Plant-based nutrition: the role of dietary choice on the development of Relative Energy Deficiency in Sport in female athletes

Student number 680005774
University of Exeter – MSc Masters in Extreme Medicine

Introduction

- Relative Energy Deficit in Sport (RED-S) is a prevalent syndrome in female athletes caused by imbalances in energy intake and expenditure (1), creating a state of low energy availability (LEA) (Figure 1):

Energy Availability = Energy Intake (EI) (kcal) – Exercise Energy Expenditure (EEE) (kcal)/kg of Fat Free Mass (FFM)

- Increasingly, athletes have turned towards vegetarianism and veganism to improve health and performance (2). However, **restrictive diets generate risks for LEA and RED-S**, which cause menstrual disturbances, poor mental health, increased injury, and decreased performance (1) (Figure 2).
- **Aims**: to assess female athlete's diets for macro and micronutrient inequalities, evaluating whether LEA may be exacerbated by plant-based diets, and increase the risk of RED-S.

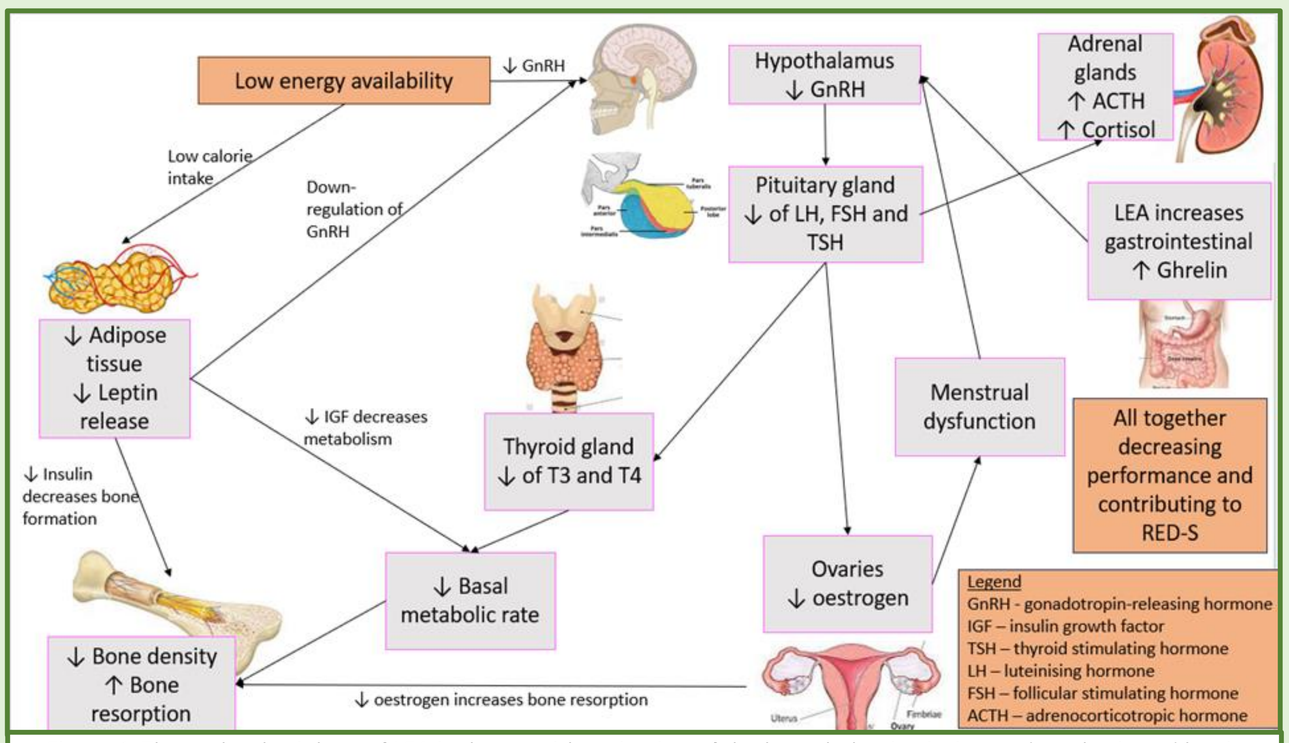
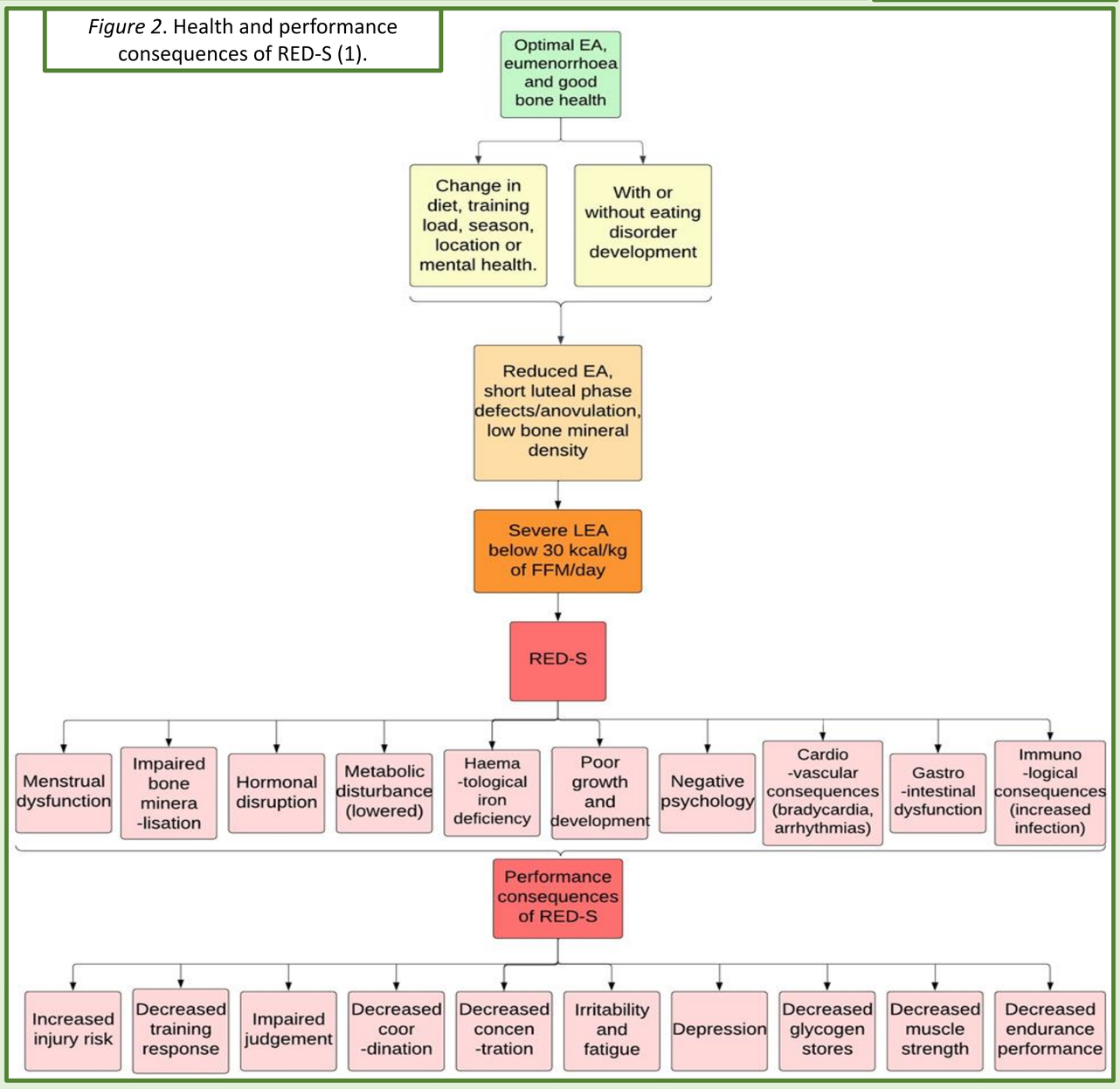


Figure 1. The pathophysiology of LEA is shown with activation of the hypothalamic pituitary adrenal axis and leptin regulation commencing the alterations in body function to conserve energy (1).

Figure 2. Health and performance consequences of RED-S (1).



Methods

- This review focused on **female athletes** to investigate the **influence of vegetarian and vegan diets on the development of RED-S** compared to omnivorous diets. Relevant studies were obtained by searching EBSCOhost, PubMed, and Web of Science using the following key words:
  - Female athletes, relative energy deficiency in sport, RED-S, low energy availability, LEA, health and performance
  - Omnivore, vegetarian, vegan, and plant-based diets
- NOT excluded topics outside this review's scope such as:
  - Breastfeeding, pregnancy, children, adolescents, pre-menopausal athletes and post-menopausal athletes
- **Included articles** focused on female athlete's **diet** and **performance**, or **RED-S** development.
- **Excluded** articles discussed **eating disorders**, RED-S **awareness** among clinicians, or **short-term race** nutrition.
- A total of **36 papers** were included in the final review via a **systematic screening approach** (Figure 3).

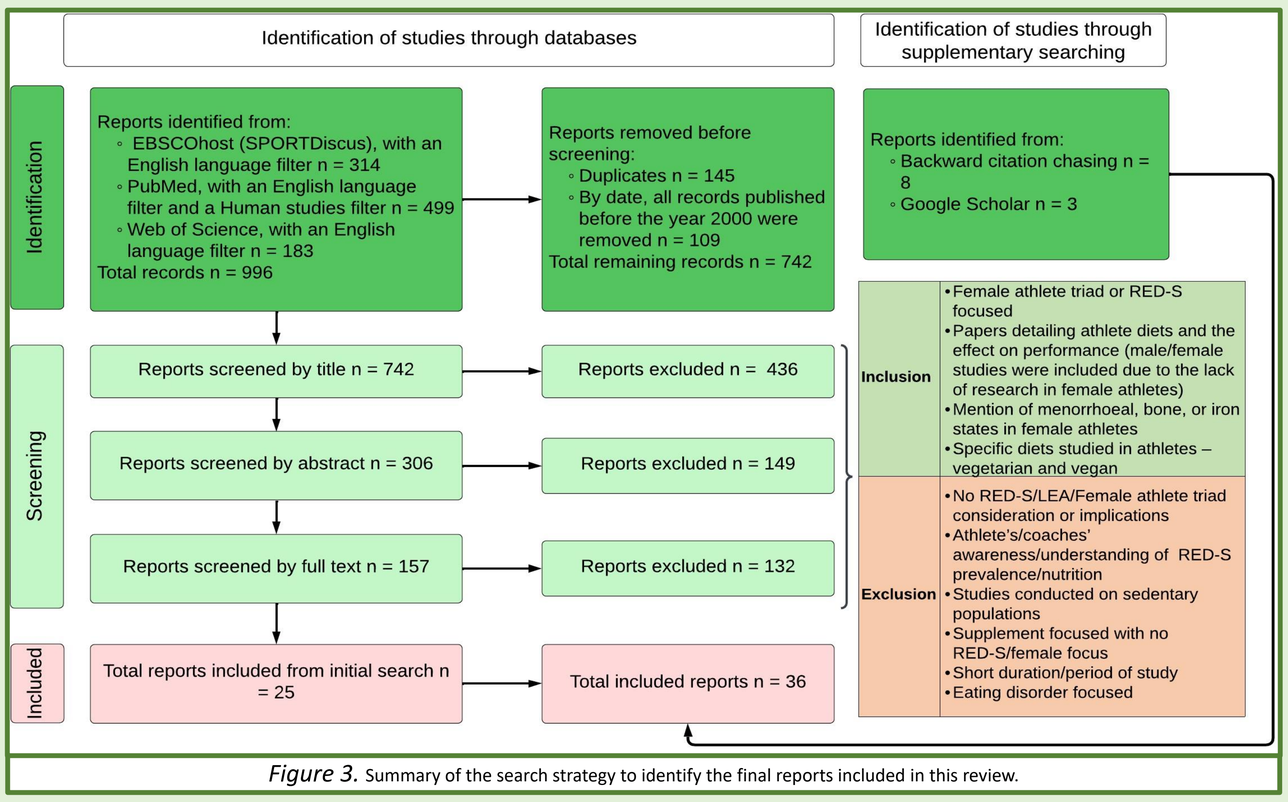


Figure 3. Summary of the search strategy to identify the final reports included in this review.

Results

- **Endurance performance** was found to be **equal if not improved in vegan female athletes** when compared to their omnivorous counterparts.
- However, these findings were only applicable when EA, macro, and micronutrients were adequately substituted.
- Vegan and lacto-ovo-vegetarian (LOV) athletes were found to under-consume:
  - Macronutrients: protein, essential amino acids, energy-dense carbohydrates, fats and essential fatty acids.
  - Micronutrients: iron, calcium, vitamin D, and vitamin B12 (Table 1).

This was due to **lower dietary intakes** and the **complex bioavailability** of nutrients when coupled with high fibre intakes and a limited variety of food.

Table 1. Comparisons of daily macro and micronutrient intakes for omnivorous, LOV, and vegan athletes, as reported by Boutros et al. (2020) and Nebl et al. (2019), in comparison to the recommended daily intakes for female athletes (3, 4).

	Daily intakes for each diet group				**Recommended intakes per day for Female Athletes.**
	Omnivore		Lacto-Ovo-Vegetarian	Vegan	
	Boutros et al. (2020) (3).	Nebl et al. (2019) (4).	Nebl et al. (2019) (4).	Boutros et al. (2020) (3).	Nebl et al.(2019) (4).	
Diet definition	Includes all food groups and is unrestricted.		Excludes animal and marine foods but includes dairy and eggs.	Excludes all foods from animal or marine origin, excluding dairy and eggs.		As described by the American College of Sports Medicine (5), and the International Society of Sports Nutrition (6).
Total energy (kcal)	1905 +/- 661	2175 +/- 532	2202 +/- 752	2077 +/- 644	2261 +/- 442	45 kcal/kg of FFM/day
Carbohydrates (% energy)	45.6 +/- 12.0	46.7 +/- 7.3	49.4 +/- 9.4	58.8 +/- 6.5	55.2 +/- 9.6	General recommendation is >50% of total energy intake should be from carbohydrates.
Dietary fibre (g)	21.8 +/- 8.3	27.0 +/- 10.4	33.4 +/- 11.6	41.2 +/- 15.5	51.7 +/- 19.4	25-38 g/day of fibre. Exceeding 40 g/day limits the absorption of fats, calories, and oestrogens.
Protein (g/kg body weight)	1.45 +/- 0.49	1.50 +/- 0.40	1.34 +/- 0.53	1.11 +/- 0.32	1.25 +/- 0.43	1.2-2.0 g/kg/day. Follicular phase: 1.6 g/kg/day. Luteal phase: 2.0 g/kg/day.
Leucine (g)	4.8 +/- 2.0	-	-	2.5 +/- 1.32	-	39 mg/kg/day
Fat (% energy)	36.1 +/- 8.7	32.5 +/- 5.1	30.8 +/- 9.7	30.3 +/- 7.0	26.3 +/- 8.9	30-35% of daily caloric intake.
EPA + DHA (g)	-	0.54	0.08	-	0.09	Greater than 0.5 g/day combined.
Vitamin D (IU) (solely dietary intake)	122.3 +/- 69.2	104.4 +/- 129.0	66.8 +/- 63.0	69.1 +/- 113.2	41.6 +/- 58.6	Varies between 300 and 2000 IU/day, depending on sun exposure.
Iron (mg)	13.4 +/- 4.8	11.9 +/- 3.3	12.8 +/- 4.6	21.4 +/- 10.1	19.6 +/- 7.1	18 mg/day
Vitamin B12 (mcg)	3.7 +/- 2.2	4.02 +/- 2.3	2.46 +/- 2.4	1.24 +/- 1.8	0.79 +/- 0.8	2.4 mcg/day
Calcium (mg)	-	981 +/- 425	901 +/- 447	-	730 +/- 293	1000 mg/day

These nutrient deficiencies may lead to reduced sporting performance, poor response to post-exercise inflammation, and poor mental health. Collectively, these factors can exacerbate food restriction, LEA, RED-S, and lead to injury.

Conclusion

- Although **female athletes are at risk of LEA and RED-S**, with adequate resources and support, **plant-based diets can provide the necessary nutrients for a balanced athletic diet**.
- **Limiting factors** for balanced plant-based diets include **affordability**, **access**, nutritional **education** and **time**.
- Hence, **recreational athletes are at higher risk** of consuming poorly planned plant-based diets that **compromises nutrient quality** and **bioavailability**, and **limits variety**, which collectively **increases the risk of LEA and RED-S**.
- **Research**: there are **no studies** in the field of RED-S development from plant-based diets, instead **existing research has been combined** to produce a critiqued understanding of the literature. **Further research is required** to clarify whether diet choice affects the development of RED-S in female athletes.
- **Limitations**: **conclusions are constrained** by **restricted evidence**, **male** confounded studies, and the **interindividual variability** of diet.
- **Implications**: This review highlights the consequences of poor nutrition which is **relevant for athletes and clinicians** when planning plant-based diets, as **restrictive diets may increase the risk of nutrient deficiencies, LEA, and RED-S**.

References

1. Mountjoy M, Sundgot-Borgen JK, Burke LM, Ackerman KE, Blauwet C, Constantini N, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. British Journal of Sports Medicine. 2018;52(11):687-97. 2. Wirnitzer K, Motevalli M, Tanous D, Wirnitzer G, Leitzmann C, Pichler R, et al. Who Is Running in the D-A-CH Countries? An Epidemiological Approach of 2455 Omnivorous, Vegetarian, and Vegan Recreational Runners-Results from the NURMI Study (Step 1). Nutrients. 2022;14(3). 3. Boutros GH, Landry-Duval M-A, Garzon M, Karelis AD. Is a vegan diet detrimental to endurance and muscle strength? European Journal of Clinical Nutrition. 2020;74(11):1550-5. 4. Nebl J, Schuchardt JP, Wasserfurth P, Haufe S, Eigendorf J, Tegtbur U, et al. Characterization, dietary habits and nutritional intake of omnivorous, lacto-ovo vegetarian and vegan runners – a pilot study. BMC Nutrition. 2019;5(1). 5. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. J Acad Nutr Diet. 2016;116(3):501-28. 6. Sims ST, Kerksick CM, Smith-Ryan AE, Janse de Jonge XAK, Hirsch KR, Arent SM, et al. International society of sports nutrition position stand: nutritional concerns of the female athlete. J Int Soc Sports Nutr. 2023;20(1):2204066.