[12]

Gillbanks et al. conducted interviews with former and current lightweight rowers trying to understand their motives as well as implications of LEA. Participants were sharing their experiences with the physical and emotional load of "making the weight", as well as the consequences of these extreme measures. Rowers also admitted that engaging in additional high intensity exercises while being lightweight, negatively impacted their relationship with sport. Some declared still feeling pressured to continue controlling their weight with excessive exertion even once they retired. Additionally, all of the reviewed rowers admitted restricting their calorie intake in order to reduce body mass before competitions. It is crucial to notice that competing athletes are usually people in their 20s and 30s. However, in order to get to high level sports, many start training in their teen years, when humans experience many physical and physiological changes[15]. In this period, LEA can lead to even more enhanced complications than in older age[16].

Hungry mind

Rowers with experience in lightweight rowing mention that in periods before competing they experienced episodes of low mood, using words like 'I felt rubbish', and poor emotional regulation which was reflected in worsened team relationships in the crew. Since eating is also of importance in social interactions, many rowers were skipping meetings with friends as it was not in line with their diet. This behaviour connected to worsened emotional control led to difficulties in maintaining friendships. Athletes reported poor concentration which impelled the quality of their professional work and academic studies. Considering how much self control is required to restrain oneself from listening to the body's hunger cues, rowers developed a sense of guilt and anxiety around food, while also comparing themselves to other athletes. Even when weight control was no longer necessary, behaviors related to disordered eating were still implemented in their daily routine[17].

Hungry body

Physiological balance in the body occurs when available energy is adequate to meet the metabolic needs. Processes in the body can be divided into essentials (circulation, neural activity, cell maintenance), reducible (growth, thermoregulation, locomotion) and expendable (reproduction, fat storage)[2]. If the energy intake does not cover all of the demand, some processes, starting from the last ones mentioned, begin to slow down or completely shut down. One of the physical consequences of RED-S included also in FAT are menstrual disturbances of which the most severe form is amenorrhea. They are the effect of hormonal imbalances such as increased ghrelin and decreased leptin and insulin level by influence of LEA on the hypothalamus and anterior pituitary[18]. Menstrual abnormalities are estimated to affect 20% of exercising females, with prevalence reported as high as 44% in ballet dancers and 51% in female endurance runners. The hormonal disturbances have been linked to increased risk of cardiovascular disorders[19]. They are also connected to bone metabolism by increasing bone reabsorption and impairing repair processes, making them prone to fractures[20]. Other consequences include compromised immunity, bowel disruption connected not just to LEA but also decreased volume of food, fiber scarcity and laxative use.

Weaker body

LEA does not only affect the previously mentioned body functions, but can also impair athletes' results[10]. Problematic LEA can be the reason for decreased training availability due to injury or illness as well as omitting key competitions regardless of performance level[21]. It is also causing perturbations in the recovery process, defined as self-reported failure to recover between training sessions, as well as a reduction in muscle glycogen, protein synthesis, and phosphocreatine recovery. LEA has been connected also to decreased muscle strength, endurance and power output. Jurov et al. in their trial with endurance athletes showed progressive decrease in performance in correlation with reducing EA[22].

Reversing the damage

Ideally, athletes and people from their entourage should be aware of mechanisms leading to LEA, be able to recognize and prevent its development and avoid further consequences. Primary prevention of RED-S can include carefully planning athlete workout and nutritional programs, conducting workshops to strengthen and demystify athletes' knowledge about nutrition, eating disorders, and teaching them healthier coping mechanisms. It might be beneficial to refrain from assessing athletes' bodyweight and body composition if it is not medically recommended[23]. The first step to help athletes with RED-S or at risk of developing its symptoms, is to be able to recognize them. In 2023, the International Olympic Committee published updated tools for RED-S risk stratification and for its assessment[10]. Indicators of RED-S include both laboratory and clinical markers of disturbances, hence athletes should be supervised by a multidisciplinary team including coaches, nutritionists and doctors[24]. It is also crucial to be aware of red flags that should not be dismissed and require urgent medical attention such as BMI ≤75% of median for sex and age, hypotension with bradycardia and electrolyte imbalances[10]. Recovering from RED-S includes reversing LEA which can be achieved by increasing EA, decreasing exercise volume or preferably combination of both. To ensure a smooth process it is recommended to involve a team that might consist of clinicians specializing in sports nutrition, sports psychology, sports psychiatry, gynecology and endocrinology. Recovery time and intensity should be individually assessed according to symptoms severity, duration of LEA and other individual factors. Although, menstrual disturbances[25], other hormonal disbalances, unfavourable lipid profile and arrhythmias, tend to subside with resolution of LEA.; It might be beneficial to refer an athlete to specialists since they require

temporary support. When it comes to impaired bone health, it is important to ensure sufficient calcium and vitamin D intake, including supplementation if needed. In adolescents and women with persistent menstrual disruption after reasonable EA increase, transdermal 17-beta-estrogen with oral progesterone has been proven to increase bone density[23].

Conclusions

Nutrition cannot be separated from sports. Fortunately, there is an increasing number of studies regarding balanced training and nutrition, as well as the consequences of neglecting them. RED-S' risks and methods of treatment have been receiving more attention in the scientific field which can help raise awareness on the importance of providing the best support possible to the athletes. Nevertheless, educating both athletes and their ecosystem is still the most effective way to synergise optimal performance with long lasting mental and physical well-being.

Conceptualization: ZS, DK
Methodology: ZS, EA
Software: NB, ST
Check: WT, MR
Formal analysis: ST, WT, DMK
Investigation: ZS, MR
Resources: EA, ST
Data curation: DT, DK
Writing rough preparation: ZS
Writing - review and editing,: EA, WT, DMK
Visualization: ZS, NB
Supervision: EA, MR
Project administration: ZS

All authors have read and agreed with the published version of the manuscript.

Funding statement: This research did not receive any special funding or grants for conducting this research.

Institutional review board statement: Not applicable.

Informed consent statement: Not applicable.

Acknowledgments: Not applicable.

Conflict of interest statement: Authors have declared no conflict of interest.

REFERENCES

1. Kris-Etherton, P. M., Petersen, K. S., Hibbeln, J. R., Hurley, D., Kolick, V., Peoples, S., Rodriguez, N., & Woodward-Lopez, G. (2021). Nutrition and behavioral health disorders: depression and anxiety. Nutrition reviews, 79(3), 247–260. https://doi.org/10.1093/nutrit/nuaa025
2. Wade, G. N., & Jones, J. E. (2004). Neuroendocrinology of nutritional infertility. AJP Regulatory Integrative and Comparative Physiology, 287(6), R1277–R1296. https://doi.org/10.1152/ajpregu.00475.2004
3. Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). Nutrition and athletic performance. Medicine & Science in Sports & Exercise, 48(3), 543–568. https://doi.org/10.1249/mss.0000000000000852
4. Lalonde M. A new perspective on the health of Canadians: a working document. Department of National Health and Welfare, 1974; Ottawa: 1981. Available at: http://www.phac-aspc.gc.ca/ph-sp/pdf/perspect-eng.pdf (accessed 16 June 2025)
5. Ellouze, I., Sheffler, J., Nagpal, R., & Arjmandi, B. (2023). Dietary Patterns and Alzheimer's Disease: An Updated Review Linking Nutrition to Neuroscience. Nutrients, 15(14), 3204. https://doi.org/10.3390/nu15143204
6. Srour, B., Fezeu, L. K., Kesse-Guyot, E., Allès, B., Méjean, C., Andrianasolo, R. M., Chazelas, E., Deschasaux, M., Hercberg, S., Galan, P., Monteiro, C. A., Julia, C., & Touvier, M. (2019). Ultra-processed food intake and risk of cardiovascular disease: prospective cohort study (NutriNet-Santé). BMJ (Clinical research ed.), 365, l1451. https://doi.org/10.1136/bmj.l1451
7. Loucks, A. B., Kiens, B., & Wright, H. H. (2011). Energy availability in athletes. Journal of Sports Sciences, 29(sup1), S7–S15. https://doi.org/10.1080/02640414.2011.588958
8. De Souza, M. J., Nattiv, A., Joy, E., Misra, M., Williams, N. I., Mallinson, R. J., Gibbs, J. C., Olmsted, M., Goolsby, M., & Matheson, G. (2014). 2014 Female Athlete Triad Coalition Consensus Statement on Treatment and Return to Play of the Female Athlete Triad: 1st International Conference held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013. British Journal of Sports Medicine, 48(4), 289. https://doi.org/10.1136/bjsports-2013-093218
9. Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016b). Nutrition and athletic performance. Medicine & Science in Sports & Exercise, 48(3), 543–568. https://doi.org/10.1249/mss.0000000000000852
10. Mountjoy, M., Ackerman, K. E., Bailey, D. M., Burke, L. M., Constantini, N., Hackney, A. C., Heikura, I. A., Melin, A., Pensgaard, A. M., Stellingwerff, T., Sundgot-Borgen, J. K., Torstveit, M. K., Jacobsen, A. U., Verhagen, E., Budgett, R., Engebretsen, L., & Erdener, U. (2023). 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). British Journal of Sports Medicine, 57(17), 1073–1098. https://doi.org/10.1136/bjsports-2023-106994
11. Chapa, D. A. N., Johnson, S. N., Richson, B. N., Bjorlie, K., Won, Y. Q., Nelson, S. V., Ayres, J., Jun, D., Forbush, K. T., Christensen, K. A., & Perko, V. L. (2022). Eating-disorder psychopathology in female athletes and non-athletes: A meta-analysis. The International journal of eating disorders, 55(7), 861–885. https://doi.org/10.1002/eat.23748
12. Gillbanks, L., Mountjoy, M., & Filbay, S. R. (2022). Lightweight rowers' perspectives of living with Relative Energy Deficiency in Sport (RED-S). PLoS ONE, 17(3), e0265268. https://doi.org/10.1371/journal.pone.0265268
13. Ficarra, G., Mannucci, C., Franco, A., Bitto, A., Trimarchi, F., & Di Mauro, D. (2024). A case report on dietary needs of the rowing athlete winner of the triple crown. Heliyon, 10(17), e36551. https://doi.org/10.1016/j.heliyon.2024.e36551
14. Slater, G., Rice, A., Jenkins, D., & Hahn, A. (2014). Body mass management of lightweight rowers: nutritional strategies and performance implications. British Journal of Sports Medicine, 48(21), 1529–1533. https://doi.org/10.1136/bjsports-2014-093918
15. Stenqvist, T. B., Melin, A. K., & Torstveit, M. K. (2023). Relative Energy Deficiency in Sport (REDs) Indicators in Male Adolescent Endurance Athletes: A 3-Year Longitudinal Study. Nutrients, 15(24), 5086. https://doi.org/10.3390/nu15245086
16. Norris, S. A., Frongillo, E. A., Black, M. M., Dong, Y., Fall, C., Lampl, M., Liese, A. D., Naguib, M., Prentice, A., Rochat, T., Stephensen, C. B., Tinago, C. B., Ward, K. A., Wrottesley, S. V., & Patton, G. C. (2022). Nutrition in adolescent growth and development. Lancet (London, England), 399(10320), 172–184. https://doi.org/10.1016/S0140-6736(21)01590-7
17. Karlson, K. A., Becker, C. B., & Merkur, A. (2001). Prevalence of eating disordered behavior in collegiate lightweight women rowers and distance runners. Clinical Journal of Sport Medicine, 11(1), 32–37. https://doi.org/10.1097/00042752-200101000-00006
18. Cabre, H. E., Moore, S. R., Smith-Ryan, A. E., & Hackney, A. C. (2022). Relative energy deficiency in sport (RED-S): scientific, clinical, andpractical implications for the female athlete. German Journal of Sports Medicine, 73(7), 225–234. https://doi.org/10.5960/dzsm.2022.546
19. Hoch, A. Z., Papanek, P., Szabo, A., Widlansky, M. E., Schimke, J. E., & Gutterman, D. D. (2011). Association between the female athlete triad and endothelial dysfunction in dancers. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine, 21(2), 119–125. https://doi.org/10.1097/JSM.0b013e3182042a9a

20. Coelho, A. R., Cardoso, G., Brito, M. E., Gomes, I. N., & Cascais, M. J. (2021). The Female Athlete Triad/Relative Energy Deficiency in Sports (RED-S). A tríade da atleta feminina/déficit energético relativo no esporte (RED-S). Revista brasileira de ginecologia e obstetricia : revista da Federacao Brasileira das Sociedades de Ginecologia e Obstetricia, 43(5), 395–402. https://doi.org/10.1055/s-0041-1730289
21. Logue, D. M., Madigan, S. M., Heinen, M., McDonnell, S., Delahunt, E., & Corish, C. A. (2018). Screening for risk of low energy availability in athletic and recreationally active females in Ireland. European Journal of Sport Science, 19(1), 112–122. https://doi.org/10.1080/17461391.2018.1526973
22. Jurov, I., Keay, N., & Rauter, S. (2022). Reducing energy availability in male endurance athletes: a randomized trial with a three-step energy reduction. Journal of the International Society of Sports Nutrition, 19(1), 179–195. https://doi.org/10.1080/15502783.2022.2065111
23. Torstveit, M. K., Ackerman, K. E., Constantini, N., Holtzman, B., Koehler, K., Mountjoy, M. L., Sundgot-Borgen, J., & Melin, A. (2023). Primary, secondary and tertiary prevention of Relative Energy Deficiency in Sport (REDs): a narrative review by a subgroup of the IOC consensus on REDs. British journal of sports medicine, 57(17), 1119–1126. https://doi.org/10.1136/bjsports-2023-106932
24. Allen, N., Kelly, S., Lanfear, M., Reynolds, A., Clarke, R., Mountjoy, M. L., Wyon, M., & Wolman, R. (2024). Relative energy deficiency in dance (RED-D): a consensus method approach to REDs in dance. BMJ open sport & exercise medicine, 10(1), e001858. https://doi.org/10.1136/bmjsem-2023-001858
25. Cialdella-Kam, L., Guebels, C. P., Maddalozzo, G. F., & Manore, M. M. (2014). Dietary intervention restored menses in female athletes with exercise-associated menstrual dysfunction with limited impact on bone and muscle health. Nutrients, 6(8), 3018–3039. https://doi.org/10.3390/nu6083018