Review article **UDC: 577.16:796**
doi:10.5633/amm.2011.0213

HYDROSOLUBLE VITAMINS AND SPORT

Vladmila Bojanić[1], Jelena Radović[1], Zoran Bojanić[2] and Marko Lazović[3]

Vitamins are organic substances needed for normal cell functioning in the human body, and therefore human health. People who train sports require an optimal psychophysical performance in order to achieve the best sports results. Athletes' needs for vitamins may be higher than in general population, also they are taking vitamin supplements more often than other people. Thus, it is very important for them to be familiar with the vitamins' roles and recommended intake levels.

Hydrosoluble vitamins are easily absorbed into the blood and excreted in urine, and so very little stored in the body. They are less likely to cause toxic effects compared to the liposoluble vitamins, but their deficiency may occur much faster. The B group of vitamins takes part in many biochemical processes, and is especially important for athletes, as these vitamins help conversion of energy from food into the muscle energy. Vitamin C is known as an antioxidant that protects against oxygen free radicals. It has a number of other roles in metabolism of carbohydrates, fats, proteins and minerals.

Athletes are likely to intake sufficient quantities of vitamins through the nutrition. Vitamins' supplements are usually unnecessary and without additional benefits on sports performance. However, if vitamins' supplements are taken, attention must be paid for their tolerable upper intake levels. *Acta Medica Medianae 2011;50(2):68-75.*

Key words: *vitamins, sport, metabolism, B group vitamins, vitamin C, coenzyme Q10*

Institute of Pathophysiology, Faculty of Medicine, University of Niš, Serbia[1]
Institute of Pharmacology, Faculty of Medicine, University of Niš, Serbia[2]
Clinic for Cardiovascular Diseases, Clinical Center Niš, Serbia[3]

Contact: Vladmila Bojanić
Institute of Pathophysiology, Faculty of Medicine in Niš, Serbia
Bulevar dr Zorana Đinđića 81, 18000 Niš, Srbija
E-mail: vladmila@medfak.ni.ac.rs

Introduction

Optimal health of the human body depends on vitamins presence. Vitamins are organic compounds with the biocatalytic functions. They take part in a large number of enzymes, and ensure normal cells functioning. Vitamins and minerals are micronutrients that work together and are required in many biological processes (1,2).

The human body is capable of depositing, to a certain extent, almost all vitamins. Hydrosoluble vitamins are absorbed directly into the blood, metabolized in the liver, but very little deposited. They are excreted in urine, and thus are less likely to cause toxic effects in contrary to the liposoluble vitamins. Fat soluble vitamins are absorbed along with fats from food and are deposited in the liver, which might facilitate hypervitaminosis occurrence. On the other hand, the hydrosoluble vitamin deficiency can occur much faster, even after few weeks or months (3).

In order to achieve the best sports results an optimal psychophysical performance is required. According to many researches, athletes' needs for vitamins may be higher than in general population. The reason for that is intense physical activity that increases energy and oxygen demand. The vitamins' needs depend on the type of sport, training intensity and load as well environmental conditions (1,2,4). Vitamin deficiency, although rare, can lead to deterioration in training and sports performance. Symptoms and signs of deficiency are numerous and may include psychical besides physical problems (2).

It is known that athletes use vitamin supplements more than other people. However, most athletes are not very familiar with the recommendations on the vitamins optimal intake, and so overuse them. Some companies that produce dietary supplements have used these facts in terms of advertising their products, without considering possible consequences of excessive intake. However, vitamins from natural foods are much better utilized than from supplements. Foods contain phytochemicals and hundreds of antioxidants that show the best action if taken together (1,3,5).

US Institute of Medicine, Nutritional Board of the National Academy of Sciences, established standards for adequate intake of all nutrients. Standards for reference dietary intake (Dietary Reference Intake - DRI) are based on the evaluation of the estimated average requirements

(Estimated average requirements - EAR), recommended daily dietary needs (Recommended dietary allowances - RDAs), adequate intake (Adequate intake - AI) and tolerable upper limits of allowed entry (Tolerable upper intake levels - ULs) (3, 6). Foods containing vitamins are shown in Table 1, while the reference dietary intake vitamins value is shown in Table 2. Pure vitamin supplements are legal and are recommended for elderly, vegetarians and females of childbearing age. It is not necessary to take more than 100-150 percent of the dietary recommendations (3,7).

Several studies have disputed the existence of significant effects of multivitamin supplements long-term use on specific laboratory tests and physical fitness (8). Supplements may be necessary for athletes who have intensive trainings. In addition to high energy expenditure, athletes also have increased production of free radicals and thus the need for antioxidant vitamins. Specifically, reactive oxygen radicals formation is greatly increased along with a strong exercise and can lead to oxidative muscle and bone damage (1-3).

The aim of our study was to examine current knowledge and recommendations on the needs of athletes in hydrosoluble vitamins, and also provide specific information regarding the necessity of vitamin supplements use. It is significant that athletes are well aware of their vitamin needs for optimal psychophysical performance and certain sports specific demands, but without toxic overdose risk or occurrence of vitamin deficiency.

Vitamin B1 (thiamine; aneurine)

Vitamins group B take part in many biochemical processes: citric acid cycle, oxidative phosphorylation, beta-oxidation of fatty acids, degradation of amino acids and the regulation of glycolysis.

Vitamin B1 in the human body is free or in monophosphate, triphosphate, or the active pyrophosphate (TPP) form. It is especially important for energetic metabolism of carbohydrates and branched-chain amino acids. Together with other B group vitamins it converts energy from food into muscle energy and heat. It is also required for bioelectric activity of cells (nerve and muscle cells), and thus the health of the cardiovascular, central nervous system, and normal bowel function (1,2,9).

Foods in which vitamin B1 is commonly found are listed in Table 1. The thiamine dietary intake recommendations of 1.1 to 1.2 mg daily may be insufficient for athletes (Table 2). Generally, it is necessary for each 1000 kcal to take about 0.5 mg thiamine, while athletes sometimes take more than 3000 kcal per day.

Table 1. Vitamins foods sources

Vitamins	Foods containing the vitamin
Vitamin B1	Whole grains cereals, fortified cereals, legumes, yeast, nuts, pork, liver
Vitamin B2	Fresh milk and other milk products, eggs, liver, meat, dark-green leafy vegetables, full grain cereals, enriched grains, fortified cereals, nuts, yeast, mushrooms
Vitamin B3	Tryptophan-rich foods: milk, eggs, poultry meat; Foods rich in niacin: whole grain cereals, enriched grains, lean meats, poultry, fish
Vitamin B4	Choline: meat, whole grain cereals, yolk, peas and legumes
Vitamin B5	In all foods except cultivated and refined: vegetable and animal fibers, liver, kidney, eggs
Vitamin B6	Foods rich in protein, liver, whole grain cereals, fortified cereals, eggs, fish, fruits and vegetables, seeds
Vitamin B7	Yolk, liver, kidney, mushrooms, dark-green leafy vegetables, tomatoes, yeast
Vitamin B9	Green leafy vegetables, whole grain cereals, oranges, bananas, lentils, seeds, wheat germ, liver
Vitamin B12	Foods of animal origin (meat, fish, shellfish, poultry, eggs, milk, cheese) and fortified cereals
Vitamin C	Fresh fruit (citrus and nuts, strawberries, mango) and vegetables (peppers, tomatoes, potatoes, cabbage, kale, green leafy vegetables)

Table 2. Dietary reference intake (DRI) and daily recommendations for athletes

Vitamins	DRI		Recommendations
	males	females	
Vitamin B1	1,2 mg	1,1 mg	1,5 - 3 mg; depending on total calories (more calories more tiamin)
Vitamin B2	1,3 mg	1,1 mg	1,1 mg / 1000 kcal
Vitamin B3	16 mg	14 mg	14 - 20 mg
Vitamin B4	550 mg	425 mg	/
Vitamin B5	5 mg	5 mg	4 - 5 mg
Vitamin B6	1,3 - 1,7 mg	1,3 - 1,5 mg	1,5 - 2 mg
Vitamin B7	30 µg	30 µg	30 µg
Vitamin B9	400 µg	400 µg	400 µg
Vitamin B12	2,4 µg	2,4 µg	2,4 - 2,5 µg
Vitamin C	90 mg	75 mg	200 mg

That is why they are advised to double their usual intake, with the upper limit intake of 3 mg. Also, higher carbohydrates intake requires a greater vitamin B1 amount. Foods rich in carbohydrates are usually rich in thiamine, and athletes who eat a lots of this food every day, probably add thiamine in larger amounts than recommended (1,4).

Intense physical activity increases the need for vitamin B1. When necessary, vitamin status improvement can be achieved after vitamin intake for a long period of time, because taking over a short time period has no effect. There is an increased need in persons engaged in sports that require good coordination (4).

Due to its role in energy production, it was assumed that thiamine deficiency can cause a reduced ability to perform physical activity by disorders of carbohydrate metabolism and lactic acid accumulation (10). Several studies have examined the effect of vitamin B1 supplementation on physical activity. Suzuki and Itokawa (11) found that high doses of thiamine (100 mg/d) significantly reduced feeling of fatigue after a short workout. Also, there is an improved neurologic control of motor movement in the shooting after supplementation. However, supplementation did not affect the sports performance of people with adequate thiamine status after intensive exercise (12).

Currently, there are no specific recommendations for vitamin B1 in athletes. Also, hypovitaminosis was not recorded in them. Hypovitaminosis occurs in alcoholics, or due to low quality diet based on processed and unenriched cereals (1).

Vitamin B2 (riboflavine; lactoflavine)

Vitamin B2 participates in normal cell functioning through its coenzyme flavin adenine dinucleotide and flavin-mononucleotide (1, 2). As a catalyst for redox reactions it has an essential role in energy production and glucose, fatty acids, glycerol and amino acids metabolism. Vitamin B2 is important in formation of other vitamins and their coenzymes (13).

There is evidence that physical activity increases the need for vitamin B2, but not more than 0.6 mg per 1000 kcal. According to the evidence, besides the recommendation that riboflavin supplements can be taken for 1.6 to 3 mg a day, some studies favor higher vitamin intake for athletes (1, 14). It has not been shown that greater amounts of the recommended cause clear symptoms and signs of hypervitaminosis. Symptoms of riboflavin deficiency are rare in developed countries, except in chronic alcoholics, and were not recognized among athletes (1,2).

There are no specific directions for riboflavin intake in athletes. Due to increasing energy consumption and its incorporation into new muscle tissue it is assumed that physical activity requires greater amount of this vitamin. Some authors propose it to athletes involved in endurance sports (2,13). Also, there is evidence that the needs of females who practice, or are on weight loss programs, range from 0.63 to 1.4 mg per 1000 kcal. However, for now, there is no proof that sports performance is enhanced by higher intake than RDA (1,15).

Vitamin B3 (niacin; vitamin PP)

Niacin comprises two compounds: nicotinic acid and nicotinamide, both required for synthesis of the coenzyme nicotinamide adenine dinucleotide and nicotinamide adenine dinucleotide phosphate. They are found in approximately 200 enzymes, especially dehydrogenases (1, 2, 16). Niacin participates in carbohydrates, protein and fat metabolism, energy production and glycogen synthesis. It can be synthesized in cells of the human body from tryptophan, that is found in all high-quality protein foods (60 mg tryptophan gives 1 mg of niacin) (Table 1). Most people meet defined recommendations, specifically 12-14 mg daily, or 6.6 niacin equivalents per 1000 kcal. Niacin equivalent corresponds to 1 mg of niacin or 60 mg dietary tryptophan (1).

There were no cases of niacin deficiency in athletes. Deficiency is seen in people suffering from hunger and on uniform grains food. Excessive intake can cause poisoning. The first signs of niacin toxicity are red and flushed skin, and later may cause liver damage and gastrointestinal problems. The upper intake limit for niacin is 35 mg daily and refers to niacin in supplements and fortified foods. There is no evidence that niacin in natural foods causes side effects (1,2).

Studies have shown that niacin supplementation in athletes leads to a decrease in overall endurance performance. It has been proven that excessive amounts cause a reduction of fat metabolism by blocking the release of free fatty acids from adipose tissue, that provides the energy to the muscles during exercise (9). This condition leads to increased use of carbohydrates as energy sources, and since the reserves of glucose and glycogen in the muscles are limited, there is an early exhaustion of the reserves and consequently reduced endurance (1,17).

There is no evidence that the needs of niacin increase during physical activity (1,2). Despite this, some authors recommend that athletes take higher doses. Also, the International Olympic Movement (IOM) approves at least 10% increase in niacin intake, in order to increase energy utilization and physical strength of athletes who exercise intensely, although there is no supporting experimental evidence (4,18).

Vitamin B4 (choline)

Choline is an amine, present in different foods and all natural fats contain it, mostly in the form phosphatydilserine or lecithin. It is grouped in the B group vitamins and in 1998 was classified as an essential nutrient by the IOM (18).

It is involved in acetylcholine synthesis and release, and its low levels in nervous system lead to a fatigue. Choline participates in neural control of muscle movement, has a role in maintaining cell membranes structure, stimulates transmembrane signalling and lipid and cholesterol metabolism (18).

A significant reduction of choline concentrations is described in marathon participants. Theoretically this vitamin supplementation can prevent weakness and fatigue caused in these people. However, there are no clear findings that increased intake has a positive effect on overall athletic performance (2, 3). For his role in the transport of fat from the liver, symptoms of choline deficiency may be the fat accumulation in the liver and its damage. Also, diets deficient in choline can cause damage and apoptosis of peripheral lymphocytes (36). On the other hand, large doses of choline (5-10g daily) are associated with serious side effects: nausea, diarrhoea, lowered blood pressure and dizziness, increased sweating, etc. Therefore, the upper limit for choline intake is set to 3.5g daily (2,18).

Vitamin B5 (pantothenic acid)

This vitamin is a structural component of coenzyme A (CoA) and plays an important role in energetic metabolic pathways of carbohydrates, fats and proteins. CoA has the function in the synthesis of cholesterol, acetylcholine, phospholipids and porphyrin ring of haemoglobin and myoglobin. The lack of it is rare, because of large distribution in foods (1,18).

The effect of pantothenic acid on sport performance is questionable, since there are studies that found a positive effect on sport performance (29) and studies that did not (30). Supplements typically contain 10mg of pantothenic acid, which is two times more than the DRI, but without reported toxic effects. According to some studies (22), this amount is too excessive and not recommended. Toxic effects are possible from large quantities, so one must take into account the amount of supplements. There is currently no direct evidence of pantothenic acid beneficial effects on training, as well specific directions for athletes (1,2).

Vitamin B6

Vitamin B6 is referred to a group of compounds: pyridoxine, pyridoxal, pyridoxamine and their 5-phosphate derivatives. Pyridoxal 5-phosphate (PLP) is a metabolically active vitamin form. As a coenzyme, PLP plays an important role in the metabolism of amino acids and proteins. Also, it is necessary for glycogen break down in muscle, and gluconeogenesis (1,2). It has a function in the synthesis of serotonin from tryptophan, the neurotransmitter involved in muscle relaxation, then in forming of sphingomyelin, nucleic acids, haem and niacin. For its role in synthesis of a large number of proteins it might be necessary for the production of muscle proteins, significant for successful sports activity (2,16).

There is an increased vitamin B6 need for higher protein intake. Adults need 0.016 mg/g protein per day. Usually, food rich in proteins is also sufficient in vitamin B6 (Table 1). Additional needs of athletes are possible if they consume purified protein supplements (1,19).

Theoretically, vitamin B6 can be related to the success in sport. Specifically, it has a role in amino acids and glycogen degradation, during which energy needed for muscular activity is released (20). In addition, the vitamin is component of enzymes that convert lactic acid into glucose in the liver, and is associated with growth hormone production, that may affect increase in muscle mass (21). According to some studies, athletes may be susceptible to a lack of vitamin B6 and the consequent deterioration of athletic performance (22).

Some sports supplements producers advertise vitamin B6 as a natural and allowed substance for sports performance improvement. However, most athletes on a balanced diet fulfil, at the same time, adequate doses of this vitamin. Those who could potentially have problems usually do not consume adequate amounts of nutrients. Also, some athletes are involved in sports where low weight is desirable, and in such cases, athletes should get enough energy nutrients rather than supplements. Higher vitamin B6 intake than required does not improve athletic performance (1).

There is currently no specific recommendations about the vitamin B6 intake for athletes. Excessive doses can be toxic, and symptoms are similar to the chronic deficiency symptoms: peripheral neuropathy, ataxia, depression and seizures. Toxic effects were not seen when the vitamin is taken from food, but with high doses of supplements. Therefore, the IOM set the upper intake limit to 100 mg per day (1,2).

Vitamin B7 (biotin)

Biotin is a vitamin that contains sulphur in its structure. It builds four carboxylase coenzymes (acetyl-CoA, pyruvate, propionyl CoA and beta-methycrotonyl-CoA carboxylase) responsible for the initiation of fatty acids synthesis, glycogen synthesis and amino acids metabolism (18). Also, with magnesium and ATP, it plays a significant role in the metabolism of carbon dioxide and gluconeogenesis (1,2,22).

Generally, all foods are poor in this vitamin (Table 1). As it is synthesized by bacteria of the gastrointestinal tract, the lack of it is rare. Deficiency is possible after taking large amounts of egg albumen containing avidin that binds biotin and disrupts its metabolism. There is no evidence that athletes are exposed to the lack of biotin and that there is a link between biotin and sports results. Therefore, there are no recommendations for an increased intake compared to the DRI (1,2).

There is a possibility that biotin has an effect on physical activity through the participation in energy metabolism. For now, there are no studies of biotin supplementation and athletic results, side effects are unknown, and so that the upper intake limit is not set (2).

Vitamin B9 (folic acid)

Structural forms of folate are dihydrofolate acid and tetrahydrofolate acid, biologically active folate coenzyme in the body. The coenzyme role is to receipt one carbon unit, usually created in amino acids metabolism. The main vitamin function is in amino acids metabolism and nucleic acid synthesis (18). It is required, together with vitamin B12, in the normal erythrocytes synthesis and megaloblastic anaemia prevention. Inadequate folate status increases the risk of cardiovascular disease and fetal growth disorders (1,2).

Folic acid is widely distributed in food (Table 1), 85% is bioavailable from foods, and 50% from folate. The recommended dietary intake is expressed in dietary folate equivalents, based on the bioavailability of synthetic folic acid that is higher than the natural. Dietary folate equivalent corresponds to 1 μg folate from food, 0.6mg of folate from fortified foods or supplements in addition to taking food, or 0.5mg of folate supplements on an empty stomach. In recent years, many grain products have been enriched with folic acid, with 140 μg of folate per 100g food. The risk of toxicity is low, but still the upper limit of 1000 μg/d is set for fortified foods or supplements, regardless of folate from natural foods (1,2,18).

Research results are limited and correlation between folic acid intake and sport achievements has not been found yet. However, there are justifications for optimal intake of this vitamin in athletes, for possible trauma in some sports, or increased rate of regeneration in damaged tissue and increased erythrocytes production (1,2). Ziegler et al. (27) reported that 20% of ice skaters (n=18) had lower serum folate levels than normal. In the study of Mattera et al. (28), 33% of females in the marathon (n=85) had reduced concentrations of serum folate. However, their success did not change after the vitamin supplementation, although the haematological parameters improved.

There are no specific guidelines for athletes related to folate. Although there is no evidence of improved athletic performance, athletes need to increase the folate intake to prevent anaemia, especially females. A lot of fresh fruits and vegetables in diet are recommended, but if this is a problem, supplementation of the DRI is approved (400 μg daily) (1,2).

Vitamin B12 (cobalamin)

Vitamin B12 form a group of cobalamin compounds, those are cyanocobalamin, hydroxocobalamin and two cofactors, adenosylcobalamin and methylcobalamin. Cyanocobalamin and hydroxocobalamin are converted in the human body in the co-enzymes, and are used as a dietary vitamin B12 supplements. Cobalamin is required in most cell functions and is particularly important in DNA synthesis, erythrocytes formation, folic acid metabolism and nervous system development. It also participates in protein synthesis and metabolism of lipids that make up myelin sheath (1,2).

Vitamin B12 is found predominantly in animal foods, while there is almost none in plants (Table 1). The lack of cobalamin, or folic acid, leads to the megaloblastic anaemia. Anaemia definitely affects sport performance, reducing the transmission of oxygen and aerobic capacity and deteriorates muscle coordination. There are no data on vitamin B12 deficiency in well-trained athletes (1,2,9).

The triathlon study in male and female athletes (23) determined that 45% of females and 30% of males consumed vitamin B12 in less than the recommended daily dose, although 40% of participants were taking the vitamin supplements. In study by Keith et al. (24) over 33% (n=23) of trained cyclist had taken a lower vitamin B12 doses than recommended, but only one had less serum levels of vitamins than normal. There are known cases of vitamin B12 misuse when athletes self-injected large doses of vitamin just before the competition. But there was no evidence that these excessive doses enhanced athletic performance (25).

For now, there is no evidence that cobalamin supplementation has an effect on sport performance. Vegetarians are a specific population at risk for hypovitaminosis, and the vitamin supplements of 1.8 to 2.4 μg or fortified foods are approved. Supplementation is advised in older athletes, as well as in athletes with inherited poor vitamin absorption (1, 2, 26).

Vitamin C (ascorbic acid)

Vitamin C is known as an antioxidant that protects against oxygen free radicals by donating electrons. There is evidence that vitamin C is involved in regeneration of other antioxidants (vitamin E) (3). It has a number of other roles: synthesis of neurotransmitters, cholesterol and hormones, fatty acids metabolism, formation of connective tissue collagen and cement substance. Also, iron metabolism is influenced by vitamin C, and its deficiency can cause anaemia and fatigue. Because all of this, optimal vitamin C status is necessary in athletes (1,2,9).

The best vitamin sources are fresh fruit and vegetables (Table 1). DRI for vitamin C is 75 to 90 mg per day and doses of 100 to 200 mg meet the needs of the body. Hypovitaminosis vitamin C almost does not exist (18). On the other hand, chronic toxicity due to increased intake is possible, as more people consume large amounts of the vitamin (1000 to 2000 mg daily). Adverse reactions were observed at doses over 3000 mg a day (31). When taken in large doses it may cause a predisposition for kidney stones, create tolerance, headaches, deep vein thrombosis, gastrointestinal problems, etc. (1,4). Moreover, some studies have reported increased iron absorption and overload, decrease in the concentration of vitamin B12 and copper levels, and increasing demands for oxygen, but these effects have not been clearly defined. Therefore, the upper limit is set to 2000 mg daily (2,31).

Association between vitamin C and sports achievement was questioned in a number of studies. Effect on sport performance did not have doses of 500 mg/day or less, while the immediate dose intake before testing showed improvement in strength, and maximal oxygen demand reduction, but without affecting the final result (32). Under the same conditions for 7 days, improved muscle strength was noticeable, but cardiovascular endurance decreased. After taking 2000 mg of the vitamin, sport performance showed no change while aerobic capacity was reduced. Because of its role in reparation of collagen fibers vitamin C improves repair of damaged tissue. It is assumed that athletes who practice contact sports would have benefit from slightly higher intake of this vitamin. Muscle pain diminishes after moderate doses of vitamin C and other antioxidants (1,33).

There are no precise recommendations for vitamin C supplementation in athletes, although it is the most commonly consumed supplement. Because higher concentrations of vitamin C can cause problems with endurance, intake level should be below the upper limit (1,2). It is believed that physically active people have adequate concentrations of vitamin C in plasma (9). Athletes on sufficient and balanced nutrition add lots of fruits and vegetables, and therefore, enough of this vitamin. Vitamin deficiency was observed in wrestlers, basketball players and gymnasts, and this might worsen their results (34, 35). In cases where intake of fruit and vegetables is problematic, supplementation within the DRI may be recommended.

CoQ10

Coenzyme Q10 is a lipid with vitamin characteristics and is referred to as an antioxidant. It can improve oxygen transport in cardiac cells mitochondria, thus is used in cardiovascular diseases treatment. Theoretically, with improving oxygen intake in heart and skeletal muscles endurance and sports performance can be enhanced. There are few studies of the vitamin supplementation effects, however, no performance improvements are proven in athletes compared to general population (3,37).

Conclusion

In addition to numerous roles in maintaining health, vitamins are essential for optimal psychophysical athlete's performance and for achievement of the best sport results. They are important for proper energy production, muscle work, and protection from adverse metabolic products of intense physical activity. Athletes are likely to intake sufficient quantities of vitamins through nutrition. Supplementation is usually unnecessary and most studies show no additional beneficial effect on sports performance in people who are not deficient in vitamins.

Vitamin supplementation is recommended for athletes who do not feed properly for various reasons, or due to the nature of their sport. In these cases, athletes must carefully take into account the warnings of the vitamins tolerable upper intake levels. For all these reasons, the best choice is a balanced diet that provides an adequate calories intake, containing a variety of foods rich in vitamins and minerals..

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HIDROSOLUBILNI VITAMINI I SPORT

Vladmila Bojanić, Jelena Radović, Zoran Bojanić i Marko Lazović

Vitamini su organske supstance neophodne za normalno funkcionisanje ćelija ljudskog organizma i time ljudskog zdravlja. Osobama koje se bave sportom potrebna je optimalna psihofizička spremnost radi postizanja najboljih sportskih rezultata. Potrebe sportista za vitaminima mogu biti veće nego u opštoj populaciji. Takođe, oni uzimaju vitaminske suplemente mnogo češće nego drugi ljudi. Zbog toga je za njih važno da budu upoznati sa ulogama vitamina i njihovim preporučenim nivoima unosa.

Hidrosolubilni vitamini lako se apsorbuju u krv i ekskretuju u urin, te tako veoma malo deponuju u telu. Manje je verovatno da izazovu toksične efekte u poređenju sa liposolubilnim vitaminima, ali se njihova deficijencija može pojaviti mnogo brže. Vitamini grupe B učestvuju u mnogim biohemijskim procesima i posebno su važni za sportiste, jer pomažu prevođenju energije iz hrane u mišićnu energiju. Vitamin C je poznat kao antioksidant koji štiti od slobodnih kiseoničnih radikala. Takođe, on ima i brojne druge uloge u metabolizmu ugljenih hidrata, masti, proteina i minerala.

Sportisti uglavnom uzimaju dovoljne količine vitamina putem ishrane. Vitaminski suplementi obično nisu neophodni i ne pružaju dodatnu korist spremnosti sportista. Međutim, ako se vitaminski suplementi koriste, mora se obratiti pažnja na njihovu gornju granicu unosa. *Acta Medica Medianae 2011;50(2):68-75.*

***Ključne reči**: hidrosolubilni vitamini, sport, metabolizam, vitamini B grupe, vitamin C, koenzim Q10*