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Evaluation of the frequency of consumption of vegetables, fruits and products rich in antioxidants by amateur and professional athletes

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Ocena częstotliwości spożywania warzyw, owoców i produktów bogatych w antyoksydanty przez amatorów i zawodowych sportowców

Streszczenie

Sportowcy należą do grupy o szczególnych wymaganiach żywieniowych. Nasilona aktywność fizyczna może powodować zaburzenia równowagi oksydacyjno-redukcyjnej. Celem pracy była ocena częstości spożywania produktów spożywczych bogatych w przeciwutleniacze wśród amatorów i zawodowców uprawiających wybrane dyscypliny sportu. W badaniu wzięło udział 119 sportowców. Grupa badana składała się z amatorów uprawiający kulturystykę i CrossFit oraz zawodowych piłkarzy i szczypiornistów. Wykorzystano autorski kwestionariusz oceniający częstotliwość spożycia wybranych produktów o wysokiej zawartości przeciwutleniaczy. Najwyższa częstotliwość spożycia surowych owoców wśród amatorów wynosiła 5–6 razy w tygodniu (40,68%, *n* = 24). Profesjonaliści sportowi zwykle raportowali 1 porcję dziennie (26,67%, *n* = 16). Największa częstotliwość spożycia surowych warzyw wynosiła 2–4 porcje tygodniowo (37,29%, *n* = 22) w grupie amatorów oraz 5–6 porcji tygodniowo (33,33%, *n* = 20) w grupie profesjonalistów. Oceniono dodatkowo spożycie czerwonego wina. Większość respondentów z grupy amatorów (47,46%, *n* = 28) i profesjonalistów (41,67%, *n* = 25) nie spożywała wina. Wszyscy respondenci spożywali produkty spożywcze zawierające antyoksydanty w ilościach znacznie mniejszych niż zalecane. Uzyskane wyniki wskazują na potrzebę opracowania zaleceń żywieniowych dla sportowców w zakresie produktów żywnościowych bogatych w antyoksydanty, a także odpowiedniej edukacji żywieniowej.

Słowa kluczowe: przeciwutleniacze, częstotliwość spożycia pokarmów, sportowcy, wolne rodniki, piłka nożna, piłka ręczna, kulturystyka, CrossFit.

Abstract

Athletes belong to a group with special nutritional needs. Strenuous physical activity causes an imbalance of oxidation reduction. The purpose of the study was to assess the frequency of consuming antioxidant-rich food products among amateurs and professionals practicing selected sports. A total of 119 athletes were included in the study. The study group consisted of amateur bodybuilders and CrossFit athletes, as well as professional football and handball players. A validated original questionnaire assessing the frequency of consumption of selected high-antioxidant products was used. The highest frequency of consuming raw fruits among amateur athletes was 5-6 times a week (40.68%, *n* = 24). Sport professionals usually reported 1 serving a day (26.67%, *n*=16). The highest frequency of consumption of raw vegetables was 2-4 portions a week (37.29%, *n*=22) in amateurs group, and 5-6 portions weekly (33.33%, *n* = 20) in professionals group. In addition, we evaluated the intake of red wine. Most of the amateurs (47.46%, *n* = 28) and professionals (41.67%, *n* = 25) did not consume wine. All the respondents consumed food products containing antioxidants in quantities that were much lower than those recommended. The obtained findings indicate the need to develop dietary recommendations on antioxidant-rich food products for athletes, as well as appropriate nutritional education.

Keywords: antioxidants, food frequency, athletes, free radicals, football, handball, bodybuilding, CrossFit.

Introduction

The formation of reactive oxygen species (ROS) during exercise is a normal and necessary response to the body's adaptation to high physical load [13]. Several hundred different transcripts, including genes, are created that encode antioxidant proteins involved in oxygen transport, inflammatory and immune responses, and muscular hypertrophy during the first 24 hours after physical exercise as a consequence of the activity of reactive oxygen species [3]. On the other hand, inhibition of ROS production due to excess use of antioxidants compromises the athlete's adaptation to oxidative stress and physical exercise [12]. Normal dietary intake of products that are a source of antioxidants ensures a proper response to physical exercise. Furthermore, it eliminates the destructive effects of reactive oxygen species that can cause many diseases, such as cancer, glaucoma, or diabetes [12, 18]. Inadequate antioxidant supplementation may lead to impaired training adaptation and have a negative rather than positive impact on sport performance. A well-balanced diet is a key element and a natural source of antioxidants for athletes [12, 5, 20].

Training can have positive or negative effects on oxidative stress depending on the training load, training specificity, and the basal level of training [21]. The level of oxidative stress has varied between studies and appears to depend, among all, on the type, intensity, volume, and duration of exercise [22]. This leads to differences in oxidative status between athletes in different sport disciplines [23]. Both acute aerobic and anaerobic exercise has the potential to result in increased free radical production, which may or may not result in acute oxidative stress [24]. In order for oxidative stress to occur, ROS produced during exercise must exceed the antioxidant defense system present, resulting in oxidative damage to specific biomolecules. Different exercise protocols may induce varying levels of ROS production, as oxidative damage has been shown to be intensity and duration-dependent [25]. During low intensity and duration protocols, antioxidant defenses appear sufficient to meet ROS production, but as intensity and/or duration of exercise increases, these defenses are no longer adequate, potentially resulting in oxidative damage to surrounding tissues [26].

Aero-anaerobic type of physical activity includes more mechanisms for the production of oxidative stress [28]. Therefore, four different disciplines characterized by different types of activity were included in the study group.

Bodybuilding is a highly static activity aimed at muscle hypertrophy, characterized by anaerobic activity. CrossFit, on the other hand, is a high-intensity power training that involves mainly aero-anaerobic activities, as well as purely interval efforts, i.e., football and handball.

The purpose of the study was to assess the frequency of consuming high-antioxidant food products among amateurs and professionals performing se-

lected sports disciplines. We hypothesized that professional athletes would be characterized by a higher intake of antioxidant-containing products.

Methods

Participant Recruitment

The study included professional football and handball athletes and amateur bodybuilding and CrossFit athletes. The sports clubs included in the survey were located in the Silesian agglomeration and were selected for the study at random. The clubs' authorities agreed to conduct the survey among the players. The professional groups included players of PKO BP Ekstraklasa clubs (top Polish professional football league) and PGNiG Superliga clubs (top Polish professional handball league). The inclusion criteria for this group were 18 years of age or older and practising a professional sport of football or handball. For amateur groups, recreationally active bodybuilding and CrossFit athletes attended training sessions in 2 randomly selected gyms in the Silesian agglomeration. Inclusion criteria for amateurs group were to be at least 18 years of age, agreeing to participate in the study, and practise amateur bodybuilding or CrossFit at least 3 times a week for 60 minutes.

Outcome measures

An original questionnaire including the respondent's details and study questions was used in the study. Personal data included age (years), body height (cm), body mass (kg), as the well as type of sports discipline and practice duration. The questions included in the main part of the questionnaire referred to eating habits, which were determined by assessing the frequency of consuming selected food products considered to be sources of antioxidants. The questionnaire contained 9 questions on the frequency of consumption of food products, the questions were single choice. The athletes completed the questionnaires individually during consultations with the person conducting the survey. The time to complete the questionnaire was 15 minutes. The internal consistency, established with the use of the Cronbach’s alpha test, was 0.88.

Data Analysis

Six categories of consumption frequency (never; 1–2 portions per week; 3–4 portions per week; 5–6 portions per week; 1 portion daily; minimum two portions daily) were established to assess consumption rates for each product. Each category was assigned a rank from 1 to 6 (R) according to increasing frequency. The mean scores and standard deviation (*SD*) for the frequency of consumption

of each product and the mean rank deviation were calculated in both groups. The results obtained were analyzed statistically using Statistica v.10.0 software (StatSoft, Palo Alto, CA, USA).

Compliance of the variables with normal distribution was verified using the Shapiro-Wilk test prior to statistical testing. The Kruskal-Wallis test was used to check for equality across the groups. For the comparison of two groups (amateurs/professionals), the Mann Whitney *U* test was used. On the other hand, a non-parametric Kruskalla-Walis ANOVA was used to compare several groups (sports groups). As for correlation analysis, Spearman's correlation was used to determine the relationship between variables and training experience in the general population. The significance level was established at $\alpha < 0.05$.

Results

Participant characteristics

A total of 119 athletes were included in the study. The first group consisted of amateurs practising bodybuilding ($n = 33$) and CrossFit ($n = 26$), while the second group included professional footballers ($n = 30$) and handball players ($n = 30$). The characteristics of the study group are shown in Table 1.

Table 1. Characteristics of the study group (mean ± *SD*)

Variable	Professionals ($n = 60$)		Amateurs($n = 59$)	
	Football ($n = 30$)	Handball ($n = 30$)	Bodybuilding ($n = 33$)	CrossFit ($n = 26$)
Age [years]	23.90 ± 4.08	24.37 ± 4.15	25.00 ± 4.00	24.30 ± 3.78
Body mass [kg]	77.2 ± 4.96	81.50 ± 7.05	81.9 ± 8.89	89.69 ± 8.97
Body height [cm]	182.70 ± 6.42	184.47 ± 6.7	182.18 ± 6.38	182.61 ± 6.28
BMI [kg/m^2]	23.33 ± 1.40	24.1 ± 2.10	25.4 ± 3.40	22.11 ± 1.87
Training experience [years]	9.00 ± 1.34	7.17 ± 0.64	3.24 ± 0.32	3.00 ± 0.32

Nutritional habits

Statistically significant differences were found in the frequency of consumption of some of the products. The amateur respondents showed significantly higher intake of raw vegetables ($p = 0.02$) and steamed coffee ($p = 0.04$). The professional groups responded statistically significantly more often to the consumption of raw fruit ($p = 0.02$), red wine ($p = 0.04$), and tea ($p = 0.01$).

Raw fruit was consumed more often by the amateur groups. Most of the respondents in the professional groups declared 1 portion a day. In amateur

groups, most of the respondents declared 3–4 portions of raw vegetables a week, whereas most of the respondents in professional groups consumed 5–6 portions per week. Raw vegetable oils were usually incorporated into meals 3–4 times a week. The respondents most often consumed herbs and spices 5–6 times a week. Most of the respondents in amateur groups consumed tea 3–4 times a week, while the majority of the respondents in the professional groups did not. The majority of the respondents in both groups declared that they did not consume natural cocoa. Coffee was most often consumed by amateur athletes 1–2 times a week, while most of the professional sportspeople did not consume brewed coffee.

The analysis of the frequency of consumption of antioxidant-rich products, including mean consumption frequency ranks, standard deviations, and statistically significant differences between amateur and professional athletes practising selected sport disciplines is presented in Table 2.

Table 2. Frequency of consumption of selected antioxidant-rich products in the amateurs and professionals (mean ± *SD*)

Food products	Amateurs (*n* = 59)	Professionals (*n* = 60)	*p* value
Raw fruit (1 portion = 2 handfuls of raspberries, 2 mandarins, 1 apple, 2 kiwis, 1 orange)	3.51 ± 0.88	3.77 ± 1.29	0.02
Raw vegetables (1 portion = 1 carrot, 100 g of cauliflower, 1 tomato, ½ pepper)	4.09 ± 1.05	3.73 ± 1.13	0.02
Vegetable oils eaten raw (1 portion = 1 tablespoon of oil)	3.70 ± 1.44	3.33 ± 1.17	0.28
Herbs and spices (1 portion = 1 teaspoon of herbs or spices)	3.63 ± 1.26	3.68 ± 1.11	0.29
Red wine (1 portion = 1 glass / 100 ml)	1.93 ± 1.15	1.94 ± 0.93	0.04
Tea (1 portion = 1 mug / 200 ml)	2.98 ± 1.07	3.07 ± 1.51	0.01
Natural cocoa (1 portion = 1 drink / 200 ml, 1 spoon powder / 10 g)	1.80 ± 1.03	1.85 ± 1.27	0.42
Steamed coffee (1 portion = 1 cup / 200 ml)	2.63 ± 1.39	2.57 ± 1.74	0.04
Raw juice (1 portion = 1 glass/ 200 ml)	2.03 ± 1.13	2.27 ± 1.23	0.31

Statistically significant differences were found in the consumption of red wine ($p = 0.001$), tea ($p = 0.001$), steamed coffee ($p = 0.02$) and fresh juice

(p = 0.04) depending on the sport played. The football players consumed less red wine and more tea and fresh juice than other athletes, while the handball players consumed less steamed coffee than other athletes. The results are shown in Table 3.

Table 3. Frequency of consumption of selected antioxidant-rich products according to disciplines (mean ± *SD*)

Food products	Bodybuilding (n = 33)	CrossFit (n = 26)	Football (n = 30)	Handball (n = 30)	p value
Raw fruits (1 portion= 2 handfuls of raspberries, 2 mandarins, 1 apple, 2 kiwis, 1 orange)	3.58 ± 0.70	3.83 ± 0.51	3.42 ± 0.59	3.70 ± 0.57	0.15
Raw vegetables (1 portion = 1 carrot, 100 g of cauliflower, 1 tomato, ½ peppers)	4.18 ± 0.55	3.96 ± 0.56	3.90 ± 0.58	3.57 ± 0.69	0.12
Vegetable oils eaten raw (1 portion = 1 tablespoon of oil)	3.81 ± 0.53	3.54 ± 0.37	3.37 ± 0.46	3.30 ± 0.54	0.20
Herbs and spices (1 portion = 1 teaspoon of herbs or spices)	3.73 ± 0.57	3.31 ± 0.57	3.50 ± 0.43	3.70 ± 0.54	0.28
Red wine (1 portion = 1 lamp / 100 ml)	1.89 ± 0.20	2.00 ± 0.35	1.33 ± 0.35	2.10 ± 0.39	0.001
Tea (1 portion = 1 glass / 200 ml)	3.06 ± 0.43	2.89 ± 0.46	3.57 ± 0.49	2.57 ± 0.51	0.001
Natural cocoa (1 portion = 1 glass drink / 200 ml, 1 spoon powder / 10 g)	1.94 ± 0.27	2.89 ± 0.46	1.62 ± 0.26	1.57 ± 0.26	0.46
Steamed coffee (1 portion = 1 glass / 200 ml)	2.52 ± 0.44	2.77 ± 0.20	3.10 ± 0.32	1.97 ± 0.21	0.02
Raw juice (1 portion = 1 glass/200 ml)	1.79 ± 0.25	2.08 ± 0.24	2.70 ± 0.32	1.83 ± 0.30	0.04

There were no statistically significant differences in the frequency of consumption of antioxidant-rich products according to training experience.

Discussion

Athletes have special nutritional requirements as a number of processes in the body intensify during physical exercise. This is associated with an increased demand for energy, nutrients, vitamins, and minerals [12, 18]. The demand for

antioxidant compounds, which are a key element in maintaining body homeostasis, also increases [8, 2].

The study showed that the amateur and professional athletes practising selected sport disciplines commit many nutritional errors and do not incorporate appropriate amounts of antioxidant-rich products into their meals. The most commonly overlooked food products include raw vegetables, raw vegetable oils, herbs and spices, tea, natural cocoa, and fresh juices. Raw vegetables were consumed on average 3–6 times a week, vegetable oils 3–4 times weekly, herbs and spices 5–6 times a week. The sport amateurs consumed tea 3–4 times a week, whereas the sport professionals usually resigned from tea. The athletes usually did not incorporate natural cocoa and fresh juices into their diet.

Most studies investigating post-training regeneration in athletes tend to focus on supplementation rather than food products. It is not easy to assess the impact of food due to difficulties in grouping products based on the type and content of antioxidants. However, the protective effects of diets that contain natural sources of antioxidants are probably equivalent to or even more beneficial than those of supplements. Food contains antioxidants in natural proportions, allowing synergistic action to optimize the effects. A diet rich in antioxidants may represent a non-pharmacological and natural way to maintain physiological homeostasis [7].

When comparing the results to the food pyramid for athletes developed by the Swiss Society for Nutrition, it can be seen that the frequency of consumption of selected food products is not in line with the recommended standards [8, 2, 7]. Raw fruit was consumed in 5–6 portions a week by most of the respondents in amateur groups and 1 portion daily in professional groups, while the recommended intake is 2 portions a day. According to current recommendations, 3 servings of vegetables should be consumed daily, while our results indicate 5–6 portions a week in the professional sportsmen and 3–4 portions a week in the amateurs. The food pyramid includes recommendations on raw fat intake. The recommended amount is one serving, that is, about 10 g. Both the professional and amateur athletes practising selected sports disciplines usually consumed 3–4 servings a week. The food pyramid suggests the possibility of replacing 1 serving of vegetables or fruit with 200 ml of juice. A large proportion of the respondents (42.37% in the amateur groups and 35% in the professional groups) did not consume products from this group [16].

Cristian Petri et al. evaluated eating habits among Italian elite football players playing in the 2014–2015 season during the preparatory period, during the match season, and after the season [10]. The authors showed that their dietary habits were not in line with the recommended international guidelines. The intake of vegetables and fruits deviated from accepted standards, while the intake

of vegetable oils was considered sufficient [10]. Our findings confirm that the intake of raw oils was 3–4 servings a week in both groups.

In their work, Sousa and Teixeira presented cherries, blueberries, and pomegranate as products showing beneficial effects on changes occurring after physical exercise [14]. Cherries show anti-inflammatory properties by inhibiting cyclooxygenase-2 activity, as well as they reduce pain. The meta-analysis suggested an improvement in sport performance after incorporating cherries into the diet of athletes [14]. Hawtson et al. conducted their study in 20 recreational marathon runners, who were divided into two groups. The first group consumed cherry juice and the other group received placebo for 5 days before the marathon, on the day of the marathon and for two days after the run. Inflammation and antioxidant status were assessed before and after the race. Reduced IL-6, CRP and uric acid, an increase of approximately 10% in TAS, as well as a reduction in TBARS after 24 hours were shown in the cherry juice [4]. Abbas Yavari et al. found out that a well-balanced diet rich in natural antioxidants and phytochemicals is the best recommendation regarding antioxidant intake in athletes [6].

Practical recommendations

Regular intake of fresh fruit and vegetables, grains, legumes, and seeds is an effective and safe way to maintain oxidant balance in physically active individuals. Increased production of free radicals induced by strenuous exercise may exceed the body's defense mechanisms and promote oxidative conditions. However, both positive and negative aspects of the generation of free oxygen species in athletes are contemplated. Scientific reports presenting controversial data have been published, some authors claiming that antioxidant supplementation prevents healthy effects of physical exercise and can be harmful by delaying muscle regeneration, as well as that it may also reduce the positive effects of physical exercise on increasing insulin sensitivity [4, 19].

Vitamin C used at different doses, alone or in combination with other antioxidants, is the most widely used antioxidant [11]. The results on the protective role of the vitamin are inconsistent, and the used dose is one of the key determinants of these differences.

A dose of 200 mg/day may be considered optimal as it allows full cell saturation [1]. A diet including five to nine portions of raw or steamed fruit and vegetables, and 200 ml of fresh orange juice is able to provide the proposed 200 mg dose of vitamin C. The vitamin C intake range is 95 to 520 mg per day for male athletes [1]. Vitamin C supplementation at a dose greater than 1 g per day may induce pro-oxidative effects, as shown in a study in 23 athletes subjected to strenuous physical activity [15].

Polyphenols, such as quercetin, curcumin, resveratrol, and catechin, are an important class of antioxidants. The study was carried out in young, fit and physically active people who received 500 mg of quercetin and 250 mg of vitamin C supplementation for 8 weeks. The study confirmed a reduction in oxidative stress and increased exercise capacity [11].

Resveratrol is an example where the results of many studies show a narrow border between antioxidant and oxidant properties, both in vitro and in vivo, in acute and chronic supplementation [11]. At a dose of 100 μM, it can switch from antioxidant to pro-oxidant behavior, increasing in vitro DNA damage with intensity depending on the basic oxidative stress [15]. Our study showed that 52.54% of the respondents in the amateur groups and 58.33% of the respondents in the professional groups consume red wine.. Despite the positive effects of some compounds contained in wine, e.g., resveratrol, the beverage contains alcohol, which should be completely eliminated from the diet [11].

Ostman et al. investigated the effects of coenzyme Q10 supplementation on oxidative stress and physical performance in their randomized 8-week study. The daily dose of coenzyme Q10 was 90 mg. The other group received a placebo. The subjects were aged 19 to 44. The tests were performed before and after the intervention. No differences were found for the levels of hypoxanthine and uric acid, which are serum markers of oxidative stress [9, 17]. In the available literature, no studies on the frequency of consumption of antioxidant-rich products have been found. Therefore, the findings obtained may be of comparative value.

Study limitations

One of the limitations of the conducted research is the size of the study group; however, it should be emphasized that many exclusion criteria were defined. The limitation of the study is the lack of representativeness of players from other clubs and other sports disciplines. However, such an attempt is worth considering and such studies are planned by the authors. Surveys are subject to the risk of error; however, it should be pointed out that the authors made every effort to minimize the systematic error in the study.

Conclusions

Based on the results obtained, it was found out that both the professional and amateur athletes consumed food products containing antioxidants in quantities significantly different from the recommended ones. There were no significant differences in the intake of antioxidant-rich products depending on the sport practice or training experience. The obtained findings indicate the need to develop dietary recommendations on an antioxidant-rich diet for athletes.

STATEMENT OF ETHICS

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. The study protocol was reviewed and approved by the Bioethics Committee of the Silesian Medical University in Katowice (PCN/0022/KB/68/I/20, Katowice, Poland). All participants provided written informed consent to participate in this study.

DECLARATION OF CONFLICTING INTERESTS

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