# IS VEGAN DIET APPROPRIATE FOR COMPETITIVE ARTISTIC GYMNASTS?

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*Review article*

***Abstract***

*The majority of scientific evidence strongly associates a well-planned vegan diet with health, a successful control of body weight, a preventive measure, and, in some cases, with the termination and the reverse of the most common chronic non-communicable diseases, such as cardiovascular diseases, type 2 diabetes, certain cancers, and some other diseases. Numerous athletes have accepted these findings and adopted this lifestyle choice. Furthermore, the athletes choose well-planned vegan diet with the intention of optimizing their athletic abilities. The position of The British Dietetic Association (BDA) and The Academy of Nutrition and Dietetics (AND) on the vegetarian diet states that well-planned vegetarian diets, including the vegan diet, are healthy and nutritionally adequate and appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence and older adulthood. What is more, AND repeats its view from nearly ten years ago on the appropriateness of the vegan diet for the needs of athletes. The aim of this article is to justify the appropriateness of a well-planned vegan diet for the needs for competitive artistic gymnasts and to do so with a relative scientific transparency.*

***Keywords:*** *vegan diet, gymnasts, health, body weight, athletic abilitie.*

## INTRODUCTION

With a constant increase of scientific evidence that support the health benefits of a well-planned vegan diet, there is also a growing number of people who decide on this type of diet (Melina, Craig & Levin, 2016). With appropriate nutrition and a generally healthy lifestyle (absence of smoking, regular physical activity, a controlled alcohol intake) we can prevent 90% of type 2 diabetes, 80% of cardiovascular diseases, 70–90% of strokes, and 70% of bowel cancer (Willet, 2002) or 90–95% of all cancers (Anand et al., 2008). Vegan diets have been associated with lowering overall and ischemic heart disease mortality, supporting sustainable weight management, reducing medication needs, lowering the risk for most chronic diseases, decreasing the incidence and severity of high-risk conditions, including obesity, hypertension, hyperlipidemia, and hyperglycemia, certain types of cancer, and even possibly reversing advanced coronary artery disease and type 2 diabetes (Hever &

Cronise, 2017; Melina, Craig & Levin, 2016). The evidence shows that vegan diets can lower the risk of coronary artery diseases by 40%, cerebral vascular diseases by 29%, and the onset of the metabolic syndrome and type 2 diabetes by 50% (Rizzo, Sabaté, Jaceldo-Siegl & Fraser, 2011). Potential mechanisms for the mentioned effects are an increased intake of fiber, antioxidants, and plant-based proteins on one hand and a reduced intake of saturated and total fats, dietary cholesterol, and a lower caloric intake on the other hand (Kahleova, Levin & Barnard, 2017).

With the increasing interest in the potential benefits for health due to vegan diet, this topic also became interesting for the researchers, who studied the effect of different vegetarian diets on weight control, recovery after training, and sports performance. Physical efficiency is a broad term, yet researchers usually study the influence of nutrition on various motor skills, such as power, speed, and endurance, while they usually do not measure the influence of different diets on balance or flexibility (Craddock, Probst & Peoples, 2016). A balanced nutrition on one side and an absence or restriction of the intake of substances in the food that are harmful for health on the other side are crucial not only for the athlete's health but also for the recovery after training or performance, the support during physical preparation, and for preventing injuries. A well-designed vegan diet (Fuhrman & Ferreri, 2010) may present a nutritionally adequate diet that provides energy, maximizes performance, offers resistance to illnesses (not being absent on trainings or competitions), enables a simple control of appropriate body weight while enjoying regular meals to full satiety, and offers an efficient recovery after repeated daily strains. Certain nutrients (Melina, Craig & Levin, 2016) are less present in a vegan diet than in a diet that includes animal source foods, e.g. protein, saturated fats, zinc, vitamin D, and vitamin $B_{12}$, but the manifestation of nutritional deficiency is no more distinct with the vegetarian population than with people with a mixed diet. In this article, the authors will justify why a well-planned vegan diet, supplemented with vitamin $B_{12}$ and most likely also with long chains of omega-3 fatty acids (EPA, i.e. eicosapentaenoic acid and DHA, i.e. docosahexaenoic acid), is a healthy and a nutritionally adequate diet, especially for a competitive gymnast, despite some concerns in the professional public about the appropriateness of a vegan diet for an athlete.

This article is the first attempt of a comprehensive overview of the potential appropriateness of a well-planned vegan diet for the needs of a gymnast due to the long-term health and sport performance that they are faced with (e.g. appropriate control of body weight, optimizing athletic abilities, efficient recovery, nutritional adequacy, etc.). Numerous experts (coaches, nutrition experts, physicians) received an education that talked about a balanced mixed diet, following moderation in everything, and enjoying less food and training more in order to be healthy and achieve appropriate body weight control. In addition, a lot of university professors still lecture their students solely on this outlived paradigm of a healthy lifestyle as the only healthy and officially accepted possibility on one side while usually stigmatizing the vegan diet on the other (e.g. that it is dangerous, nutritionally inadequate, hard to implement, still without reliable scientific evidence, etc.). There exists a problem of a lack of awareness of the current scientific evidence about well-planned vegan diet, since the majority of the scientific evidence about the positive effects of a well-planned vegan diet was only researched in the last 10 to 20 years. Therefore, it is hard to communicate to people (and athletes) objective information that helps them make an informed decision. Frequent concerns of the appropriateness of the vegan diet can, on the other hand, also result from the expected behaviors and norms, or in other words old habits (it is difficult to change dietary patterns), as well as personal strain and conflict of interests, often wrongly associating a well-planned vegan diet with an inappropriately structured vegan diet where the motive for this type of diet can often also be associated with the ideology (ethical, environmental, and philosophical standpoints). Despite the urgent need of well-designed randomized controlled studies, the authors wish to contribute to changing the conservative thinking about the possibilities of a healthy and for sports performance appropriate diet for a gymnast by providing an overview of scientific evidence about the vegan diet, the publications of standpoints of some health and dietetic authorities about the vegan diet, and finally the examples of good practice of vegan athletes. The aim of this article is also to encourage researchers to decide on executing well-designed short-term and long-term clinical researches of a well-planned vegan diet on gymnasts, especially in relation to other dietary patterns.

***The starting point of nutritional needs and the state of artistic gymnast's eating habits***

When talking about competitive gymnasts and the potential appropriateness of a vegan diet, we must keep in mind that their gymnastic development starts quite early (Burke, 2007; Sands et al., 2016), that the majority of gymnasts are female[1], and that, especially elite female gymnasts, often end their career in late teenage years or early 20s (Atiković, Delaš Kalinski & Čuk, 2017; Louer, Elferink-Gemser & Visscher, 2012), while many of them remain involved in different roles in the world of gymnastics (Ba, Jakše, personal communication, November, 2016). We cannot ignore the fact that competitive gymnastics is, among other things, a sporting discipline "for life" and that gymnasts are first and foremost people, so it is only ethical that they do not achieve their goals in sport at the expense of their long-term health (Jakše & Jakše, 2017). Besides the basic energy, motor, and cognitive requirements for a successful sports performance of a gymnast on individual gymnastics tools and in all-around gymnastics, we must also recognize the needs of a successful recovery after every training in the various eras of periodization[2]. The absence of injuries is generally the basis of every successful development of the athlete and competitive gymnasts can often experience delayed onset muscle soreness or DOMS, various chronic tendon inflammations, and repetitive injuries due to repeated extreme burdens on the musculoskeletal system. A successful performance on the floor, the pommel horse, the rings, the vault, the uneven and parallel bars, the balance beam and the horizontal bar (Sleeper, Kenyon, Elliot & Cheng, 2012) requires a number of motor skills, such as speed, strength, endurance, agility, flexibility, and balance, while the level of gymnast's skills is tightly associated with the absence of injury. Appropriate body weight, excellently developed motor skills, and a high level of various perceptual abilities enable the gymnasts to control their posture while executing demanding elements, despite the fact that they cannot completely rely on their eyesight (personal experience of one of the authors, who is a former successful competitive gymnast). Because competitive gymnastics demands a combination of explosive and submaximal muscle contractions when executing numerous demanding elements, there is also a relatively high heart rate (from 170–190 beats/min with women and from 150–180 beats/min with men). Due to repetitive gymnastics elements with short breaks (lasting up to 90 seconds), competitive gymnastics primarily includes anaerobic metabolism (average assessment is 80% of energy requirements) and blood lactate concentration between 8 and 11 mmol/l. The performance on the floor can be an

[1] E.g. data for Portugal for the year 2012 shows that from the sample of 14742 gymnasts from all gymnastic disciplines 81.2% are female and only 16.7% are male (Silva & Barata, 2016). In the USA (USAGym, 2016) there are over 5 million registered gymnasts over the age of 6 and the majority of them are female (76%).

[2] Elite competitive gymnasts usually train 2 times a day from 1 to 4 hours per training and they have one day off in a week. A typical amount of training usually consists of 10–20 hours per week, while the preparations for an important competition may include even 30–40 hours of training per week (Burke, 2007).

exception in certain cases, because there remains a possibility that the gymnast will reach up to 85% of maximal oxygen consumption (Marina & Rodríguez, 2014).

Based on the stated, the appropriate eating habits are very important for effective trainings and a successful performance in competitions. Due to repeated trainings, gymnasts usually train in a constant state of exhaustion, using their physical and cognitive abilities to extreme capabilities. Muscle and nervous system fatigue can weaken the immune system and general health, despite the potentially sufficient glycogen stores, especially due to caloric restriction with the intention of maintaining appropriate body weight. This can lead to a less effective recovery, an increased possibility of injuries, and a lower quality of trainings. All this can at some point complicate the ability to effectively control the appropriate body composition, especially with the need of simultaneous maintenance of high level of motor skills (Batatinha et al., 2013; Coelho, Gomes, Ribeiro & Soares, 2014; Dallas, Dallas & Simatos, 2016). A well-planned vegan diet, especially in its unrefined form, can be low in energy and without nutritional inadequacy, even without the control of the quantity of the portion, while in the case of greater energy needs (e.g. training on the floor) a well-planned vegan diet can be enriched with more calorically-dense refined or minimally refined foods that enable the body a sufficient energy and micronutrient intake and consequently a more efficient recovery after practice or performance. Burke (2007) lists a literature review of the actual intake of energy and nutrients in different age groups of competitive gymnasts, include elite ones, and compares them with the recommended daily intake. The author notes that numerous researchers report, in addition to energy and fluid inadequacy of the gymnasts' diet, on the micronutrient inadequacy for calcium, zinc, iron (below 70% of RDI), and a number of vitamins. In one of the more recent researches that evaluated the dietary intake and the body composition of female gymnasts, the researchers measured nutritional inadequacy of 67 elite rhythmic gymnasts with the average age of 18.7. The examined gymnasts had a low mean intake of carbohydrates (below the minimum recommended level of 55%) and a low intake of micronutrients, such as pantothenic acid, folate, vitamins D, E, and K, and of minerals, including calcium, iron, and magnesium (Silva & Paiva, 2015). Eating disorders (ED)[3], which are proven to be associated with hormonal imbalance (reproductive disorders), are more frequent with female athletes in aesthetic sports than in endurance and team sports (Torstveit & Sundgot-Borgen, 2014). Estimates of incidence of eating disorders, which can have negative, sometimes even fatal, consequences on health as well as on physical performance, reach up to 62% with female athletes and 33% with male athletes (Bonci et al., 2008). Competitive gymnastics holds the highest percentage of eating disorders among all sporting disciplines (Coelho, Soares & Ribeiro, 2010; Rosen & Hough, 1988). In older researches, Rosen and Hough (1988) even found that 75% of female gymnasts admitted to using inadequate weight loss methods. In one study (Andersen & Petrie, 2012) researchers surveyed 414 National Collegiate Athletic Association (NCAA) Division-I female athletes from 26 universities, who participated in either gymnastics (n=280) or swimming/diving (n=134), to examine the prevalence of clinical and subclinical EDs as well as the extent of pathologic eating (binging) and weight control methods (purging, vomiting, dieting). 65% of the surveyed gymnasts were found to be asymptomatic, 28.9% of gymnasts subclinical and 6.1% as having EDs. We can only speculate what percentage of these cases manifests into a mental disorder later in life, after the

[3] Eating disorder (ED) in athletes is characterized by a wide spectrum of maladaptive eating and weight control behaviors and attitudes. These include concerns about body weight and shape; poor nutrition or inadequate caloric intake, or both; binge eating; use of laxatives, diuretics, and diet pills; and extreme weight control methods, such as fasting, vomiting, and excessive exercise (Bonci et al., 2008).

finished period of competing, due to different pressures of the environment and the expected behavior. One of the more recent studies also examined the nutritional status of two elite female artistic (18.5 years) and rhythmic gymnasts (16.1 years) who were randomly selected among 20 eligible members of the Greek national team. Using a 7-day weighed food record protocol, the researchers found that only vitamin C, zinc, and vitamin B6 exceeded the daily recommended amounts for an artistic gymnast athlete, whereas the calcium intake was insufficient and had the highest deviation from the recommended daily amounts. The study also showed a large energy deficit during the training of the athletes, where one of the athletes presented a strong predisposition to nutritional risk factors, pathological eating behavior, and negative emotions with both the external appearance and body weight (Dallas, Dallas & Simatos, 2016). The assessed eating habits of female gymnasts in scientific literature are by no means optimal, which is why it is worth considering the potential appropriateness of a well-planned vegan diet as one of the possible forms of dieting for a competitive gymnast.

### *The content of vegan diet*

The concept of vegan diet (Williams & Patel, 2017) can have very different definitions in scientific literature; from excluding all animal source foods to including "only" a greater intake of vegetables, fruit, fruit juices, cereals, and legumes, while still excluding the intake of fish, pork, and yoghurt. Some vegan diets reduce or exclude even the intake of highly refined plant-based food, e.g. white flour, sugar, and vegetable oils. Other scientific publications categorize vegan diets by its actual content, e.g. semi-vegetarian (typically western nutrition with a small part or frequency of consuming animal source foods), pesco-vegetarian (consuming seafood with or without eggs and dairy products), lacto ovo-vegetarian (consuming eggs and dairy), and vegan diet (no animal source foods). Unfortunately, the dichotomous division to vegetarian and non-vegetarian diet does not offer an overall insight into the quality of diet. Williams and Patel (2017) continue that a plant-based diet, which includes whole-grain cereals as a basic source of carbohydrates, unsaturated fats as the dominant source of dietary fats, an abundance of fruit and vegetables, and an adequate intake of omega-3 fatty acids, can have a decisive influence on the prevention against cardiovascular diseases and numerous other chronic diseases. Strict vegan diet, often referred to as "plant-based diet" (Ostfeld, 2017), includes minimally processed fruit, vegetables, wholegrain cereals, legumes, nuts, seeds, herbs, and spices, while it excludes all animal source foods, including red meat, pork, fish, eggs, and dairy. The recommended well-planned vegan diet, as it is usually defined by some advocates of a vegan diet[4], usually contains the following macronutrient balance: 10–15% fat, 10–20% protein, and 70–80% carbohydrates (Esselstyn et al., 2014; McDougall et al., 2014; McMacken & Shah, 2017; Ornish et al., 2005). Other advocates of the vegan diet are more inclined to define the diet based on the content or plant-based food groups and the frequency or the consumed portions in a day. This makes it easier for people to successfully implement the well-planned vegan diet in order to improve their health (Fuhrman & Singer, 2015; Hever & Cronise, 2017) and achieve more effective trainings and recovery and resistance to illness (Fuhrman & Ferreri, 2010). If we wish to talk about dietary intervention and therapeutic or sports effects of the vegan diet, the term "vegan diet" is simply not representative enough, since it can include too many highly refined and caloric foods, such as vegetable oils

[4] Scientists, doctors, and dietetics, who in their clinical researches and practices use terms such as "plant-based", "starchy", "low-fat", or "nutrient-dense, plant-rich diet" to describe nutrition, usually do not wish to declare themselves as advocates of vegan diet. Their view on the frequently used and generally accepted term "vegan diet" is primarily associated with the credibility of scientific evidence and not so much with personal, ethical, environmental, and philosophical views, even though they can be noble and important for humanity.

(sunflower, olive, pumpkin oil), exotic fats (coconut and palm fat, cocoa)[5], refined cereals, highly refined packaged food, too much salt, refined sugar, and so on, which can completely change the nutritional composition of the diet and, consequently, the effect on the body. A well-planned vegan diet does not only include the absence of animal source foods but also a much larger intake of fruit, vegetables, nuts, and legumes in comparison with other non-vegetarian and vegetarian diets (Tantamango-Bartley et al., 2016). A "well-planned" also means that we take into account the macronutrients and micronutrients, which should be adjusted according to the individual's needs (Kahleova, Levin & Barnard, 2017). The term "well-planned vegan diet" is in this article associated solely with the context of scientific evidence or the effects on human health and the potential appropriateness for the needs of a competitive gymnast. In this article, the term "well-planned vegan diet" replaces the terms "plant-based diet" or "whole food plant-based diet", which are frequently used even in scientific literature and which more clearly define the level of whole or refined plant-based foods.

### *A well-planned vegan diet is high in carbohydrates*

When talking about a well-planned vegan diet, we cannot ignore the fact that the main source of calories are carbohydrates (usually from 70–80% of all calories), which can be found in cereals, legumes, fruit, and vegetables. Researches about cereals (wheat, oats, brown rice, etc.) consistently show that they are beneficial for health. Two systematic reviews and meta-analyses (Chanson-Rolle et al., 2015; Ye, Chacko, Chou, Kugizaki & Liu, 2012) have unequivocally demonstrated that consuming cereals is inversely related with the state of being overweight and with reducing the risk of type 2 diabetes and the risk of cardiovascular diseases. The same is true of legumes, where a 20-gramme intake per day can reduce the mortality rate by 8%, while their consumption is considered the most important global dietary predictor of longevity (Dermadi-Blackberry et al., 2004). The next carbohydrate food is potato, which is often regarded as the main culprit for the epidemic obesity and type 2 diabetes, but is usually not controlled in scientific researches due to different ways of preparation (roasting and frying with the use of vegetable oils or by adding butter or margarine). Potato has been an important food in the nutritional system of numerous cultures for centuries and is today, at a global level, the most widely used food, not counting cereals (rice, wheat, and corn). An overview of 13 researches about the influence of potato on obesity (5), diabetes (7), and cardiovascular diseases (1) has shown that consuming fried potatoes is associated with obesity and type 2 diabetes, whereas the researchers have not found that association with potato as a food (Borch et al., 2016). Veronese et al. (2017) have confirmed the findings of the overview of researches that, due to the inappropriate way of preparation, the problem lies in French fries, not the potato as a food. White potato is a nutrient rich food, while sweet potatoes of different kinds are even more so (Bovell-Benjamin, 2007; Drenowski, 2013). The potato offers a significant amount of important nutrients in a small number of calories and it also contains numerous substances that are good for the human health and have been proven to improve the lipid profile, the glucose in the blood, and blood pressure (Visvanathan, Jayathilake, Chaminda Jayawardana & Liyanage, 2016). It is most likely unnecessary to lose words over the usefulness and health effects of a regular consumption of fruit as the next

[5] An overview of researches studying the effect of dietary fats on cardiovascular diseases, performed by the American Heart Association (AHA), showed that reducing or replacing saturated fats (found in animal source foods, vegetable oils, and exotic fats) with polyunsaturated and monounsaturated vegetable oils, but not with refined carbohydrates, lowers the incidence of cardiovascular diseases and other major causes of mortality (Sacks et al., 2017). Consuming vegetable oils (e.g. olive oil) and exotic fats (e.g. coconut fat), which are most refined and caloric foods, is scientifically proven to be potentially harmful to optimal health (Blankenhorn, Johnson, Mack, el Zein & Vailas, 1990; Eyres, Eyres, Chisholm & Brown, 2016; Rueda-Clausen et al., 2007; Sacks et al., 2017; Vogel, Corretti & Plotnick, 2000).

food group that includes carbohydrates. Despite that, Jenkins et al. (2001) measured the effect of consuming 20 portions of fruit daily in a period of two weeks and measured a decrease in lipids and blood pressure and an increase in the volume of feces. Similar positive benefits to health also occur when consuming nuts, which – in addition to other nutritients (protein, primarily unsaturated fats, fiber, minerals, phytonutrients, etc.) – contain complex carbohydrates. An overview of researches and their analysis showed that their consumption could support cardiovascular health (Freeman et al., 2017). For a competitive gymnast this kind of dietary pattern is potentially optimal in all respects, because it allows them to eat tasty food to full satiety with every meal. A simple control of energy intake, with a "spontaneous" caloric restriction and without nutritional inadequacy, allows them to eat unrefined (unprocessed or minimally processed) plant-based food. With greater energy needs (e.g. training on the floor), a competitive gymnast can choose from a number of ways to increase the energy adequacy of vegan diet (Venderley & Campbell, 2006), e.g. with more frequent meals and snacks and by including highly concentrated carbohydrates (spaghetti, bread, polenta, dried fruit, fruit juices, honey, marmalades) and high-fat, unrefined and fermented plant-based foods (avocado, nuts, seeds and their spreads, tofu, and tempeh).

### *Nutritional adequacy of a vegan diet*

The Academy of Nutrition and Dietetics (AND) states that a well-planned vegetarian diet, including vegan diet, is healthy and nutritionally adequate and appropriate for all stages of life, including pregnancy and lactation, infancy, childhood and adolescence, and also for athletes (Melina, Craig & Levin, 2016). Vitamin $B_{12}$ probably deserves the greatest attention in the vegan diet. It is not synthesized by plants or animals, even though it can be found in animal source foods (formed by the intestinal bacteria in the large intestine). In their diet, vegans need a reliable source of vitamin $B_{12}$, which can be consumed with conventional foods enriched with vitamin $B_{12}$ (twice a day) or with a dietary supplement, in quantities of 500–1000 mg several times a week (Melina, Craig & Levin, 2016). Despite the dietary pattern, the recommended intake of a reliable source of vitamin $B_{12}$ also applies to people older than 50 years, due to the weakened ability of the cleavage of vitamin $B_{12}$ from the binding proteins (impairment of protease and stomach acid), to people with intestinal abnormalities, e.g. with Crohn's disease and ulcerative colitis, and to people using certain medications for lowering stomach acid, lowering blood sugar levels, etc. (NIH, 2016; USAIM, 1998).

Based on the Healthy Eating Index and the assessment of the Mediterranean diet, which were tested on 1475 subjects (104 vegans, 573 vegetarians, 498 semi-vegetarians, 145 pescatarians, and 155 people with a mixed diet), a group of researchers (Clarys et al., 2014) assessed that the vegan diet is the "most" healthy diet (the lowest energy and protein intake, a better profile of the consumed fats, and the highest intake of fibers), while the mixed diet received the lowest grade from both indicators of the quality of diet. In a 22-week long, randomized controlled study, Turner-McGrevy et al. (2008) divided 99 people with type 2 diabetes into two groups, where one of them followed a vegan diet and the other followed recommendations of the American Diabetes Association (the ADA diet). Researchers measured the quality of the diet assessed by the Alternate Healthy Eating Index (AHEI)[6], where a lower AHEI score is strongly negatively associated with the risk of major chronic

[6] The AHEI is a nine-component dietary index used to rate foods and macronutrients related to the risk of chronic diseases. AHEI scores were calculated for each participant based on food categories, including vegetables (servings per day), fruit (servings per day), nuts and soy protein (servings per day), the ratio of white to red meat (grams), cereal fiber (grams per day), trans fat (percent of energy), and the ratio of polyunsaturated to saturated fatty acids (grams). Each of these categories received a score ranging from zero to ten. A higher score is associated with a lower risk of developing a major chronic diseases and cardiovascular disease, but not most cancers.

diseases and cardiovascular diseases, but not most cancers. The vegan group improved every AHEI food category, including the fact that they consumed significantly more vegetables, fruit, nuts, soy protein, and dietary fibers and less common, saturated and trans fats, while also achieving a better ratio between polyunsaturated and saturated fats. Based on the fact that the group with the ADA diet did not improve the AHEI result, the authors conclude that a long-term low-fat vegan diet can be associated with a significantly lower risk of chronic diseases, especially cardiovascular ones. Ma et al. (2007) have studied the AHEI, this time as a useful tool in grading various popular methods for weight loss, namely Glucose Revolution, Weight Watchers, Atkins, South Beach, Zone, Ornish, and 2005 US Department of Agriculture Food Guide Pyramid (2005 Food Guide Pyramid) diet, which maximize two things: weight loss and a prevention against cardiovascular diseases. The quality of diet was the highest with the Ornish vegan diet (result 64.6 out of 70 possible), while other low-carb diets had AHEI between 42.3 and 50.7 and Food Guide Pyramid 48.7. In the largest prospective research of the vegan diet (Nurses' Health Study, Nurses' Health Study 2, and Health Professionals Follow-up Study), Satija et al. (2017) studied the association between different qualities of vegan diet with the incidence of cardiovascular diseases. The vegan diet was divided into three index levels; overall plant-based diet index (PDI), healthful plant-based diet index (hPDI), and unhealthful plant-based diet index (uPDI). They found that a healthier vegan diet (whole-grain cereals, legumes, fruit, vegetables, nuts, tea) is associated with a lower risk of cardiovascular diseases and type 2 diabetes, while the less healthy vegan diet (fruit juices, refined cereals, unhealthy preparation of potato, sweets) and consuming animal source foods are associated with a higher risk. An analysis of the vegetarian dietary pattern for the control of body weight on 13,292 adults, including 851 vegetarians, showed that vegetarian diets are nutritionally adequate and are therefore recommended for weight control without compromising the quality of diet. Due to the used method of this research, we must put the results into context (defining who is vegetarian, a one-day questionnaire about diet). However, even with a caloric restriction of 500 calories less than the estimated energy requirement, vegetarians still had a nutritionally adequate diet, which showed as a greater intake of fibers, vitamin A, C, and E, folates, calcium, magnesium, iron, and potassium and a lower intake of total and saturated fats and dietary cholesterol when compared with non-vegetarians. Meanwhile, the intake of protein with vegetarians was consistent with the recommended (Farmer, Larson, Fulgoni, Rainville & Liepa, 2011). As long as the diet is adequate in energy, the risk of a potential lack of protein, iron[7], calcium, or essential fatty acids is low and there are no scientific reports about these shortages for any of the natural human diets (Millward, 1999, in McDougall & McDougall, 2013). Protein deficiency is most likely not a concern for anyone in the developed world. It is almost impossible to consume too little protein, no matter what you eat, unless your diet is significantly deficient in calories or if you consume too much junk food (nutritionally empty food). As a reply to the letter by McDougall and McDougall (2013) with the title Plant-Based Diets Are Not Nutritionally Deficient, Tuso, Ismail, Ha, and Bartolotto (2013) wrote an original article, stating that it is true that a healthy vegan diet enables an optimal amount of the majority of needed nutrients. However, as not all individuals will adhere to a good diet, it is important that the authors warn about the potential shortcomings from a clinical perspective, even if these risks are small. A well-planned vegan diet, contrary

[7] Even though numerous cohort researches (e.g. Clarys et al., 2014; Shridhar et al., 2014) state that vegetarians, and especially vegans, have a greater intake of iron than people who eat meat, an overview of 27 crossover and 3 intervention studies on the status of iron among vegetarians showed that vegetarians have lower body iron stores in comparison with people who eat meat, which can potentially increase the risk of anemia (Haider, Schwingshack, Hoffmann & Emekcioglu, 2016).

to common beliefs, is not associated with a lack of protein intake or with the need for a conscious combination of plant-based foods (AHA, 2014; Golden, 2002; Mclaren, 1974; Young & Pellett, 1994; Waterlow, 1984). Although marketing and education usually focus on animal sources of protein, it is scientifically unequivocal (Young & Pellett, 1994) that all essential amino acids derive from a bacterial synthesis and synthesis in plants, which means a person can conveniently obtain them through plant-based foods.[8] The greatest research today, which studied the adequacy of protein intake among vegans, compared the nutritional profile of approximately 30,000 non-vegetarians, 30,000 different vegetarians, and 5,000 strict vegans, and discovered that vegetarians and vegans consume 70% more protein than is needed,[9] while non-vegetarians consume even more (Rizzo, Jaceldo-Siegl, Sabate & Fraizer, 2013).

Omega-3 fatty acids are the next essential nutrient that is sometimes seen as problematic in vegan diet. Under the term “omega-3 fatty acids” we usually think of the essentially short chain of omega-3 fatty acids (ALA), which the body converts into SDA (i.e. *stearidonic acid*) and long chains (EPA and DHA) of omega-3 fatty acids[10]. ALA can be found in flaxseeds, hemp seeds, and chia seeds, in walnuts, soya, and, in smaller amounts, also in dark green vegetables, e.g. Brussels sprouts, spinach, and sea vegetables. SDA can be directly consumed with blackcurrant, hemp seeds, or fish, while EPA and DHA are present in marine microalgae and plankton and also in fish that feed on marine microalgae, e.g. salmon, sardines, tuna, mackerel, and others (Saunder, Davis & Garg, 2013). According to AND, a person may already consume the RDI of ALA with one spoon of flaxseeds and chia seeds, and partly by eating dark green vegetables and various berries (Vannice & Rasmussen, 2014). The conversion from ALA into EPA and DHA is slow and inefficient and generally depends on heredity, gender, age, and dietary patterns (Saunder, Davis & Garg, 2013). Clinical studies have shown a potential inadequate or inefficient conversion[11], which results in the current consensus of health authorities that recommend daily intakes of EPA and DHA ranging from 250 to 550 mg/day for adult males and non-pregnant/non-lactating adult females (Flock, Harris & Kris-Etherton, 2013; Harris et al., 2009). Meanwhile, Simopoulos (2007) states, based on the available scientific evidence, that it is recommended for most athletes to consume omega-3 fatty acids in quantities of 1–2 g of EPA and DHA daily in the ratio 2:1, which should, with the changes and improvements in the background diet, prevent the inflammation in muscles and joints. For the needs of EPA and DHA, the vegan diet can be supplemented with laboratory-grown seaweed. From the standpoint of clinical efficiency, it is comparable with fish oil, without any traces of industrial chemicals (Doughman, Krupanidhi & Sanjeevi, 2007) and signs of digestive problems (diarrhea) or any consequences of the taste of fish after consumption (burping) or belching (Neff et al., 2011).

[8] The American Heart Association (AHA, 2014) states that it is not necessary to consume animal source foods in order to get enough protein. Plant-based protein can provide enough essential and non-essential amino acids on its own, as long as we consume various sources of protein and the caloric intake is large enough to cover the individual’s energy needs. Wholegrain cereals, legumes, seeds, and nuts include both, essential and non-essential amino acids. There is no need to consciously combine these foods (“complementarity” of proteins) with every meal.

[9] The RDA of protein is the same for all types of nutrition, although some experts recommend a 10% greater intake of protein for adults and 15–20% for children older than 6 years, as a compensation for a decreased absorption of plant sources of protein due to fibers (Melina, Craig & Levin, 2016). Vegetarian athletes were advised to increase their protein intake by 10% to 1.3–1.8 g/kg bodyweight/day for aerobic and strength sports (Agnoli et al., 2017).

[10] EPA and DHA are not technically “essential” because they can be produced endogenously, but the process is slow and inefficient and is affected by genetics, gender, age, and dietary composition (Saunder, Davis & Garg, 2013).

[11] The researchers discovered that a low-fat diet enabled a higher percentage of conversion of ALA into EPA and DHA compared with the high-fat diet (Raatz, Bibus, Thomas & Kriss-Etherton, 2001). However, in one of the researches (Kornek, Kucharska & kamela, 2016) vegans had almost a 40% higher intake of ALA than non-vegetarians.

Competitive gymnasts also face the problem of a potential lack of vitamin D[12]. Vitamin D, or calciferol, is also known as the "sunshine vitamin" because it is the only nutrient that is acquired from the sun. Although vitamin D is classified and treated as a fat-soluble vitamin, it is actually a prohormone produced in the skin upon exposure to ultraviolet B sun radiation and then activated by the liver and kidneys (Hever, 2016). Sources of preformed vitamin D can be found in natural sources of food, e.g. when consuming fatty fish, fish liver oil, egg yolk, milk, enriched with vitamin D, and so on (Ross, Taylor, Yaktine & Del Valle, 2011). Adequate vitamin D and calcium[13] intake are important for bone mass accrual and long-term skeletal health. Lovell (2008) measured the status of vitamin D in 18 Australian competitive gymnasts, aged 10 to 17, and found that 15 of them had a lower content of serum vitamin D when compared with the current recommendations (75 nmol/l), while 6 of them had values even lower than 50 nmol/l. The American Institute of Medicine (USAIM) recommends 600 IU of vitamin D from a source of dietary supplement as a preventive measure for bone health to all adults who get little or no exposure to the sun. This would help them achieve 50 nmol/l of vitamin D in the blood, thereby meeting the needs of 97.5% of the population (Ross et al., 2011) or 1100 IU of vitamin D per day (up to 4000 IU without credible evidence about the side effects), achieving 75–110 nmol/l of vitamin D in the blood. Based on intervention studies, this still has proven positive effects on certain types of cancer (colorectal cancer, breast cancer, ovarian cancer, lymphoma) or, in other words, a longer life expectancy (Bischoff-Ferrari et al., 2010; Keum & Giovannucci, 2014). Sensible sun exposure can provide an adequate amount of vitamin $D_3$, which is stored in body fat and released during winter, when vitamin $D_3$ cannot be produced. An individual who is exposed to sunlight (arms, legs, and face) twice a day, from 10 AM to 3 PM, from 5 to 30 minutes (depending on time of day, season, latitude, and skin pigmentation), gets the adequate amount of vitamin D. For light-skinned people 5 to 10 minutes are quite enough, while dark-skinned need at least 30 minutes. We must emphasize that excessive exposure to sunlight, especially when it causes sunburn, will increase the risk of skin cancer. Thus, sensible sun exposure and the use of supplements are needed to fulfill the body's vitamin D requirements (Holick, 2007). In the end, we are faced with the problem of an institutionalized lifestyle and, in some places, a lower exposure to sun, which is also associated with the geographical area with a lower or higher UV index, especially in autumn, winter, and early spring (from October to March), when the day is shorter and the clock shifts to winter time. With gymnasts the problem lies in daily trainings in the gym and the daily rest between two trainings, which can be spend more or less institutionally. The scientific public often mentions the potential introduction of a screening test to measure the possible lack of vitamin D. USAIM and numerous osteoporosis societies do not recommend the screening test because the costs of the tests are incomparable with the benefits (which may not be relevant for athletes). The values in the blood of healthy people can already be improved by mere exposure to sunlight or by consuming a responsibly prescribed dietary supplement. Furthermore, the test is not reliable and the results are very fluctuating (Fuleihan et al., 2015). In one of the studies, the researchers sent one blood sample into testing to 1090 different laboratories around the world and

[12] The incidence of vitamin D deficiency in elite gymnasts is up to 83% (Lovell, 2008; Willis, Peterson & Larson-Meyer, 2008).

[13] Calcium, a macromineral, is the most abundant mineral in the human body. Excellent plant sources of calcium include leafy green vegetables as well as fortified plant milks, calcium-set tofu, dried figs, sesame seeds and tahini, tempeh, almonds and almond butter, oranges, sweet potatoes, and beans. However, because bone metabolism is multifactorial and complex, it is important to emphasize the consumption of ample sources of calcium as well as vitamins K and $B1_{12}$, fluoride, magnesium, phosphorus, and potassium in order to maintain serum vitamin D levels and to ensure consistent exercise. Many variables affect calcium levels via absorption or excretion, including overall calcium consumption, age, phytates, oxalates, serum vitamin D levels, and the intake of sodium, protein, caffeine, and phosphorus (Hever, 2016).

the results about the vitamin D content varied between 20 and 100 nmol/l (Lucas & Neale, 2014).

### *Vegan diet and health*

Vegan diet is becoming more and more popular due to the increasing amount of scientific evidence about the beneficial effects on numerous health conditions. Vegetarians and vegans have a lower risk of certain health conditions, including ischemic heart disease, type 2 diabetes, hypertension, certain types of cancer, mortality for any reason, and obesity. A low intake of saturated fats and a high intake of vegetables, fruit, wholegrain cereals, legumes, soy-based food, nuts, and seeds (all rich in fiber and phytonutrients) are characteristic of vegetarian and vegan diets, resulting in a lower total and LDL cholesterol and a better control of blood sugar (Melina, Craig & Levin, 2016). These factors contribute to a lower risk of chronic diseases. In a scientific overview of the most common ways of dieting, authors concluded that the majority of scientific evidence strongly associates vegan diet with health and prevention against a wide range of health conditions, while also offering advantages for other beings, the environment, and ecology (Katz & Meller, 2015). Well-planned vegan diet is nutritionally adequate, safe, affordable, and has the potential to end the epidemic of cardiovascular disease (Esselstyn Jr., Gendy, Doyle, Golubic & Roizen, 2014; Ornish et al., 1998) and cancer[14], the first two causes of death.

Besides a lower risk of cardiovascular diseases and certain types of cancer, type 2 diabetes, and some other chronic diseases (Hever & Cronise, 2017; Melina, Craig & Levin, 2016), science also associates vegan diet with a successful control of body weight (Barnard, Levin & Yokoyama, 2015; Huang, Huang, Hu & Chavarro, 2016; Turner-McGrievy, Mandes & Crimarco, 2017), with a reverse of progressive cardiovascular diseases (Esselstyn Jr., Gendy, Doyle, Golubic & Roizen, 2014; Ornish et al., 1998), with a reverse of type 2 diabetes (Anderson & Ward, 1979; Barnard et al., 2009; Dunaief, Fuhrman, Dunaief & Ying, 2012), with a reverse of the early stage of prostate cancer (Ornish et al., 2005), etc., which significantly lowers the need for medication (Hever & Cronise, 2017) and most likely increases longevity (Orlich et al., 2013; Ornish et al., 2013). Numerous reputable researches, such as the EPIC Oxford, Adventist Health Study 1 and 2[15], and GEICO Study (Wirnitzer et al., 2016) and an overview of researches (Dinu, Abbate, Gensini, Casini & Sofi, 2016) have shown that vegans have the lowest incidence of cardiovascular diseases and cancer. A research by Loma Linda University (Adventist Health Study 2), financially supported by the American National Cancer Institute (NCI), has shown that vegans not only have a lower ITM and a lower incidence of type 2 diabetes and other chronic diseases, but also a longer life expectancy (9.5 years for men and 6.1 for women) in comparison with people with a mixed diet (Orlich et al., 2013).

### *100% vegan diet or mixed diet with less animal source foods and more fruit and vegetables*

A Swedish research (Bellavia, Stilling & Wolk, 2016) on 74,646 men and women tried to answer the frequently asked question whether a greater intake of fruit and vegetables, while simultaneously consuming meat, acts as a counterbalance to the increased risk of cardiovascular disease

[14] Two systematic reviews and meta-analyses of researches (Dinu et al., 2015; Yokoyama, Levin & Barnard, 2017) showed that vegan diets are associated with a lowest risk of incidence of all types of cancer and lower values of lipids in comparison with a mixed diet.

[15] According to the EPIC Oxford and AHS-2 research, vegans consume more fiber, vitamin C and E, folates, magnesium, iron, copper, and polyunsaturated fats, while people who eat meat consume more protein, total, saturated, and trans fats, vitamin $B_2$, $B_{12}$, and D, zinc, and iodine (Wirnitzer et al., 2016). The research is all the more important because it included a "well-planned" mixed diet (a lot of fruit and vegetables) and a poorly planned vegan diet (28% of all calories from the source of fats – a well-planned diet has up to 15%, 28 g of fiber – a well-planned diet has at least 45 g, and 54% of all calories from the source of carbohydrates – a well-planned diet has at least 70%).

and premature mortality. Researchers discovered that people who consume more red meat suffer a 29% greater risk of premature mortality due to cardiovascular diseases (21% of all-cause mortality) than those who enjoy less red meat. The research showed that even the greatest intakes of various fruit and vegetables did not cancel the negative effect of meat and, consequently, the increased risk of death due to cardiovascular diseases. The authors concluded that there remains an increased risk with the intake of red meat and with a low, middle, or high intake of fruit and vegetables, including the lowest intake of red meat (on average 30 grams per day). So far, a group of researchers from Taiwan offers us the best answer to the question "Where is the limit of enjoying animal source foods without the potential 'significant' negative influence on the human health?" Chiu et al. (2014) compared two equally health-conscious groups that consumed traditional Asian food (cereals, vegetable, soy, nuts), where one group consumed strictly plant-based food and the other group "occasionally" consumed meat and meat products (women once a week and men twice a week). They discovered that, despite observing the ITM and other factors, the group that consumed only small amounts of meat (which is still seen as primarily vegan diet, since the women consumed meat and meat products once a week, which is approximately 3% of the meat and meat products that a typical European woman consumes, and men consumed it twice a week, which is approximately 5% of the amount that a typical European man consumes) had a higher degree of type 2 diabetes than the group that did not consume meat (without the case of diabetes). On the other hand, Singh et al. (2014) researched (Adventist Mortality Study and Adventist Health Study 1) how a change in diet from vegetarianism (no meat) to non-vegetarianism (a weekly consumption of meat) affects weight gain, type 2 diabetes, cardiovascular diseases, and life expectancy. People who changed their diet from vegetarian to non-vegetarian (consuming meat at least once a week) have been exposed to an increased risk of weight gain, diabetes, and heart attack in a period of 17 years, while their life expectancy lowered for 3.6 years in a period of 12 years.

### *Vegan diet and athletes*

AND states that well-planned vegetarian diets, including vegan diets, are healthy and nutritionally adequate and appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence and older adulthood, and for athletes (Melina, Craig & Levin, 2016). The Italian Society of Human Nutrition (Agnoli et al., 2017) also states that well-planned vegetarian diets, as well as the vegan diet, are compatible with successful athletic performance. Numerous former and current top athletes, e.g. Tony Gonzalez (American football), Carl Lewis (sprinter and long jumper), Scott Jurek and Brendan Braizer (triathlon), Kenneth Williams (bodybuilder), Novak Djoković and Venus Williams (tennis), Mac Danzig and David Haye (martial arts), Salim Stoudamire and Marc Gasol (basketball) and others, are proof that the highest achievements in competitive sports can be achieved or maintained even without consuming animal source foods (Fuhrman & Ferreri, 2010; Gatto, 2016; GreatVeganAthletes, 2017; McDougall, 2015; Tachdjian, 2017; Viva, 2017). At this point we must emphasize that the diet of these athletes is most likely also supported by specific supplementation, so their diet does not rely exclusively on conventional plant-based sources of food (author's assumption). According to the typical modern diet of athletes in power sports, we would expect that the athletes in ancient Rome (gladiators) consumed high-protein food. However, the analysis of their bones reinforced the hypothesis that their diet was actually vegan and that 78% of all calories came from a source of carbohydrates, primarily from wheat and barley (Curry, 2008; Longo, Spiezia & Maffulli, 2008;

Losch, Moghaddam, Grossschmidt, Risser & Kanz, 2014). Science has also documented a number of successful endurance and ultra-endurance athletes with a vegan diet, so we can therefore conclude that a well-planned and a potentially supplemented vegetarian or vegan diet with high nutrient density successfully and efficiently supports the factors that have an effect on the immune system and a successful endurance and ultra-endurance performance (Wirnitzer et al., 2016). Excellent Kenyan runners are a good example of "vegan" endurance athletes, since they consume 90% of caloric intake from plant-based foods or, to be more exact, 75% of all calories from a source of carbohydrates, 15% from a source of dietary fats, and 13% from a source of protein – 1.6 grams on kilogram of bodyweight (Christensen, Van Hall & Hambraeus, 2002). The same applies to Ethiopian endurance runners (Beis et al., 2011), whose diet consists of 88% of plant-based foods; 65% of all calories comes from a source of carbohydrates, 23.3% from a source of dietary fats (73% plant-based), and 12.4% from a source of protein (76% plant-based). In a cross-over study, Lynch, Wharton, and Johnston (2016) examined 70 endurance athletes; 27 vegetarian ones and 43 athletes with a mixed diet, aged 21–58 (average of 35 years), who competed on a national university level or have prepared themselves for a greater endurance competition, such as a marathon, triathlon, cycling race, and so on. The results of the research have again shown that vegetarian diets offer adequate support for the development of strength and cardiovascular development in sports, while vegan diet, with a higher intake of carbohydrates, fiber, and iron in comparison with vegetarian diet, can even present an advantage in supporting cardiovascular endurance. Well-planned vegetarian and vegan diet that is highly nutritional and properly supplemented with certain dietary supplements can adequately support the nutritional needs of an athlete, which affect the sports performance (Rodriguez et al., 2009) of e.g. a tennis player, basketball player, skier, football player (Fuhrman & Ferreri, 2010). Numerous researches have shown that the identified shortages of certain nutrients are more a problem of poorly planned meals than vegan diet as such (Katz & Meller 2015; Leitzmann, 2005; Nieman, 1999; Rogerson, 2017). One of the last overviews of research (Craddock, Probst & Peoples, 2016), which compared the influence of vegetarian and mixed diet on sports performance, analyzed 7 randomized controlled studies and 1 cross-over study (3 for muscular strength, 4 for anaerobic and aerobic performance, and 1 for immune parameters). The researchers discovered that vegetarian diet is not associated with a worsened or improved sports performance, which is consistent with the results of an overview of 17 researches almost 20 years ago (Nieman, 1999), which were not included in the abovementioned 7 studies. With a strategic selection and management of food choices, with special attention to the achievement of energy, macro and micronutrient recommendations, and with an appropriate supplementation a vegan diet can satisfactorily achieve the needs of most athletes (Rogerson, 2017). Having said that, it is important to emphasize that there exists a great need for well-planned randomized controlled studies that would compare the long-term effects of a vegan diet on sports performance, the immune system, weight control, and health in comparison with athletes with a mixed diet. Based on the stated, we can conclude with great certainty that, as long as a well-planned vegan diet presents results in representative aerobic and anaerobic individual and group sports, it is most likely also appropriate for a competitive gymnast.

### *Animal-based and plant-based proteins*

Different types of protein (animal-based vs. plant-based) have different effects on the human body. Animal-based proteins, not plant-based (Chen et al., 2016), are associated with an increased risk of chronic diseases, such as kidney disease (Haring et al., 2017), cardiovascular disease (Richter, Skulas-Ray, Champagne & Kris-Etherton, 2015), type 2 diabetes (Sluijs et al., 2010), and cancer (Levine et al., 2014). On the other hand, consuming plant-based proteins reduces the lipid concentration in the blood, the risk of increased weight and obesity and cardiovascular diseases, while also having an anti-inflammatory and anti-carcinogenic effect (Kahleova, Levin & Barnard, 2017). The relative protein restriction of conventional plant-based proteins, especially methionine, leucine, and tryptophan, which is traditionally seen as a restriction of vegetarian or vegan diets, is today recognized as potentially beneficial for mechanisms associated with health, slower aging, and longer life expectancy (Hever & Cronise, 2017; Levine et al., 2014; McCarty, Barroso-Aranda & Contreras, 2009).

All plant-based foods include proteins, but in different amounts. According to dry weight, the majority of proteins in plant-based foods can be found in legumes, which contain the same (if not a higher) amount of proteins compared with animal source foods, while also lacking sodium and saturated fats (Freeman et al., 2017). In general, consuming plant-based proteins results in a lower synthesis of muscle proteins in comparison with the same amount of animal-based proteins (Wilkinson et al., 2007; Yang et al., 2012), which is supposedly due to the differences in protein metabolism, amino acid composition, and the absorption of amino acids (van Vilet, Burd & van Loon, 2015). Here, the content of the amino acid leucine is particularly important, since it is seen as the strongest trigger of protein capacity that influences the synthesis of muscle proteins (Philips, 2016). The majority of the more representative plant-based proteins (van Vilet et al., 2015) has a leucine content of approximately 7–8% of the total content of proteins (with the exception of corn that has 12.2%), while most of the more frequently used animal-based proteins usually contain 9–10% of the total content of proteins (whey even contains 13.6%). Studies that compare different proteins according to their weight (e.g. grams per gram) do not necessarily offer us a complete understanding of the topic, since some studies have shown that a greater content of "low-quality" proteins, especially in the form of a dietary supplement, can result in a comparable muscle growth as with "high-quality" proteins (Babault et al., 2015; Joy et al., 2013). This may indicate that the key is the correct amount or mixture of amino acids and not the source of protein (plant or animal) in itself. Van Vilet et al. (2015) state that this realization can result in the use of many strategies in sports practice, among other things adding individual amino acids to plant-based proteins in the form of a dietary supplement, e.g. methionine, lysine, and/or leucine, by consuming greater amounts of plant-based sources of protein, or by consuming more plant-based sources of protein, which can ensure a more balanced profile of amino acids.

### *Protein dietary supplements of animal or plant origin*

Supplementing a diet with proteins in the form of dietary supplements is one of the popular choices, yet theoretically unnecessary for the majority of athletes who follow a well-planned vegan diet (and especially the ones following a mixed diet), especially when they pay attention to an adequate energy intake and the frequency and amount of the intake of representative plant-based foods with a greater content of protein. Due to numerous myths (complete proteins, recommended needs, biological value, the speed of absorption, etc.), athletes very much like to consume animal-based proteins (which are very concentrated) and more often also animal-based and plant-based proteins in the form of dietary supplements. The most commonly used sources are whey and casein when it comes to animal-based proteins and soy, rice, pea, and hemp proteins when it comes to plant-based proteins. With this they easily exceed the necessary (and for the body still safe) amount of protein.

Regardless of certain doubts about nutritional adequacy, the professional public is well aware of the positive effect of a well-planned vegan diet and, with it, the intake of proteins from unrefined plant-based sources of protein. On the other hand, the effect of refined plant-based proteins is little less known; that is in the form of dietary supplements, e.g. pea, hemp, wheat, and other protein concentrates and isolates. A high intake of proteins, rich in essential amino acids, especially from animal sources (milk and dairy, meat and meat products, fish), and soy proteins (soy milk and soy tofu) most likely increase IGF-1[16] (Dewell et al., 2007). Some interventional studies (Dewell et al., 2007; Li et al., 2008; Ornish et al., 2005) performed on patients with prostate cancer show that plant-based sources of protein in a minimally refined and processed form (e.g. tofu) or in the form of a dietary supplement (e.g. soy isolate) with a low-fat vegan diet are not associated with the effect of excessive increase of the hormone IGF-1. The results of Ornish et al. (2005) have shown that an additional increase of soy isoflavones (soy tofu, flaxseeds) and soy proteins in the form of dietary supplements (soy isolate) in a low-fat vegan diet (10% of calories) did not significantly affect the IGF-1 of patients with prostate cancer, despite the increased total intake of proteins (from 80 grams daily or 16% of calories before the intervention to 115 grams daily or 20% of calories during the intervention; the fiber intake increased from 31 to 59 grams daily) in a period of one year and in the context of a greater change in lifestyle (physical activity, relaxation techniques, support group). In addition, the researchers measured a decrease of prostate cancer for 70%, which indicates that a low-fat diet and physical activity most likely lower the effect (increase IGF – binding protein level) of a potential increase of IGF-1 due to consuming soy isolate, which has a higher value of essential amino acids (Dewell et al., 2007). These results are consistent with the results of Li et al. (2008) who performed a low-fat and high-fiber dietary intervention (15% fat, 5–8 portions of fruit and vegetables, and 8–11 portions of cereals and flakes), adding 40 grams of soy protein isolate, on 40 cancer patients (26 in the intervention group and 14 in the control group) who had undergone radical prostatectomy. They discovered a decrease of the serum IGF-1 from the initial 260 ng/ml to 221 ng/ml by the end of a 6-month intervention. It seems that both the quantity and the amino acid distribution of dietary protein determine whether IGF-1 production is overstimulated and these results imply that the soy protein (supplemental or unrefined and minimally refined), though it may raise IGF-1 levels, is still not as detrimental to health as animal proteins. Saxe et al. (2001) carried out a 4-month dietary intervention with a vegan diet on 10 men who underwent radical prostatectomy, where the cancer has already metastasized (PSA was increasing), and discovered that the dietary intervention worked (it slowed the progress) with 8 out of 10 patients and even reversed the course of the disease with three of them. Patients who had the highest intake of dietary fibers had the best PSA results. Teixeira et al. (2004) examined the effect of consuming soy protein isolate in patients with nephropathy and type 2 diabetes and discovered that consuming soy isolate improves numerous factors that are beneficial for patients with nephropathy and type 2 diabetes, while consuming casein (milk protein) worsens them.

A protein dietary supplement is by definition a supplement to a normal

[16] The hormone insulin-like growth factor 1 (IGF-1) is the most important stimulant for growth and the development of the fetus and the body in the period of childhood and until the end of puberty. In adulthood, high levels of IGF-1 accelerate aging and growth of the cells, potentially leading to common types of cancer, especially prostate, breast, and colorectal cancer (Fontana et al., 2016). Diet is, among hereditary factors and age, one of the main factors influencing IGF-1 (Dewell et al., 2007). A greater intake of proteins rich in essential amino acids, especially from animal sources (milk and dairy products, meat and meat products, fish), is in a mixed diet associated with an increase of the hormone IGF-1 (Dewell et al., 2007), while a decreased intake of animal-based proteins, fasting, and regular exercise decrease the hormone (Barnard, Gonzalez, Liva & Ngo, 2006; Fontana et al., 2016). A long-term caloric restriction, even without malnutrition, has no effect on the IGF-1 in the blood, but does have an effect on its desirable lower bioavailability (Fontana et al., 2016).

nutrition because of the simplicity of nutrition or an easier recommended daily intake of protein. It is commonly accepted that exercises for strength increase the muscle size (hypertrophy) as well as their strength (Yang et al., 2012). In scientific literature, animal-based proteins in the form of a dietary supplement after a workout for strength of the entire body do not offer an ever-increasing synthesis of muscle proteins in comparison with plant-based proteins. For example, soy proteins (isolate) cause greater muscle growth than casein and a smaller one than hydrolysis of whey proteins (Tang et al., 2009). Even though one overview of studies showed that when an individual consumes additional proteins during an exercise for strength, the intervention will additionally increase the strength and size of the muscle (Cermak et al., 2012), this result was not found in all systematic reviews that studied the effect of adding proteins in the form of a dietary supplement on muscle strength and hypertrophy (Pasiakos, McLellan & Lieberman, 2015; Schoenfeld, Aragon & Krieger, 2013). The cause of different results lies in the design of the scientific research, how trained the athlete is when it comes to exercises for strength, the training protocol, the used source of protein, the total intake of proteins and the intake of proteins after the exercise for strength, the choice of the right moment of consuming additional proteins, the control of other nutritional factors, etc. (Cermak et al., 2012; Pasiakos, McLellan & Liberman, 2015; Samal & Samal 2017; Schoenfeld, Aragon & Krieger, 2013). When talking about various protein sources in the form of dietary supplements, we can conclude that the refined plant-based sources of protein, e.g. soy isolate, pea concentrate, or wheat gluten, have a similar digestibility (>90%) as animal-based proteins (van Vilet et al., 2015). In a randomized controlled, double blind study with placebo, researchers compared the effect of consuming whey and pea proteins after a muscle workout on 161 young men (aged 18–35). This was carried out three times a week in a period of 12 weeks. The participants were divided in three groups. The first one consumed whey proteins, the second one pea proteins, and the third one placebo. The beverage was consumed twice a day, in the morning and in the evening or after workout on the days of the workout. Each of the two beverages (together 50 g daily from a source of a dietary supplement) in the two intervention groups included 25 g of pea (isolate) or 25 g of whey protein (concentrate), while the placebo group consumed maltodextrin instead of proteins. The research showed that they all became stronger, which shows that the basis for gaining muscle mass are exercises for strength not protein consumption. The group that consumed pea protein showed significantly greater progress in muscle mass than the placebo group and was completely comparable to the group that consumed whey protein. After 6 weeks of the training protocol, the placebo group no longer progressed in muscle mass. The mentioned results are consistent with the results of the predecessors who studied a similar intervention, which lasted 8 weeks and compared whey concentrate with rice isolate on men who were well trained in exercises for strength. What was interesting was the fact that the study discovered that the differences in protein composition[17] were less important if an individual consumed an adequate amount of protein. The group that consumed rice proteins achieved comparable results to the group that consumed whey protein, namely a reduction in body fat and an increase in lean muscle mass and strength (Joy et al., 2013). One of the last comprehensive analyses that studied the benefits and disadvantages of consuming protein supplements concluded that, despite the general conviction that an intake of protein supplements results in "better" and faster growth of muscle mass and a more efficient sports performance, studies show that the recommended intake

[17] Whey isolate had a total of 285 mg BCAAs per gram of protein (5.5 grams of leucine in two meals), while rice isolate had 151 mg (3.8 grams of leucine in two meals of supplementation). However, rice protein had 3.3 times more of the amino acid arginine.

of protein should be consumed from natural food sources. Protein supplements should only be enjoyed when a conventional diet nutrition fails to provide an adequate protein intake (Samal & Samal, 2017). Besides promoting excellent health, a carefully designed and thoughtfully supplemented vegan diet can meet the caloric needs and can supply adequate protein without excess (Fuhrman & Ferreri, 2010). To conclude, the relative protein restriction of conventional plant-based sources of protein (consumed with food), traditionally viewed as a restriction of vegetarian and vegan diets, especially methionine, leucine, and tryptophan, is today recognized as potentially beneficial in mechanisms associated with health, slower aging, and longer life expectancy (Hever & Cronise, 2017; Levine et al., 2014; McCarty, Barroso-Aranda & Contreras, 2009).

### *Vegan diet and control of body weight*

Researchers of a non-profit Physicians Committee for Responsible Medicine (PCRM) analyzed 15 studies on 755 participants from Europe and USA and concluded that vegan diet helps lose weight without a calorie count or including regular exercise (Barnard, Levin & Yokoyama, 2015), which could drastically reduce the rising trend of excess weight and obesity. Huang et al. (2016) conducted a scientific overview of 12 randomized controlled studies on 1511 participants, where researchers compared the effect of vegetarian and non-vegetarian diet on the loss of excess weight. The results showed that vegetarian diets, especially vegan, are more effective in losing excess weight (in average even up to 2.02 kg more than non-vegetarian) in comparison with non-vegetarian diets with an approximate intervention of 18 weeks. Turner-McGrievy, Mandes, and Crimarco (2017) conducted an overview of observational and intervention studies on the effects of vegan diet, excess body weight, and obesity and discovered that the vegan diet offers an effective preventive response to excess weight and obesity as well as an efficient intervention (treatment) for the loss of excess weight. Based on the available evidence, the authors conclude that vegan diet should be offered to people as a way of losing excess body weight, improving the quality of their diet, taking preventive measures, and, in some cases, even affecting the treatment of chronic disease. The largest randomized controlled study that researched the effect of vegan diet on the loss of excess body weight, on type 2 diabetes, and on cardio-vascular diseases (Broad Study) showed that vegan diet could present a safe and effective diet that significantly improves the ITM, diabetes, cholesterol, and other risk factors for the development of cardiovascular diseases, where the participants could eat up to full satiety without limiting the amount of the consumed food and without including exercise (Wright, Wilson, Smith, Duncan & McHugh, 2017). Vegan diets are rich in carbohydrates and a comparison of popular low-carb and high-carb diets showed (Bowman & Spence, 2002) that high-carb diets (more low-fat foods, e.g. cereals and fruit) have a lower energy intake, a higher nutritional density, and a more successful control of body weight. A well-planned vegan diet can be regarded as a kind of low-energy diet for weight control, with a lower calorie intake, which is something normal for vegans and not a part of a deliberate energy-restricted diet. In one of the researches (Thedford & Raj, 2011) a vegetarian group without a restriction of calorie intake (not on a diet) spontaneously consumed around 363 calories less than the non-vegetarian group. This means that a well-planned vegan diet naturally leads to a loss of excess weight and later on presents an easy way of long-term maintenance of healthy body weight. Vegetarian, vegan, and low-fat diets were studied for over a year, proving the permanence of maintaining the lost body weight over a longer period of time, which was most likely not only due to the loss of body weight but also due to a greater well-being and a better quality of life in general (Berkow, Barnard, Eckart & Katcher, 2010). One of the greatest challenges of a competitive gymnast, especially with the female population, is a constant and often unsuccessful struggle for an appropriate body weight (with an optimal general physical preparation and excellent health). According to the majority of scientific evidence, a well-planned vegan diet is probably quite optimal for a competitive gymnast.

## RECOMMENDATIONS AND CONCLUSION

1. A well-planned vegan diet, supplemented with vitamin $B_{12}$ and most likely also with EPA and DHA omega-3 fatty acids, is healthy and nutritionally adequate and appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence and older adulthood, and for athletes. An adequate intake of vitamin D is usually a problem of an institutionalized lifestyle and living in a geographical area with a lower or higher UV index, especially in autumn, winter, and early spring. Besides regular and sufficient exposure to sunlight, competitive gymnasts can also consume vitamin D in the form of a dietary supplement.
2. In case of greater energy needs, competitive gymnasts who follow a well-planned vegan diet can consume either more unrefined high-carb meals or they can include in their composition more concentrates from the source of unrefined but more processed carbohydrates, e.g. foods from whole grain flour (spaghetti, bread, polenta, meal) and dried fruit, and from the source of high-fat, unrefined and fermented plant-based foods (avocado, nuts, seeds and their spreads, tofu, tempeh).
3. Conventional plant-based sources of food, which are especially rich in protein, contain in a typical portion a lower content of some essential amino acids in comparison with animal source foods. However, this difference presents an advantage for health and a longer life expectancy. If competitive gymnasts believe that they need a higher intake of protein, they can resort to greater or more frequent intakes of foods with a higher content of protein, e.g. legumes, nuts, seeds and their spreads, soy foods (tofu, tempeh), and products from whole grain cereals (buckwheat or oatmeal, spaghetti, seitan). They can also wisely choose plant-based protein in the form of a dietary supplement tested on illicit substances by the world class sports anti-doping laboratory.
4. Based on the available evidence on the benefits of vegan diet for the needs of an appropriate control of body weight, we can conclude that a well-planned vegan diet is a perfectly viable option for those competitive gymnasts who wish to lose excess weight, control the nutritional adequacy with a smaller energy intake (which is often their need), improve the quality of diet, and at the same time reduce the risk of modern chronic diseases in the long term.
5. A well-planned vegan diet is often seen as something that is hard to implement, especially because of eating habits that usually represent our cultural, family, and personal identity. Nevertheless, we can overcome these challenges by a more objective and widespread reporting on the benefits of a well-planned vegan diet, through numerous examples of good practice among vegan athletes and through the availability of healthy vegan meals outside of our home environment (restaurants, sport camps) and by respecting the decisions of those who have decided on vegan diet.

To conclude, there is a scale of scientific evidence about the wide range of benefits of a well-planned vegan diet and the energy and nutritional needs of a competitive gymnast for a variety of goals (support of the strenuous and repeated training with gymnastics apparatus or in all-around gymnastics, effective recovery, simple control of appropriate body weight, and long-term health). Furthermore, the actual inadequate nutrition of competitive gymnasts, especially female ones, is relatively well documented so we can safely conclude that a well-planned vegan diet can be one of the appropriate and undoubtedly healthy forms of dieting for a competitive gymnast.

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