



Applied nutritional investigation

Association of Healthy Eating Index and oxidative stress in adolescent volleyball athletes and non-athletes



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ABSTRACT

Objectives: The objective of this study was to compare the relationship between the Healthy Eating Index and oxidative stress parameters in adolescent athletes and non-athletes.

Methods: A cross-sectional study was carried out with 18 adolescent male and female volleyball athletes who were paired with 15 adolescent non-athletes. Body fat percentage, food intake, free radical production, anti-oxidant enzyme activity, and thiol and protein damage were measured.

Results: In the Healthy Eating Index assessment, the food quality of 72.7% of the sample was classified as low, and no participant was found to have good food quality. The mean intake of vitamins A and E was below recommendations in both groups and sexes; however vitamin C intake was appropriate for the age group. Increased free radical production was observed in the athletes' erythrocytes ($p < 0.001$), accompanied by lower levels of plasma reduced glutathione ($p = 0.01$), but there were no correlations between Healthy Eating Index and oxidative stress parameters or between body composition, vitamin A, C and E intake and oxidative stress.

Conclusions: The sample's diet quality was classified as low and, despite the fact that there was greater production of free radicals in the athletes' erythrocytes and plasma, in addition to lower levels of plasma reduced glutathione, there was no correlation between Healthy Eating Index and oxidative stress.

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Introduction

In sports, food is one of the pillars of health and performance. The development of nutritional guidelines and the consensus and positioning of sport societies and reference agencies have multiplied in recent years because of the increasingly evident influence of macro- and micronutrients on exercise [1].

Although exercise has a protective effect against disease and improves many aspects of health, it also increases the production of free radicals, which are part of the process of muscular adaptation to training [2]. However, systematized training also can induce positive adaptations in enzymatic antioxidant defense systems in response to increased free radical production. This system primarily consists of the enzymes superoxide dismutase, catalase, and glutathione

peroxidase. However, antioxidant intake through diet or supplements also is a fundamental part of the cytoprotective response [3].

Considered a sport that alternates aerobic and anaerobic energy production pathways, volleyball (including both training and competition) increases free radical production, which when not neutralized by endogenous or exogenous antioxidant defenses, triggers the oxidative stress (OS) process, which contributes to the mechanisms of cellular injury. Such injuries impair the intracellular metabolism of muscles and joints, compromising exercise efficiency [4]. Thus, balance between the production and neutralization of free radicals is essential to avoid the deleterious effects of OS, which highlights the importance of strategies to modulate antioxidant response, including nutritional adequacy through good food quality [5].

The US Department of Agriculture has developed an instrument to evaluate overall diet quality to determine whether the population's dietary habits meet established guidelines. Called the Healthy Eating Index (HEI), it has been used to better understand the relationships between nutrients, food, and diet patterns and their health outcomes [6]. Inadequate food choices, including the

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increase of junk food consumption, result in overweight and obesity in adolescence and has lately developed into a global health issue [7]. These choices, in addition to affecting nutrient deficiency, may influence the pathways of neuropsychomotor development, which may predispose to deregulated behaviors of impulsive eating [8].

To our knowledge, no other studies have evaluated HEI in adolescent athletes or tested the relationship between HEI and OS. Conscious that diet quality influences sports performance and modulates antioxidant response, our hypothesis was that poor food consumption, with a lower HEI score, is correlated with poor OS parameters. Therefore, the objective of this study was to compare the HEI and parameters of OS in adolescent volleyball athletes with those of non-athletes.

Methods

A cross-sectional study was conducted with 18 volleyball athletes of both sexes (9 boys and 9 girls), 15 to 18 y of age, from a sports club in Porto Alegre, Brazil. The athletes were paired with 15 non-athlete adolescents (6 boys and 9 girls) from the local community. The included convenience sample consisted of non-smoking adolescent athletes, competitive regional level, with regular training of five times a week, without chronic diseases. The athletes did not have nutritional monitoring. Any athletes who were injured or were not participating in the current training and competition schedule were excluded. The control group included adolescents who did not regularly exercise apart from school physical education classes. Those who smoked or had a chronic illness were excluded.

The study was approved by the Research Ethics Committee of the Hospital de Clínicas of Porto Alegre (case 14-0052). In compliance with Brazilian National Health Council resolution 510/2016, participation began only after written informed consent was given by the parents or guardians of the participants.

Anthropometry

Weight and height were measured on an anthropometric scale coupled with a Welmy stadiometer (Welmy®, São Paulo, Brazil). Waist circumference (WC) was measured with Cescorf (Cescorf®, Rio Grande do Sul, Brazil) non-stretchable anthropometric tape, and three skinfolds (triceps, subscapular, and calf) were measured with a Cescorf (Cescorf®, Rio Grande do Sul, Brazil) clinical plicometer. All anthropometric measurements were performed according to International Society for the Advancement of Kinanthropometry protocols and measured in triplicate by the same evaluator. WC was classified according to Taylor et al. [9], and body fat percentage was determined according to the equations of Slaughter et al. [10]. In the athlete group, these measurements were classified according to Wilmore and Costill's [11] cutoff points for volleyball athletes.

Food intake and HEI assessment

Food intake was assessed using a 3-d food record (2 weekdays, 1 weekend day). The data were recorded in the week before blood collection, with the final recording day occurring immediately before collection. Dietary data were analyzed using Nutwin diet software (UNIFESP, Escola Paulista de Medicina, Brazil) and supplemented with nutritional information from processed foods when the data were

Table 1
Anthropometric characterization of adolescent athletes and non-athletes

	Athletes (n = 18)	Non-athletes (n = 15)	Reference value
Sex (M/F)	9/9	6/9	–
Weight (kg)	71.1 ± 8.2 ^a	60.6 ± 11.6 ^b	–
Height (m)	1.80 ± 0.1 ^a	1.7 ± 0.1 ^b	–
WC (cm) [*]	M: 74.5 ± 3 F: 77.8 ± 8 ^a	M: 78 ± 9 F: 67.9 ± 5 ^b	M: 81.1–84.9 F: 78.3–80.1
Body fat (%) [†]	M: 14.1 ± 3.1 F: 24.4 ± 5.6 [‡]	M: 20.1 ± 8 F: 23.5 ± 5.3	M: 7–15 F: 11–18

WC, waist circumference.

Data are presented as mean ± SD.

Superscript letters ^{a,b} indicate significantly different values between groups.

^{*}From reference 9.

[†]From reference 11.

[‡]Group mean significantly different from the reference value.

unavailable in the software. The intake of carbohydrates; proteins; fats; fiber; sodium; vitamins A, C, and E; and the total energy value were calculated. Dietary reference intake values (i.e., the estimated average requirements for different groups) were compared with the recorded intake.

The HEI assessment was based on the US Department of Agriculture's 2010 Healthy Eating Index (the instrument is revised every 5 y). This version of the instrument includes 12 components, 9 of which are related to the adequacy of food consumption (total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy products, total proteins, seafood and plant proteins, and fatty acids), whereas the other 3 focus on moderation (refined grains, sodium, empty calories), adding to a maximum score of 100 points. The recommendations for food, fats, and empty calorie groups are expressed in terms of absolute values, which vary according to the level of energy consumed by the individual. The scores can be expressed as a percentage of calories (in cases of lower estimated average requirements) or per 1000 calories. The only exception to this is fatty acid, which is scored on the basis of unsaturated/saturated fatty acids. The scores are classified as follows: a low-quality diet, ≤51%; a diet requiring improvement, 51% to 79%; and a good-quality diet, ≥80%.

OS evaluation

On the same day as the anthropometric evaluation and completion of the 3-d food record, blood samples were collected in heparinized tubes. After collection, the blood was centrifuged at 1000g for 10 min at room temperature to separate the plasma and erythrocyte fractions. The plasma was then removed and stored. The erythrocytes were washed with saline solution three times, diluted in saline solution (1:10 v:v), and stored in a freezer until the experiments were conducted. The following biochemical assays were performed to verify the participants' blood redox status: oxidation of dichlorofluorescein (free radicals) [12] and proteins by determining carbonyls [13]; activity of the antioxidant enzymes catalase and glutathione peroxidase (GPx) [14]; and determining the concentrations of plasma reduced glutathione (GSH) and plasma thiols [15]. All the methodologies are done with reagents prepared in the laboratory, and all samples are dosed in parallel with standard curve, to guarantee the homogeneity of results.

Table 2
Assessment of antioxidant vitamin intake and HEI

	Athletes (n = 18)	Non-athletes (n = 15)	Reference value
HEI (%)	43.3 ± 8.2 [*]	46.4 ± 11.8 [*]	≤51%: Low quality 51%–79%: Need for improvement >80%: Good quality
Vitamin A (μg)	M: 583.7 ± 173.3 ^{a*,†}	M: 307.5 ± 112.3 ^{b*,†}	M: 630 μg/d F: 485 μg/d
Vitamin C (mg)	F: 345.3 ± 108.3 ^{a*} M: 121.8 (38–316) F: 112.5 (59–290)	F: 348.4 ± 242.2 ^{b,*} M: 79 (13–214) F: 68 (10–244)	M: 63 mg/d F: 56 mg/d
Vitamin E (mg)	M: 5.3 ± 1.8 [*] F: 4 ± 1.5 [*]	M: 5.5 ± 2.5 [*] F: 3.5 ± 1.5 [*]	M: 12 mg/d F: 12 mg/d

HEI, Healthy Eating Index.

Data are presented as mean ± SD or median (minimum–maximum).

Superscript ^{a,b} letters indicate significantly different values between groups.

^{*}A mean intake lower than the recommended values for age and sex or below the minimum reference cutoff point (HEI; *P* < 0.05).

[†]Significantly different values between sexes in the same group.

The data were analyzed in SPSS version 20 (IBM, Armonk, NY, USA) and their normality was assessed with the Shapiro–Wilk test. A *t* test for single samples (HEI, average vitamin intake) was then applied, followed by Student's *t* test for independent samples or the Kruskal–Wallis test (percentage of body fat, mean vitamin intake, HEI, and OS parameters), in addition to the Pearson or Spearman's correlation test (body fat percentage or HEI versus OS parameters). The results were expressed as percentages, means and SD, or median (minimum–maximum) and the significance level was set at $P < 0.05$.

Results

The mean age of the athlete participants was 16.3 ± 0.7 y and 16.9 ± 0.9 in the non-athlete group ($P > 0.05$). The distribution of anthropometric variables is shown in Table 1. Body weight and height were significantly greater in the athlete group ($P < 0.01$), which was expected because of the demands of the sport. WC was significantly greater in female athletes than female non-athletes ($P < 0.05$); no such difference was observed among the male participants. There was no difference in body fat percentage between male or female athletes and non-athletes. However, in the group of female athletes, this percentage was significantly higher than the acceptable upper limit for this variable ($P < 0.01$).

Table 2 shows the HEI scores and mean intake of antioxidant vitamins. According to the HEI results, the diets of only three athletes and five non-athletes were not of low quality, and none of these were classified as good quality. The participants' HEI assessment revealed surprisingly poor diet patterns, given that 72.7% of

the sample obtained a low-quality score in this index and no participant obtained good-quality score. Many of the participants did not consume vegetables, either cooked or raw, and many were low consumers of dairy products. Although fruit was better represented, most of this intake was in the form of juice. Therefore, the overall mean participant diet quality, regardless of sex or group, was low ($P < 0.05$). The mean intake of vitamins A and E were below the estimated average requirements in both groups and in both sexes. Vitamin A intake differed between sexes in the same group and between the same sex in different groups ($P < 0.05$). On the other hand, vitamin C intake was within the reference values for this age in both groups. Analysis of the OS parameters between the groups indicated higher free radical production in the erythrocytes of athletes ($P < 0.001$), accompanied by lower plasma GSH levels ($P=0.01$; Fig. 1A and B), although vitamin C intake was higher in this group ($P=0.03$).

In addition, there was a tendency in the athlete group toward greater free radical production in plasma ($P=0.07$) and higher levels of plasma thiols ($P=0.06$; Fig. 1C and D). No correlation was found between body fat percentage; intake of vitamins A, C, and E; or HEI with OS parameters (data not shown). Weak but significant correlations were found among the OS parameters: free radicals in erythrocytes versus GPx content: $R=0.3$, $P < 0.01$; free radicals in plasma versus GPx content: $R=-0.3$, $P < 0.05$; free radicals in plasma and protein carbonylation: $R=0.07$, $P < 0.01$; and free radicals in plasma and thiol content: $R=0.05$, $P < 0.01$.

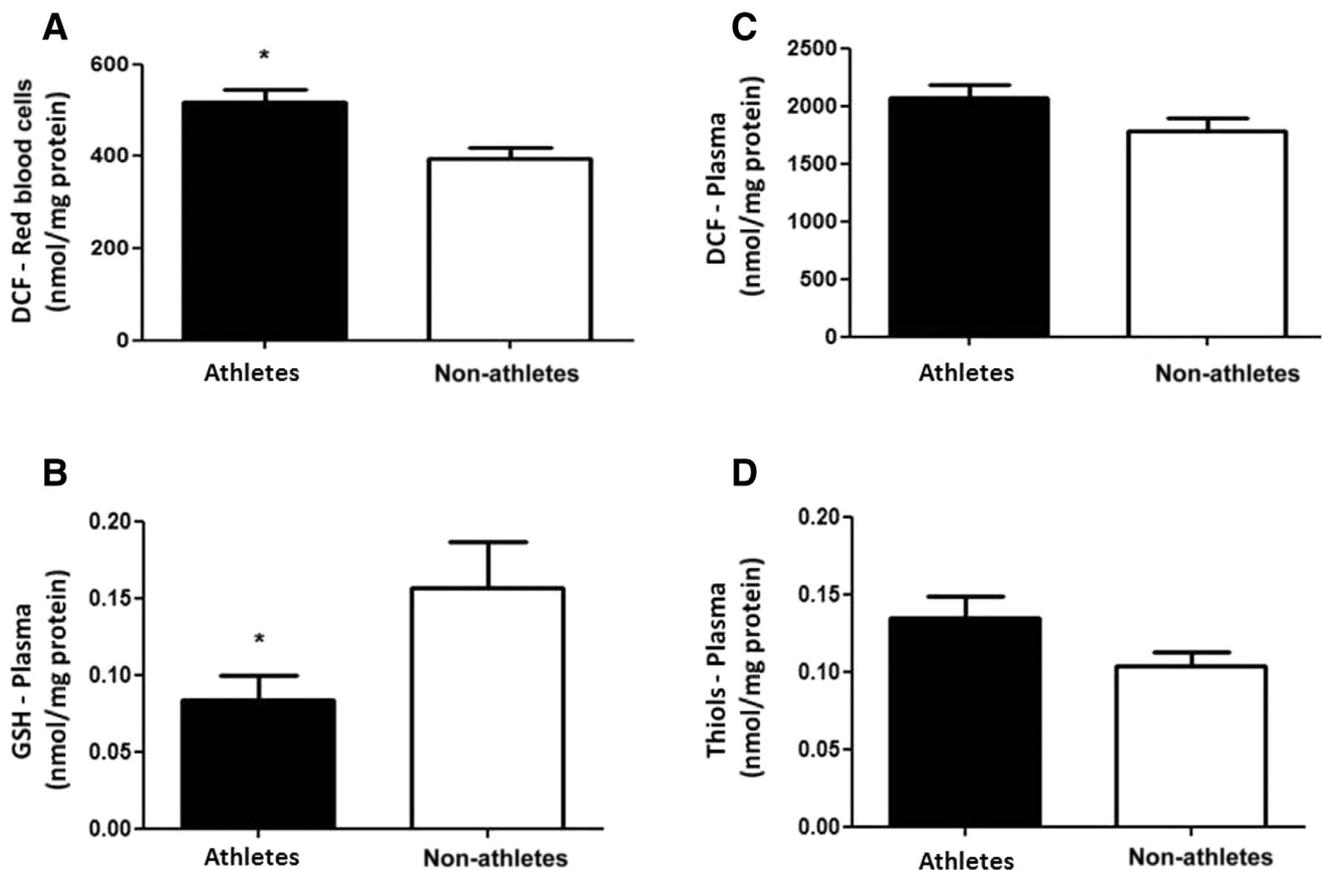


Fig. 1. (A, B) Analysis of the overall survival parameters between the groups indicated higher free radical production in the erythrocytes of athletes ($P < 0.001$), accompanied by lower plasma GSH levels ($P=0.01$), although vitamin C intake was higher in this group ($P=0.03$). (C, D) There was a tendency in the athlete group toward greater free radical production in plasma ($P=0.07$) and higher levels of plasma thiols ($P=0.06$). DCF, oxidation of dichlorofluorescein; GSH, plasma reduced glutathione. *significant differences between groups.

Discussion

The diet quality of this sample of adolescents, whether athletes or not, was low, including insufficient intake of vitamins A and E. However, different than expected, there was no correlation between the score of HEI and the OS parameters. The OS parameters and diet quality also were not correlated with body composition. Moreover, in athletes of both sexes, free radical production was higher and plasma GSH levels were lower.

The essential role of calcium intake for athletes should be pointed out. Calcium is essential for exercise because it mediates the muscle contraction process and the structural role of bone mass. Moreover, stress fractures are frequent in athletes with low bone density [16]. Certainly, these poor diet patterns contributed synergistically to inadequate vitamin A and E intake, which was observed throughout the sample. Other studies of adolescents have pointed out their low-quality diets, in which the consumption of fruits and vegetables—major sources of vitamins—is below recommended values, whereas the consumption of processed, high-calorie foods is excessively high [17]. Although inappropriate consumption of certain food groups is prevalent among all age groups, it is particularly characteristic of adolescence, and this is cause for concern because unhealthy nutritional habits during adolescence may persist through adulthood [18].

Although the body mass index of this sample of adolescents was within the limits of eutrophy (data not shown), the body fat percentage was above normal for female athletes, which probably reflects their diet pattern, as corroborated by their HEI scores. The female athletes also had a greater WC than female non-athletes, which was unexpected because the athletes' activity level does not favor the accumulation of fat. Body composition and weight are two of many factors that contribute to optimal exercise performance; together, they can affect an athlete's potential and contribute to success. An individual's weight can influence speed, endurance, and potency; whereas body composition may affect an athlete's strength and agility. These factors are determinant in sports such as volleyball [19,20]. This dietary consumption and body fat percentage of adolescent volleyball players found in this study does not necessarily reflect the consumption of volleyball players in general or their body fat. In a study with female volleyball athletes with mean age of 22 y (ranging from 16 to 29 y), data found that the body fat percentage is normal or even relatively below expected [21].

Over the past few decades, dietary antioxidants have received attention predominantly as a nutritional strategy to prevent or minimize the detrimental effects of OS imbalance, generated during and after exercise [22]. When a competitive athlete's diet contains a sufficient level of foods rich in antioxidants, the diet can protect against exercise-induced OS [23]. Regarding the dietary antioxidants assessed in the present study, low vitamin E intake could be harmful because this vitamin can protect cell membranes against lipid peroxidation [24]. Similarly, the present sample's low vitamin A intake could be deleterious, especially to the athletes, because its intake through diet or supplementation has a compensatory effect on lipid peroxidation from strenuous exercise [25]. Thus, insufficient consumption of these nutrients may be one of the causes of the high free radical production in the erythrocytes and plasma of the athletes, in addition to their lower levels of plasma GSH. However, despite the effects that dietary antioxidants could have on performance, OS, and cell damage, supplementation of these compounds still remains controversial [26,27] and is not subject to recommendation [1]. However, studies on obese adolescents involving exercise and calorie-restriction interventions, whose results include improved OS markers, have attracted attention, and these results have been replicated with obese adults [28,29].

Although often reported as injurious, the relationship between exercise and OS is extremely complex, depending on the type, intensity, and duration of exercise. Moderate regular training has beneficial effects on health through physiological adaptations regulated by innumerable cellular pathways, including free radical production [30]. Because only a single moderate correlation was found in the assessed OS parameters, despite the sample's poor diet quality, it is difficult to speculate about the actual effects of volleyball training on adolescents and their correlation with these OS parameters. One possible reason for the lack of correlation between the variables may be the difficulty of in vivo OS measurement, considering the extreme complexity of the antioxidant and oxidant network and the very short half-life of free radicals [31]. Thus, the OS values in the present results may not accurately reflect values in the biological system. Moreover, to our knowledge, there is currently no consensus on which biomarkers or groups of biomarkers should be used to estimate the effects of exercise or the bioefficacy of dietary or supplemental antioxidants in sports to assess OS [32]. It is important to point out the limitations of the food consumption estimates. Many nutrients require more than 3 d of assessment to determine deficiencies or genuinely insufficient consumption patterns. These can be considered study limitations, along with the sample size, which was obtained by convenience.

Conclusion

The diet quality of this sample of adolescent athletes and non-athletes was classified as low according to the HEI, and the intake of vitamins A and E was below recommended levels. Body composition did not correlate significantly with any of the other parameters evaluated in this study. Although higher levels of free radicals in erythrocytes and lower plasma GSH levels were found in the athlete group, there was no correlation between the OS parameters and diet quality, measured by HEI, or between the two groups.

References

- [1] American College of Sports Medicine and Academy of Nutrition and Dietetics, Dietitians of Canada. Nutrition and athletic performance. *Med Sci Sports Exerc* 2016;48:543–68.
- [2] Steinbacher MBP, Eckl P. Impact of oxidative stress on exercising skeletal muscle. *Biomolecules* 2015;5:356–77.
- [3] McLeay Y, Stannard S, Houltham S, Starck C. Dietary thiols in exercise: oxidative stress defence, exercise performance, and adaptation. *J Int Soc Sports Nutr* 2017;14:12.
- [4] Tipton KD. Nutritional support for exercise-induced injuries. *Sports Med* 2015;45:93–104.
- [5] Bjorklund G, Chirumbolo S. Role of oxidative stress antioxidants in daily nutrition and human health. *Nutrition* 2017;33:311–21.
- [6] Guenther PM, Casavale KO, Reedy J, Kirkpatrick SI, Hiza HA, Kuczynski KJ, et al. Update of the Healthy Eating Index: HEI-2010. *J Acad Nutr Diet* 2013;113:569–80.
- [7] World Health Organization. Obesity and overweight, 2017. Available at: <http://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight>; Accessed July 31, 2018.
- [8] Reichelt AC, Rank MM. The impact of junk foods on the adolescent brain. *Birth Defects Res* 2017;109:1649–58.
- [9] Taylor RW, Jones IE, Williams SM, Goulding A. Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children ages 3–19 y. *Am J Clin Nutr* 2000;72:490.
- [10] Slaughter MH, Lohman TG, Boileau RA, Stillman GV. Skinfold equations for estimation of body fatness in children and youth. *Hum Biol* 1988;6:709–23.
- [11] Wilmore JH, Costill DL. Physiology of sport and exercise. Champaign, IL: Human Kinetics; 1994.
- [12] Lebel CP, Ischiropoulos H, Bondy SC. Evaluation of the probe 2',7'-dichlorofluorescein as an indicator of reactive oxygen species formation and oxidative stress. *Chem Res Toxicol* 1992;227–31.
- [13] Reznick AZ, Packer L. Oxidative damage to proteins: spectrophotometric method for carbonyl assay. *Methods Enzymol* 1994;233:357–63.

- [14] Wendel A. Glutathione peroxidase. *Methods Enzymol* 1981;77:325–33.
- [15] Aksenov MY, Markesbery WR. Changes in thiol content and expression of glutathione redox system genes in the hippocampus and cerebellum in Alzheimer's disease. *Neurosci Lett* 2001;302:141–5.
- [16] Goolsby MA, Boniquit N. Bone health in athletes. *Sports Health* 2017;9:108–17.
- [17] Rauber F, Campagnolo PD, Hoffman DJ, Vitolo MR. Consumption of ultra-processed food products and its effects on children's lipid profiles: a longitudinal study. *Nutr Metab Cardiovasc Dis* 2015;25:116–22.
- [18] Lipsky LM, Haynie DL, Liu D, Chaurasia A, Gee B, Li K, et al. Trajectories of eating behaviors in a nationally representative cohort of U.S. adolescents during the transition to young adulthood. *Int J Behav Nutr Phys Act* 2015;12:138.
- [19] Grigoryan S. Concept of optimal body composition of professional football players. *Georgian Med News* 2011;198:23–8.
- [20] Nikolaidis PT, Gkoudas K, Afonso J, Clemente-Suarez VJ, Knechtle B, Kasabalis S, et al. Who jumps the highest? Anthropometric and physiological correlations of vertical jump in youth elite female volleyball players. *J Sports Med Phys Fitness* 2017;57:802–10.
- [21] Copic N, Dopsaj M, Ivanovic J, Nestic G, Jaric S. Body composition and muscle strength predictors of jumping performance: differences between elite female volleyball competitors and nontrained individuals. *J Strength Cond Res* 2014;28:2709–16.
- [22] Braakhuis AJ, Hopkins WG. Impact of dietary antioxidants on sport performance: a review. *Sports Med* 2015;45:939–55.
- [23] Brisswalter J, Louis J. Vitamin supplementation benefits in master athletes. *Sports Med* 2014;44:311–8.
- [24] Santos SA, Silva ET, Caris AV, Lira FS, Tufik S, Dos Santos RV. Vitamin E supplementation inhibits muscle damage and inflammation after moderate exercise in hypoxia. *J Hum Nutr Diet* 2016;29:516–22.
- [25] Patlar S, Baltaci AK, Mogulkoc R. Effect of vitamin A administration on free radicals and lactate levels in individuals exercised to exhaustion. *Pak J Pharm Sci* 2016;29:1531–4.
- [26] Stepanyan V, Crowe M, Haleagrahara N, Bowden B. Effects of vitamin E supplementation on exercise-induced oxidative stress: a meta-analysis. *Appl Physiol Nutr Metab* 2014;39:1029–37.
- [27] Cogley JN, McHardy H, Morton JP, Nikolaidis MG, Close GL. Influence of vitamin C and vitamin E on redox signaling: implications for exercise adaptations. *Free Radic Biol Med* 2015;84:65–76.
- [28] He F, Zuo L, Ward E, Arciero PJ. Serum polychlorinated biphenyls increase and oxidative stress decreases with a protein-pacing caloric restriction diet in obese men and women. *Int J Environ Res Public Health* 2017;10:14.
- [29] Li C, Feng F, Xiong X, Li R, Chen N. Exercise coupled with dietary restriction reduces oxidative stress in male adolescents with obesity. *J Sports Sci* 2017;35:663–8.
- [30] Dimauro I, Mercatelli N, Caporossi D. Exercise-induced ROS in heat shock proteins response. *Free Radic Biol Med* 2016;98:46–55.
- [31] Halliwell B, Whiteman M. Measuring reactive species and oxidative damage—*in vivo* and in cell culture: how should you do it and what do the results mean? *Br J Pharmacol* 2004;142:231–55.
- [32] Pingitore A, Lima GP, Mastorci F, Quinones A, Iervasi G, Vassalle C. Exercise and oxidative stress: potential effects of antioxidant dietary strategies in sports. *Nutrition* 2015;31:916–22.