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Original Article

Relationship between the dietary intake of sport climbers according to climbing grading scales and the dietary supply of antioxidants

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Abstract:
Introduction Intense exercise, both aerobic and anaerobic, results in an increased production of reactive oxygen species (ROS) in the body. Along with the climbing level increase, the intensity of the workouts performed rises, which can result in a disruption of the body's antioxidant potential. The diets of climbers with higher levels of training should provide a rich source of antioxidants. The aim of this study was to evaluate differences in the dietary supply of selected antioxidant substances according to the climbing level. **Methods** A total of 26 women and 29 men who regularly practice sport climbing participated in the study. The subjects, using the IRCRA standardized scale, were classified into intermediate, advanced, or elite climbing levels. Anthropometric measurements were performed, and resting metabolic rate of the subjects was measured. The dietary supply of vitamins C, E, beta carotene, and flavonoids was analyzed from a record of current intake over 3 days. **Results** A marginally statistically significant relationship was observed between dietary vitamin E (0.052), C (0.056), and beta-carotene (0.012), but not flavonoids, and the level of climbing. In the study group, the diets of elite climbers had the highest average vitamin C and beta-carotene content. The most statistically significant differences in dietary antioxidant vitamins tested were observed between the advanced and elite groups. **Conclusions** The elite climbers surveyed were characterized as being very careful in their choice of vitamin C and beta-carotene sources. The dietary intake of flavonoids in studied population was low. Emphasis should be placed on increasing natural sources of flavonoids among sport climbing representatives. Regular inclusion of natural antioxidant-rich foods (e.g., fresh fruits, vegetables, and tea) may be the best way to increase ROS neutralization caused by intense training .
Keywords: **sport climbing, oxidative stress, sport nutrition, dietary intake, dietary antioxidants**

Introduction

Physical activity is considered beneficial to health. However, intense and prolonged exercise can induce oxidative stress due to the overproduction of reactive oxidative species (ROS) [1]. Oxidative stress has been linked to the pathogenesis of many diseases and decreased immune function, which may affect exercise performance [2]. During and immediately after aerobic and anaerobic exercise, ROS levels increase in skeletal muscle tissue and circulating blood. In an overtrained athlete, there is a continuous production of ROS and a decrease in antioxidant defenses. The imbalance between oxidants and antioxidants in the body may play an important role in muscle fatigue during prolonged or intense exercise [3]. In the study, short-term rock climbing was associated with high levels of oxidative stress markers. Moreover, results suggested that an ischemia-reperfusion prooxidant-based mechanism related to climbers' sustained and intermittent isometric forearm muscle contractions may have a significant influence on observed plasma oxidative stress [4]. The growing evidence on exercise-induced oxidative damage being the possible cause of impairment of athlete performance has spurred intense research on the evaluation of antioxidant supplementation's influence on muscle protection in exercising individuals. Dietary intake of antioxidants is often excluded from consideration in studies observing the association between exercise and oxidative stress. This is a major limitation, regarding the variability of dietary intake between individuals and the impact that dietary intake has on the antioxidant profile. What's more, environmental factors such as exercise and diet can also influence the synthesis of antioxidant molecules and the gene expression of antioxidant enzymes [3]. A diet rich in antioxidants and endogenous antioxidants may have a preventive effect on exercise-induced increases in ROS [5]. A positive correlation between fruit and vegetable intake and blood antioxidant capacity was found in untrained subjects [6].

Trained athletes pay more attention to their diet, which could suggest that as climbing levels increase, the antioxidant content of the diet, due to the increased demand resulting from intense training, will be higher to protect the body from free radical damage. However, there is no sport-specific recommendation for sport climbing nutrition and climbing representatives continuously follow restricted diets to decrease body fat, which can lead to the low nutritional status of this group [5]. The purpose of this study was to evaluate the presence of an association between dietary vitamin C, E, beta-carotene, and flavonoid supply with the climbing level of athletes.

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Methods

Fifty-five sport climbers participated in the study. The eligibility criterion for the study was the regular practice of the sport as a form of physical activity.

Subjects fasted overnight before the visit, at which anthropometric measurements, including body height measurement and body composition measurement, were performed using Jawon Medical bioimpedance scales, and resting metabolic rate (RMR) was measured by indirect calorimetry Cosmed Fitmate GS instrument. Participants also had their blood pressure, pulse, and compression force measured. During the visit participants also filled out the questionnaire about their eating habits, supplementation, and climbing level. Participants were asked to record current intake over 3 days using the Fitatu mobile application [7]. To obtain the most accurate data on the portion sizes of the products consumed, their intake was supplemented by photographs of the meals consumed. The food record was then transferred to the ESHA Food Processor program with the database from the Nutrient Tables of Foods [8] and the USDA database of flavonoid content in selected foods [9]. The average dietary content of flavonoids, vitamin C, vitamin E, and beta-carotene of the tested diets was used for the statistical analysis. The climbing level of the participants was assessed using the 3:3:6 method, with respondents indicating the difficulty of the tracks they had successfully repeated three times in the last 6 months on 3 different routes. The climbing level was standardized using the IRCRA scale [10]. Based on the IRCRA level subjects were classified as intermediate, advanced, or elite.

The study was approved by the Bioethics Committee of the Piastow Slaskich Medical University in Wroclaw. All participants of the study provided written informed consent to participate in the study.

Statistical analyses

Calculations were performed using Statistica 13.3 (StatSoft Inc., USA). A Box-Cox transformation was used to obtain normal distributions. Data were analyzed using general linear models (GLM) and Pearson's correlation coefficient. The equality of variances was assessed using Levene's test. A NIR test was performed for components in which a significant correlation was observed between dietary content and climbing level.

Results

Characteristics of the subjects' climbing level

Fifty-five people participated in the study, including 26 females and 29 males aged 18-53 years. Based on the participants' indicated route evaluation, which had been repeated three times in the past 6 months, subjects were assigned to one of three climbing groups according to the IRCRA standardized climbing scale. The most frequently declared level in the female group was advanced, while in the male group it was intermediate. Only in the women's group were there representatives of the elite level. Table 1 shows the values of anthropometric measurements of male and female participants according to the climbing level presented.

Table 1. The anthropometric measurement values of female participants according to their climbing level

Studied parameter	Female climbers			Male climbers	
	Intermediate (N=25)	**Advanced (N=23)**	**Elite (N=7)**	**Intermediate (N=17)**	**Advanced (N=13)**
	x±SD	x±SD	x±SD	x±SD	x±SD
Body weight (kg)	60.71 ±4.64	56.51±7.38	58.98±6.4	73.85±8.27	71.82±8.01
Height (cm)	167.75±3.18	163.91±4.82	167.36±6.47	177.59±6.16	177.79±6.05
Fat-free body mass (kg)	46.64±3.84	43.20±4.04	45.60±3.92	61.28±6.82	60.31±6.28
Proportion of body fat (%)	23.01±5.96	23.14±4.61	22.48±3.21	16.82±5.64	15.91±3.96
Body fat mass (kg)	14.08±4.31	13.31±4.01	13.37±3.16	12.57±5.18	11.52±3.74
Proportion of skeletal muscles (%)	42.68±3.54	42.60±2.75	42.99±1.88	46.38±3.37	46.92±2.33
Skeletal muscle mass (kg)	25.85±2.21	23.94±2.19	25.29±2.15	34.14±3.85	33.65±3.52
Body water (kg)	33.588±2.77	31.11±2.90	32.84±2.82	44.12±4.90	43.43±2.33
BMI	21.59±1.98	20.97±1.88	21.02±1.63	23.39±2.21	22.27±1.52
Right hand grip strength (kg)	32.81±8.38	29.71±3.52	36.42±6.63	48.09±7.95	46.71±7.01
Left hand grip strength (kg)	30.40±8.06	25.34±4.33	31.51±5.71	44.79±6.95	47.77±6.36
SMR	0.52±0.12	0.50±0.9	0.58±0.11	0.63±0.10	0.67±0.09
Systolic blood pressure (hPa)	104.50±5.24	101.82±11.87	93.43±6.97	122.41±13.71	119.58±12.02
Diastolic blood pressure (hPa)	69.88±7.92	62.09±13.12	59.58±6.97	71.82±6.90	71.00±7.42
Pulse (beats/min)	67.88±7.91	63.18±12.54	60±4.40	65.18±9.77	62.83±15.61
RMR (kcal)	1416.88±201.98	1564.82±128.77	1609.14±137.24	1950.765±244.63	1958.42±186.09

x – mean, SD – standard deviation, BMI – body mass index, SMR – hand grip/body weight ratio, RMR – resting metabolic rate

Table 2 shows the macronutrient supply per body weight of the participants.

Table 2. The dietary macronutrient intake per kilogram of body weight

Tested dietary component	**Study group (n = 55)**	**Women (n = 26)**	**Men (n = 29)**
	x±SD	x±SD	x±SD
Energy (kcal/kg bw)	31.7±6.61	30.4±6.73	32.8±6.33
Protein (g/kg bw)	1.36±0.32	1.39±0.34	1.33±0.30
Carbohydrates (g/kg bw)	3.63±1.04	3.92±1.06	3.37±0.94
Fats (g/kg bw)	1.16±0.26	1.13±0.24	1.19±0.28

x - mean, SD - standard deviation

Dietary supply of antioxidant vitamins and flavonoids in the subjects

Of the climbers surveyed, nearly half reported limiting or eliminating meat products. 34.5% of the respondents declared to follow a semi-vegetarian diet, 14.5% a vegetarian diet. 3.6% of the climbers surveyed reported following a special diet. Of the respondents, 47.3% reported eating meat.

In the study population, the mean dietary supply of vitamin C was 155.07 ± 86.03mg, vitamin E 13 ±6.2 mg, beta-carotene 6174.45± 4948.10 mcg. The mean flavonoid content of the diets studied was 180 ±275.46 mg. A comparison of the dietary content of the studied components according to the declared climbing level of the subjects is shown in Table 3.

Table 3. The comparison of the dietary content of the studied components according to the declared climbing level of the subjects

Tested dietary component	Climbing level		
	Intermediate (N=25)	**Advanced (N=23)**	**Elite (N=7)**
	x±SD	x±SD	x±SD
Flavonoids (mg)	218.57 ±357	150.84 ±200.27	138.05 ±120.61
Vitamin E (mg)	14.78 ±7.17	10.73 ±5.07	14.06 ±3.48
Vitamin C (mg)	158.3 ±83.15	128.52 ±61.82	230.77 ±124.52
Beta carotene (mcg)	5667.49 ±3955.82	4786.32± 3191.76	12546.02 ±7427.31

x - mean, SD - standard deviation

The diets of the elite level climbers had the highest average vitamin C and beta-carotene content. The diets of climbers at the intermediate climbing level had the highest average vitamin E and flavonoid content. Climbers at the advanced level provided the lowest average amount of antioxidant vitamins with their diet.

The observed correlation between climbing level and flavonoid content in the diet of the climbers studied was not statistically significant. A statistically significant correlation was observed between the dietary content of the antioxidant vitamins studied and the climbing level presented (Table 4).

Table 4. The relationship between the dietary content of the antioxidant vitamins studied and the climbing level presented

	Vitamin E				
Effect	df	R	R^2	F-value	p -value
Intercept	1,000	-	-	547,048	0,000
Climbing level	2,000	0,328	0,073	3,128	0,052
	Vitamin C				
Effect	df	R	R^2	F-value	p -value
Intercept	1,000	-	-	1086,574	0,000
Climbing level	2,000	0,324	0,070	3,041	0,056
	Beta-carotene				
Effect	df	R	R^2	F-value	p -value
Intercept	1,000	-	-	4057,724	0,000
Climbing level	2,000	0,395	0,124	4,816	0,012

R- correlation coefficient, R^2- determination coefficient

The coefficient of determination R^2 for the study variables was low and was 12% for vitamin E, 6% for vitamin C, and 11% for beta-carotene, respectively (Table 5). This indicates that there are other variables with greater influence on dietary antioxidant content.

Table 5. Evaluation of the influence of the 'climbing level' variable on the dietary content of the antioxidant vitamins studied using general linear models (GLM)

	atio	Lower limit of 95.00% CI	Upper limit of 95.00% CI	-value	-value
Vitamin E					
Intercept	3,91	3,57	4,24	23,39	0,00
Intermediate	0,23	-0,18	0,65	1,13	0,26
Advanced	-0,48	-0,90	-0,06	-2,30	0,03*
Vitamin C					
Intercept	10,51	9,87	11,15	32,96	0,00
Intermediate	-0,29	-1,08	0,50	-0,74	0,46
Advanced	-0,92	-1,72	-0,12	-2,30	0,03*
Beta-carotene					
Intercept	10,33	10,00	10,65	63,70	0,00
Intermediate	-0,34	-0,74	0,06	-1,69	0,10
Advanced	-0,50	-0,91	-0,10	-2,48	0,02*

CI- confidence interval

The correlation between energy intake per kilogram of body mass and the content of flavonoids and vitamin E in the diet of climbers at particular levels of climbing was evaluated; however, the low coefficient of determination of the obtained results indicates the presence of factors, other than the energy value of the diet, with a more significant effect on the studied diet components (Table 6). There was no correlation between the content of the examined components in the diet of the subjects and the declared type of the implemented diet.

Table 6. Evaluation of the correlation between energy intake per kilogram of body mass and the content of flavonoids and antioxidant vitamins in the diet of climbers at particular levels of climbing using the Pearson's correlation coefficient test

Studied variables	x± SD	R	R^2	t-value	p-value
kcal/kg bw	31,66±6,67				
Flavonoids	6,60±2,89	0,309	0,095	2,362	0,022*
kcal/kg bw	31,66±6,67				
Vitamin E	3,84±1,09	0,270	0,073	2,043	0,046*
kcal/kg bw	31,66±6,67				
Vitamin C	10,15±2,09	0,186	0,034	1,376	0,175
kcal/kg bw	31,66±6,67				
Beta-carotene	10,07±1,09	0,081	0,007	0,590	0,558

x- mean, SD- standard deviation, R- correlation coefficient, R^2- determination coefficient,

In the case of vitamin E, a significant difference in the average dietary content of the test component was observed between the intermediate and advanced groups. Significant differences in vitamin C content were observed between the advanced and elite groups. Significant differences in dietary beta-carotene content were reported between the intermediate and advanced groups, and the advanced and elite groups. The most statistically significant differences in dietary antioxidant vitamins tested were observed between the advanced and elite groups. The results of the tests obtained are shown in Table 7.

Table 7. Evaluation of the significance of differences (p) in the content of vitamin E, C, and beta-carotene in the diet between the studied groups of climbers

Vitamin E			
Climbing level	**intermediate p-value**	**advanced p-value**	**elite p-value**
Intermediate		0,020*	0,969
Advanced	0,020*		0,105
Elite	0,969	0,105	
Vitamin C			
Climbing level	**intermediate p-value**	**advanced p-value**	**elite p-value**
Intermediate		0,285	0,087
Advanced	0,285		0,018*
Elite	0,087	0,018*	
Beta-carotene			
Climbing level	**intermediate p-value**	**advanced p-value**	**elite p-value**
Intermediate		0,583	0,010*
Advanced	0,583		0,004*
Elite	0,010*	0,004*	

Discussion

In a study by Sas-Nowosielski et al. [11] evaluating energy and nutrient supply with the diets of elite climbers, the female subjects weighed an average of 55.1kg and the male subjects weighed 68.8kg. The mean BMI for women was 20.4 kg/m2, while for men it was 21.8kg/m2. In our study, the mean body weight and BMI values for women and men were 58.1 kg and 21.18 kg/m2 and 73.01 kg and 22.93 kg/m2, respectively. Similar mean energy and nutrient supply from the diet per kilogram of body weight were observed in the groups from the mentioned study and in our study. Our study reported a lower carbohydrate supply among men compared to the study by Sas- Nowosielski et al. (3.37 vs. 4.19 g/kg/mc). The obtained results of average nutrient supply are also lower compared to the results of a previous study on a group of sport climbers [12]. In the study by Gibson-Smith et al. [13], similar carbohydrate supply but higher protein supply and dietary fat supply were observed in the analyzed climbers' diets, compared to the values in the climbers' diets in our study. Sport climbers often strive to reduce their body weight and body fat by reducing the energy value of their diet and, consequently, the supply of individual nutrients. This group is at risk of developing nutritional deficiencies [14]. Joubert et al. [15] observed the prevalence of eating disorders in a group of international climbers. Eating disorders were confirmed in 8.6% of the study population. Women (16.5%) were significantly more likely to declare an eating disorder, especially among elite climbers (42.9%).

It is estimated that the ratio of compression force to the bodyweight of climbers is an important indicator of climbing ability [16]. In the self-report study, women at the elite level and men at the advanced level had the highest index value. The climbers' index values were lower than those obtained in a study by Watts et al. [17] among participants in the semifinals and finals of the World Cup Sport Climbing Competition.

The correlation between the dietary antioxidant vitamin supply and exercise-induced oxidative stress parameters among sport climbing athletes has not yet been the subject of scientific research. However, the content of these components has been analyzed in the diets of representatives of other sports [18].

A study by Devrim-Lanpir et al. [18] evaluated the correlation between total dietary antioxidant supply and exercise-induced oxidative stress damage among ultra-athletes. Total dietary antioxidant supply was negatively correlated with the value of total oxidative status (TOS), the difference in levels of oxidative stress-related biomarkers after exercise compared with before exercise, and positively correlated with the difference in the value of total antioxidant capacity (TAS) and post-exercise lactate concentration. A significant positive correlation was also observed between dietary antioxidant supply and treadmill running exhaustion time in male subjects.

In a self-reported study, intermediate-level climbers had the highest mean dietary intake of vitamin E and flavonoids, while elite-level climbers had the highest mean intake of beta-carotene and vitamin C. In an earlier study by the author [12], the advanced level female participants had higher vitamin C and vitamin E dietary intake compared to intermediate and beginner level climbers. In the male study group, higher vitamin E and lower vitamin C dietary intake were observed in the advanced group compared to the lower level climbing group. Insufficient dietary diversity in sources of antioxidant components may result in a worsening of the body's response to oxidative stress from intense climbing training [3].

In an earlier study conducted by the author [12], a positive correlation was observed between the climbing level of women and the dietary supply of vitamin C. For the group of male climbers studied, a positive correlation was observed with the amount of vitamin E supplied from the diet.

A study by Rousseau et al. [19] assessed the prevalence of high levels of lipoperoxidation markers in relation to estimated daily energy expenditure and dietary supply of vitamins C, E, and beta-carotene among 118 trained athletes. Athletes had significantly lower intakes of vitamin C and E of the French RDA standard for athletes (FRDA). However, vitamin C supply among the subjects was significantly higher than the recommended standard for moderately active individuals (110 mg/d), but only 40% of the athletes achieved FRDA. For vitamin E, 81% of athletes and 68.7% of those with a sedentary lifestyle had intakes below two-thirds of FRDA. The b-carotene supply was below two-thirds of FRDA for 43% of athletes and 56% of those with a sedentary lifestyle. In our study, although the average supply of the analyzed vitamins exceeded the value of the EAR standard, among the climbers studied 10.9% of the diets did not meet the standard for vitamin C, and 29.1% the standard for vitamin E. There is no recommended dose of beta-carotene intake for the Polish population. However, it is suggested that doses not exceeding 20 mg/day are safe for health. In the study population, the average dietary supply was 6.2 mg. This value is significantly higher compared to the results obtained by Rousseau from the diets of the athletes studied, where the highest supply of 4.08mg was found in the diets of participants performing aerobic sports. Discrepancies in the data obtained may be due to differences in the standards compared. In the norms for the Polish population, there are no norms for athletes and the values obtained from the analysis of diets are compared to the EAR norm.

Based on the results, the authors concluded that a supply of >200mg/d of vitamin C appears to be optimal for trained athletes [19].

It is estimated that lower doses of vitamin C consumed in fruits and vegetables (up to 250 mg per day) may be sufficient to reduce oxidative stress and provide other health benefits without interfering with training adaptations [20].

Analysis of the results of the study by Plunkett et al. [21] showed that limiting fruit and vegetable intake to 1-2 servings per day reduces plasma carotenoid concentrations, an important group of antioxidants, alters plasma carotenoid concentrations in response to exercise, and increases plasma inflammatory marker TNF-a. It has been suggested that a diet rich in fruits and vegetables is an important defense mechanism against oxidative stress for athletes. Analysis of the effects of a 5-week low-calorie diet characterized by a reduced supply of antioxidant vitamins on climbers showed an increase in oxidative stress markers and a decrease in plasma vitamin C concentrations in the subjects [3].

To date, no other analyses have been performed on the flavonoid content of the diets of sport climbing representatives. However, higher flavonoid intake was observed in the study with representatives of the Polish population compared to the group of climbers from our study. In a group of 50-year-old inhabitants of Wroclaw, a supply of 622.6 mg was observed among women and 616.89 mg among men [22]. A flavonoid supply of 801 mg per day was reported in a group of Polish students [23]. The results obtained in the cited studies far exceed the values obtained among the climbers surveyed. In the studies cited above, the high proportion of flavonoids in the subjects' diets was due to the consumption of tea, which was not a frequently chosen beverage in the subjects of our study. There is 118.35mg of flavonoids in 100g of ready infusion of black tea, 54.38mg of green tea, and 69.45mg of white tea. The same amount of coffee is a source of only 0.18mg of flavonoids [9]. Coffee, which has a significantly lower flavonoid content compared to tea, was chosen more often than tea. Another reason for the low tea consumption was the spring-summer period of the dietary record, during which consumption of warm tea-type beverages is likely to be lower compared to the fall-winter periods.

In a study by Potter et al. [24], supplementation with New Zealand blackcurrant extract, which is high in anthocyanins, in a group of sport climbers resulted in increased climbing exercise duration compared to a placebo group. A trend was also observed toward improved arm flexion overhang, an indicator of the strength of muscles used in climbing, in the supplementation group. These results support the beneficial effects of dietary flavonoid supply on climbing training performance.

A diet deficient in antioxidant sources is associated with increased plasma concentrations of inflammatory mediators and decreased plasma antioxidant concentrations in endurance athletes both at rest and after exercise [21,25]. It has been suggested that the use of an antioxidant-rich diet in athletes may lead to increased protection against training-induced respiratory disease due to a better balance of prooxidants to antioxidants, especially at high altitudes [26].

A study by Koivisto et al. [27] showed a reduction in ferric reducing antioxidant power (FRAP) and proinflammatory cytokines IL13 and IL6, micro-CRP in a group of athletes during a 3-week high-altitude training camp with a diet rich in antioxidant-rich foods compared to a control group.

It is estimated that over-supplementation with antioxidant-like substances may reduce the body's adaptive capacity to high-intensity exercise [28]. At the same time, there are no recommendations for the supply of these antioxidant vitamins for athletes, among whom the supply at the level recommended for the general population may be insufficient to meet the increased needs of the body. The results of previous studies on the effectiveness of antioxidant substances with diet are inconclusive [28]. It is estimated that the implementation of a varied diet with a high content of fresh and seasonal vegetables and fruits is a sufficient source of antioxidant vitamins and flavonoids [19].

Restriction of energy supply and nutritional disturbances caused by the desire to drastically reduce body fat and body mass to achieve better climbing results may result in a deficient supply of both macro-and micronutrients with the diet [14]. The following of an incomplete diet with concurrent climbing activity may increase oxidative stress in the body of sport climbers [3].

Studying the effect of natural foods is difficult because the antioxidant content of foods is dependent on many factors, is variable depending on the processing techniques used and the source of product acquisition [9]. The available database of flavonoid content, although constantly updated, does not include many regional products and dishes, making it impossible to accurately assess the dietary content of this group of substances.

The effect of a diet containing natural sources of antioxidants probably does not equal the protective effect of supplementation. Natural foods, compared to supplements, contain antioxidants in natural proportions that can work synergistically to optimize antioxidant effects. In this context, an antioxidant-rich diet may be a nonpharmacological form of maintaining physiological antioxidant status [1].

The study led by Frączek et al. [29] showed that food rations prepared for athletes of disciplines that require maintaining low body mass, in accordance with recommendations, rich in fruit and vegetables and other products with high nutrient value, and with high content of dietary antioxidants, including vitamin C and polyphenols, ensure high antioxidant properties.

To meet antioxidant requirements, athletes should consume a diet rich in fruits, vegetables, and other plant foods that are rich in antioxidants, as well as other potentially beneficial bioactive compounds [30].

Conclusions

The results of the study showed a correlation between dietary vitamin E, C, and beta carotene content and the climbing level of the studied group of sport climbers. In comparison with the Polish population, the dietary intake of flavonoids was low.

There was no correlation between dietary energy supply and the dietary content of these components. This may indicate that the elite level climbers were characterized by great care in selecting sources of these antioxidant vitamins, and it was not energy value that determined the high supply of vitamin C and beta-carotene. We recognize it as an important finding as sport climbing is considered the discipline that requires maintaining low body mass, often accompanied by a low energy supply which creates the risk of insufficient supply of vitamins.

Emphasis should be placed on increasing natural sources of flavonoids among athletes such as tea, which is the largest and most economical source of this component, to ensure the body's natural antioxidant defense, especially during periods of increased training activity.

According to poor regulatory constrictions of commercial antioxidant supplements, emphasizing modifying nutritional habits and regular inclusion of naturally antioxidant-rich foods, such as fresh fruits, vegetables, and tea, can be the best way to increase ROS neutralization caused not only with intense training but also non-exercise related factors. At the same time, it is necessary to research the role of dietary antioxidant vitamins and flavonoids in the body's adaptation to intense training.

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