Global Journal of Health Science; Vol. 14, No. 4; 2022
ISSN 1916-9736 E-ISSN 1916-9744
Published by Canadian Center of Science and Education

Dietary Recommendations for Active and Competitive Aerobic Exercising Athletes: A Review of Literature

Sylven Masoga[1] & Gerald P. Mphafudi[1]

[1] Department of Human Nutrition and Dietetics, University of Limpopo, Limpopo Province, South Africa

Correspondence: S Masoga, Department of Human Nutrition and Dietetics, University of Limpopo, Sovenga 0727, South Africa. Tel: (+27)-15-268-3376/2782. E-mail: sylven.masoga@ul.ac.za

Received: January 30, 2021 Accepted: March 16, 2022 Online Published: March 28, 2022

doi:10.5539/gjhs.v14n4p95 URL: https://doi.org/10.5539/gjhs.v14n4p95

Abstract

Aerobic exercise is a common sport activity participated by numerous individuals in many parts of the world. Individuals involved in this sport may participate for various reasons, for instance, improved health and weight management while others are involved for competitive purposes. Recommendations, therefore, vary according to the aim and the intensity of the engagement. Depending on the purpose, dietary practices related to the type of foods or meals to be consumed, timing of intake and hydration strategies used by athletes remain important. There is a concern, however, that dietary recommendations for aerobic sport lack scrutiny. It is important for athletes involved in aerobic exercises to adhere to recommendations for them to enjoy their sports engagement while maintaining good health. Therefore, the purpose of this review is to discuss the aerobic exercise nutrition recommendations for aerobic exercising athletes with a specific focus on energy, macro- and micronutrients, nutrients dosing, and timing thereof.

Keywords: Aerobic exercises, Macronutrients, Micronutrients, Recommendations

1. Introduction

Aerobic exercises use several muscles, rhythmically, for 15–20 minutes or even longer while maintaining 60–80% of maximum heart rate (Abdulla et al., 2016). This exercise activity is popular at health clubs and community centers (Ciomag et al., 2013) for improving cardiovascular function and local muscular endurance. It further contributes towards improved ideal body weight, reduced body fat mass, and plays a vital role in the prevention of osteoporosis (Haskell et al., 2007). A combination of aerobic exercises with appropriate dietary interventions and nutrient timing, can accelerate improvements in health, enhance training and recovery from exercises (Jäger et al., 2017; Trakman et al., 2017). Individuals involved in sport and exercise may often require guidance towards food and nutritional choices. Some athletes being influenced by social, economic and physiological factors, may ignore the significance of nutrition when making food choices (Birkenhead & Slater, 2015). Individuals originating from low socioeconomic areas may, at times, find difficulties in matching the required needs for their specific sports. Trainers, the internet, and/or fellow gym mates, usually serve as a nutrition information guide to most athletes. However, some of these nutrition information sources may hold insufficient scientific support (Hornstrom et al., 2011). Good nutrition supports the ability to train intensely, muscle recovery and metabolic adaptations during exercises, increasing performance (Potgieter, 2013). The purpose of this review is therefore, to explore aerobic exercise categories, nutrient recommendations for those categories and further discuss nutrient timing in an attempt to guide these athletes in their life-long sport.

1.1 Aerobic Exercises

Exercises that deliver oxygen to muscles to generate energy to support muscles during exercise are classified as aerobic exercise (Armstrong & McManus, 2017). Aerobic exercises, especially done two to three times per week for 30–60 minutes are important for weight management (Barrow et al., 2019). This activity depends much on functional physiological and metabolical mechanisms to perform better during exercise or performance (Harrison et al., 2015). For instance, the conversion of lactate produced during exercise requires a functional liver to convert it to glucose for the muscles to utilize as energy (Armstrong & McManus, 2017). To determine an individual's characteristics of aerobic ability, lactate threshold (LT) and maximal oxygen uptake (VO_{2Max}) can be measured (Armstrong & McManus, 2017; Harrison et al., 2015). The VO_{2Max} is the highest rate at which exercising muscles consume oxygen. Aerobic exercises can be classified into cardiodynamic, moderately intense, and heavy intense phases. The cardiodynamic phase is independent of oxygen and usually lasts for 15–20 minutes. The moderately intense exercise lasts between 30–60 minutes while the heavy intensity lasts for 60–120 minutes. As aerobic exercise intensifies, lactate is produced (Harrison et al., 2015). A few monitoring models to measure the success of athletes during competitions have been implicated elsewhere (Armstrong & McManus, 2017). However, due to a lack of clear guidelines, monitoring of dietary practices and the timing by athletes remain a challenge. Nutrition intervention strategies should be designed the specific exercise programs. Therefore, sports nutrition professionals should, among other things, assist in adjusting nutritional needs, sports performance goals, and practical challenges related to food, diets and fluids for athletes (Thomas et al., 2016). For this reason, the current review attempts to deliberate on this identified gap related to dietary recommendations for active and competitive aerobic exercising athletes for them to enjoy aerobic sports involvement while maintaining good health.

2. Nutrient Recommendation

2.1 Energy

Individuals may participate in exercises for health and weight management (Barrow et al., 2019), while for some, for competitive purposes. In groups aiming to achieve weight maintenance, the amount of energy required is usually lesser than what is required during training (Helms et al., 2014). Energy serves as a fuel during exercise, and the main sources of supply are protein, carbohydrates (CHO), and fat (van Heerden et al., 2014). Adequate energy intake is important to regulate impaired bone density, compromised immunity, and endocrine functioning (Sale & Elliott-Sale, 2017). Individuals involved in aerobic exercises or sport are encouraged to practice intake of smaller frequent meals throughout the day to obtain the required nutrients. The intake of frequent meals has a potential to minimize fatigue, replenish glycogen stores, build and repair tissue muscles, and maintain the desired (sports-specific) weight (Odysseos & Avraamidou, 2017). Therefore, individuals involved in exercise and performance should strive for energy balance as this determines the capacity for macro- and micronutrient intake. Generally, energy amount of 25–35 kcal/kg/day (105–147 kJ/kg/day) should be adequate to evade energy deficits for both active and competitive aerobic exercising athletes (Kerksick et al., 2018).

2.2 Macronutrients

Adequate intake of macronutrients specific to sport and exercise category is recommended to maintain body weight, replenish glycogen stores, and build and repair tissues (Rodriquez & Dimarco, 2009; Wierniuk & Wlodarek, 2013). Therefore, the appropriate selection of foods, fluids, and timing of nutrient intake for optimal health and exercise performance is important (ADA/AC/ACSM, 2009). Nutrient intake timing is a strategy involving the consumption of certain nutrients before, during and after exercise sessions (Aragon & Schoenfeld, 2013) to enhance tissue repair, muscle protein resynthesizes and injury recovery (Jäger et al., 2017).

2.2.1 Carbohydrates

Carbohydrates (CHO), stored in the body as glycogen, serve as the main nutrient during muscle contraction (Indoria & Singh, 2016). Varying intakes of energy and macronutrients including CHO amongst different genders were reviewed (Spendlove et al., 2015). While some macronutrients intake were reported adequate, some were suboptimal. Diets that are low in CHO generally impair performance resulting in fatigue. Therefore, to offset this complication, CHO amount of 5–10 g/kg/day is generally recommended (Kerksick et al., 2017). For moderate exercises lasting for up to an hour, lower end of the range 5–7 g/kg/day is recommended; while 6–10 g/kg/day is reserved for athletes exercising for more than an hour or more (1–3 hours) per day. The latter would include individuals participating in aerobic exercises for competitive purposes (van Heerden et al., 2014).

Glycogen stores are easily depleted in prolonged high intensity exercises (Dunford & Doyle, 2019). Therefore, a meal containing 1–4 g/kg of CHO should be consumed at least three to four hours leading to exercise or training (Kreider et al., 2010; Kerksick et al., 2018). Fructose should, however, be avoided as it is slowly metabolised and may induce some gastrointestinal distresses. Preference should be given to high glycaemic index CHO to fasten the entry of glucose in circulation (Dunford & Doyle, 2019).

During the aerobic exercise or performance, CHO amounts of 30–60 g/hour in events lasting for an hour or more are encouraged (Smith et al., 2015). Athletes should further sustain blood glucose levels throughout the exercise or competition every 15–20 minutes through a CHO solution (Llorenten-Cantarero et al., 2018). The solution used for hydration should preferably be high in glycemic index to sustain glucose supply. Again, fructose containing solutions should be avoided as it is slowly metabolised. To replenish muscle glycogen stores immediately after the exercise, CHO intake of 1–1.2 g/kg is generally recommended (Dunford & Doyle, 2019). Additional amounts of 1.5 g/kg are encouraged 30 minutes to 6 hours after exercise to achieve optimal glycogen resynthesis (Pritchett et al., 2017).

2.2.3 Protein

Protein is another nutrient of importance during aerobic exercises. For training individuals, protein recommendations are usually 2–3 times above the recommended daily intakes (Odysseos & Avraamidou, 2017).

Protein is required as a building material for muscles, transport for nutrients, and a substrate for increased muscle glycogen storage (Potgieter, 2013; Indoria & Singh, 2016). Some athletes may habitually consume high protein diets or supplements in an attempt to increase muscle mass (Kim, 2007). This practice has, to some extent, been associated with increased urea production leading to gout (van Heerden et al., 2014) and osteoporosis later in life. For individuals participating in a general fitness program, a protein amount of 0.8–1.0 g/kg/day is recommended (Kreider et al., 2010). In a review by Odysseos and Avraamidou (2017), a high-quality protein amount of 1.4–1.7 g/kg/day was generally recommended for exercising athletes. A marginally lower amount of 1.2 g/kg/day is, however, recommended (van Heerden et al., 2014) for individuals involved in moderate-intensity exercises. Amounts of 1.8 g/kg/day or higher were further recommended by Kreider et al. (2010) to constantly support the building and maintenance of lean body tissues. These protein amounts should be spread evenly throughout the day.

A pre-exercise meal containing 0.25–0.4 g/kg of protein should be taken 1–4 hours before physical activity (Egan, 2016). To repair damaged muscles, exercising individuals need to consume 0.25–0.3 g/kg (Dunford & Doyle, 2019) or 20g or of high-quality protein combined with CHO intake immediately after exercise/performance (van Heerden et al., 2014).

2.2.4 Dietary Fat

The fat recommendation for exercising individuals does not differ from that of general population, 25–30% of total energy (Smith et al., 2015). Fat serves as fuel during low to moderate intensity activities (Indoria & Singh, 2016). In general, fat intake should be optimal to minimize essential fatty acid deficiencies, increase the absorption of fat-soluble vitamins, and the production of cholesterol (Smith et al., 2015). Chronic fat restriction (<20% TE) is associated with the risk of essential fatty acid and fat-soluble vitamin deficiencies, imbalances in high–and low–density lipoproteins, and inability to form reproductive hormones (Dunford & Doyle, 2019). Intake of fat above 30% of TE is associated with adverse health outcomes (Phillips, 2012) such as cardiovascular diseases, and weight gain (Smith et al., 2015). Therefore, the general recommendation for athletes is to consume 0.5–1 g/kg/day of fat (Kerksick et al., 2018). Summary of recommendations for energy and macronutrients are presented in Table 1.

Table 1. Energy and Macronutrients

Energy (kJ/kg/day)	**105–147** (Distributed throughout the day)
CHO (g/kg/day)	**5–7** (General fitness/Moderate exercise programs)
	8–10 (Intense exercise programs)
Pre-exercise (g/kg)	*1–4 (2–3 hours before exercise)*
During exercise (%)	*6–8 (CHO solution, every 15–20 minutes)*
Post-exercise (g/kg)	*1–1.5 (Within 30 minutes post exercise, then up to 3–4 post)*
Protein (g/kg/day)	**0.8–1.2** (General fitness); **1.4–1.8** (Intense programs)
Pre-exercise (g/kg)	*0.25–0.4 (2–3 hours before exercise)*
Post-exercise (g/kg)	*0.25–0.3 (High-quality protein within 30 minutes post-exercise)*
Fat (g/kg/day)	**0.5–1** *(Excessive fat should be avoided to minimize gastrointestinal problems)*

2.3 Micronutrients

Micronutrients play an important role during energy production, hemoglobin synthesis, and maintenance of bone health for aerobic exercising athletes (Dunford & Doyle, 2019). Chronic micronutrient deficiencies among athletes usualy affect health and exercise performance outcomes (Wardenaar et al., 2017). Naturally, aerobic exercises predispose athletes to increased oxidative stress. Therefore, adequate consumption of micronutrients to reduce oxidative stress, hemolysis, and muscle degradation is recommended (Heaton et al., 2016).

2.3.1 Vitamins and Minerals

In general, exercise results in an increased need for vitamins and minerals, due to losses through urine, sweat, decreased gastrointestinal absorption, and/or high demands of exercise. Several vitamins are required to facilitate physiological processes. Other than solubility, vitamins can also be classified according varying functions, such as, effects in energy metabolism, red blood cell formation, and the antioxidant function (Dunford & Doyle, 2019). For instance, vitamin C is water-soluble, while vitamin E is fat-soluble (Kerksick et al., 2018). Additionally, both vitamins can serve as antioxidants, limiting the damage caused by free radicals during exercise (Heaton, 2016). In balancing the redox reactions, vitamin C acts by donating an electron. Consumpsion of food sources containing vitamin C as part of dietary plans may help reduce the negative health burden imposed by supplemental antioxidants (Heaton, 2016). Vitamin E is beneficial in reducing oxidative stress, neurodegenerative changes, and hemolysis. Therefore, vitamin C and E dietary intake or supplemental amounts of 250–1000mg/day and 15mg/day are recommended to positively influence training adaptations and antioxidative properties respectively (Kreider et al., 2010).

The B-vitamins, especially thiamine and riboflavin, were also highlighted as of importance in sports by Dunford and Doyle (2019). These two serve an important role during the chemical reactions. Vitamin B_{12} together with folate are recommended by the same authors for enhancing the immune system and preventing anaemia. Additionally, Madden et al. (2017) explored the role of calcium and vitamin D for exercising athletes. These micronutrients are responsible for developing bone structure during sports. Vitamin D is classified as a fat-soluble vitamin linked with enhanced calcium absorption in the body (Kreider et al., 2010) and improved muscle strength (Kerksick et al., 2018). Therefore, vitamin D and calcium amounts of 15 mcg/day and 1000 mg/day are recommended respectively (Kreider et al., 2010).

Iron is another mineral of importance forming part of the hemoglobin component and is involved in oxygen delivery to tissues (van Heerden et al., 2014). Individuals involved in aerobic exercises or sports may often experience anemia from haemodilution, reduced dietary intakes, hemolysis, gastrointestinal bleeding, and lastly, losses through menstrual cycles, particularly in women (Pritchett et al., 2017). Anemia in sports may predispose athletes to early fatigue, weakness, and ultimately limit sports performance (Madden et al., 2017). Therefore, iron recommendtions for both men and women involved in sports are 8 mg/day and 18 mg/day respectively (Rodriquez & Dimarco, 2009). Recommendations are higher among female athletes due to the explained iron losing mechanism earlier (Madden et al., 2017). The recommended daily allowance and Upper Tolerable Limits (UL) for specific vitamins and minerals are summarized in Table 2.

Table 2. Summary of Micronutrients (Dunford & Doyle, 2019)

Micronutrient	**Gender**	***RDA (per day)**	**#UL**
Vitamin C	Male	90 mg	2 000 mg
	Female	75 mg	
Vitamin D	Male	15 mcg	100 mcg
	Female	15 mcg	
Vitamin E	Male	15 mg	1 000 mg
	Female	15 mg	
Calcium	Male	1000 mg	2 500 mg
	Female	1000 mg	
Iron	Male	18 mg	45 mg
	Female	8 mg	
Thiamine (B_1)	Male	1.2 mg	-
	Female	1.1 mg	
Riboflavin (B_2)	Male	1.3 mg	-
	Female	1.1 mg	
Niacin (B_3)	Male	16 mg	35 mg
	Female	14 mg	
Cyanocobalamin (B_{12})	Male	2.4 mcg	-
	Female	2.4 mcg	
Folate	Male	400 mcg	1 000 mcg
	Female		

*RDA=Recommended Daily Allowance; #UL=Upper Tolerable Limit.

2.3.2 Hydration

Fluid, particularly water, is important for temperature regulation, lubrication of joints, and nutrients transportation to active tissues during exercises (Indoria & Singh, 2016). Due to the nature of aerobic exercises, more fluids including electrolytes may be lost through sweats and insensible loses. Therefore, athletes should not rely entirely on the thirst for hydration (Kerksick et al., 2018). Athletes should strive for the consumption of adequate amount of fluids containing electrolytes (Casazza et al., 2018). Adequate amounts can be accomplished through distributed intakes of 150–200 ml every 5–20 minutes during the exercise duration (Potgieter, 2013). Athletes involved in the competitive aerobic sport should habitually hydrate using 500 ml of water a night before the competition. Additional 400–600 ml of water or sports drink 20–30 minutes before the competition is recommended (Kerksick et al., 2018). Lastly, athletes are encouraged to consume 1.0–1.5 liters of water for every 1 kg of body mass lost

(Kerksick et al., 2018). A summary of fluid recommendations for individuals involved in aerobic exercise (competitive and non-competitive) is given in Table 3.

Table 3. Summary of Fluid recommendations

Timing	Recommendations (ml)
The night before the competition	500
Thirty minutes before competition	400–600
During sports performance	250–300 (every 15–20 minutes)
Every 1 kg lost	1.0–1.5 liters

4. Conclusion of literature and recommendations

Nutrition, diet, and exercise for sports performance are inseparable (van Heerden et al., 2014). To obtain the desired nutritional status, athletes should aim to balance the energy, macro- and micronutrient intakes. Sufficiently planned diets offering optimal nutrients or nutrition education advice through the involvement of nutrition practitioners (Dietitians) may assist individuals involved in exercise and sport to strike a balance while enjoying aerobic sports as a career (Barrow et al., 2019; Masoga, 2019). All categories of aerobic individuals, competitive and non-competitive, are advised to consume smaller frequent meals spread throughout the day to meet specific nutrient requirements. Furthermore, the timing of consumption of meals; before, during, and after the exercise or training is important to replace losses during the event.

Acknowledgments

The Nutrition and Dietetics team of the University of Limpopo for peer-reviewing this document.

Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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