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THE IMPORTANCE OF NUTRITION AT POST COVID-19 PERIOD*

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***Abstract**: Post-COVID is a syndrome we define as symptoms that are present even after 12 weeks of COVID 19, and cannot be explained by any other condition or disease. Common symptoms include fatigue, muscle weakness, shortness of breath, cognitive dysfunction, loss of appetite and changes in taste / smell, mental "fog" and generally have an impact on daily functioning. It is often characterized by malnutrition, weight loss and low-grade inflammation, but also many other symptoms. Food and nutrition play a key role in recovery from Covid-19. When it comes to diet and post-COVID, it is important to assess nutritional status (degree of nutrition and eating habits). Thus, dietary advice can be individualized. Energy balance is crucial in recovery. The important fact is that during the disease there is a loss of muscle mass that needs to be compensated. Foods rich in protein can help recover from loss of muscle mass. Adding protein to every meal is key to rebuilding the body. Depleted protein intake also means reduced immunity. When dealing with symptoms, it is important to apply general principles of proper nutrition, but also functional foods and dietary supplements where antioxidants are especially recommended: vitamins C and E, minerals zinc and selenium, carotenoids, polyphenols, flavonoids and many others. A well-balanced diet can help in recovering from COVID-19 infection. It is very crucial to meet the increased nutritional needs because it helps to restore physical, mental and emotional well-being.*

***Keywords:** post-COVID-19 syndrome; nutrients*

Introduction

Post-COVID is a condition characterized by long-term consequences that persist or appear after the typical period of convalescence of the disease. It is also known as post-Covid-19 syndrome, post-Covid-19 condition, post-acute sequelae, or chronic COVID syndrome [1,2]. It can affect almost every organ system, with consequences of respiratory and nervous system disorders, neurocognitive and mental health disorders, metabolic, cardiovascular and gastrointestinal disorders, weakness, fatigue, musculoskeletal pain and anemia [3]. A wide range of symptoms are often reported, including fatigue, headaches, shortness of breath, anosmia (loss of smell), parosmia (distorted smell), muscle weakness, low-grade fever. About 1/3 of patients develop neuropsychiatric symptoms in the chronic course of the disease. Neutralizing antibodies can act on myelin sheaths causing damage that leads to muscle weakness.

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Hematological disorders with increased coagulability and neuronal degeneration are also possible. Therefore, nutrition is of great importance in order to prevent the numerous complications caused by COVID-19 [4]. However, post-COVID cannot be considered as a unique pathology considering that it is characterized by a specific long-term immune dysregulation with a number of different morbidity states [5]. There are certain risk factors that increase the possibility of post -COVID. These are: female sex, people over 60 years old and visceral type of fat [6]. Certain comorbidities also increase the risk of a chronic form of the disease, such as diabetes mellitus, diseases of the cardiovascular system, hypertension, asthma, pathological obesity, diseases of the gastrointestinal tract, and people with autoimmune diseases [4,7].
Research by the UK Office for National Statistics estimated that around 14% of people who tested positive for SARS-CoV-2 had one or more symptoms for more than three months. An Oxford University study of 273,618 survivors of COVID-19, mostly from the United States, found that about 37% experienced one or more symptoms between three and six months after diagnosis [8]. When it comes to nutrition, during and after COVID 19 very often in practice there is a strong loss of appetite, reduced energy level and weakness which in themselves deters from eating. The key is to motivate the sick person to consume food and that with the principles of proper nutrition and dietetics. Proper nutrition is a kind of support in the treatment and recovery from COVID-19. Most of the specific food ingredients that work to strengthen the immune system are included in proper nutrition guides. All dietary guidelines boil down to: moderate and varied consumption of locally produced and seasonal foods. At the base of all guides is the recommendation of the intake of desirable nutrients and biologically active food ingredients in the correct ratio for health.

Nutrition and Covid-19

Nutrition is such a routine part of everyday life that it is easy to assume how important it is when a person is recovering from C OVID -19. The chosen diet is key to recovery and the better the quality of the chosen diet, the greater the likelihood that the recovery will be faster and more effective. The best approach is the individualization of the diet for each person adapted to the health and nutritional status [9].Balancing food intake and energy expenditure as with any infection is essential. In these conditions, and related to nutrition, the body needs more energy from food (carbohydrates and lipids), building materials (protein and water), and protective substances (vitamins and minerals). In addition, additional proteins are needed for the biosynthesis of the protective components of the body as well as for the repair of tissue cells.

After getting over the infection in 15-20 days, the body fought against the virus - the invader. Possible damages have occurred that must be repaired. Most often, total body energy is lost, and muscle mass is reduced (sarcopenia), then appetite is lost, so they all have to be restored again. At the same time, the body and diet need to cope with the consequences often caused by the use of strong drugs and especially the experienced psychological trauma. Nutrition is the best tool for overcoming malnutrition and weakness.

For the most part, the traditional Mediterranean diet can be recommended for recovery from COVID-19. This diet recommends important types of food and nutrients that the body needs after an infection. This means lots of fruits, vegetables and fatty fish and healthy oils. This type of varied, high-fiber diet also supports a wide range of good gut bacteria and a healthy gut lining, both of which play an important role in regulating the immune system.

One of the most important nutritional measures is good hydration, in addition to drinking hygienically and healthily correct clean water, as well as other liquids. Thus, teas, fermented milk products, fruit juices would be a good recommendation in the post-Covid diet.

During post-Covid it is helpful to gradually reintroduce food after a period of eating little or nothing so as not to overload the gut. Softer foods are easier to restore bowel function at first, but it may take several days for patients to return to a normal diet. Eating little and often can be easier and more appealing than preparing three large meals every day.

To maintain the homeostasis of the body, the most important need is to balance energy intake and consumption. It is most easily obtained from carbohydrates, which are food based on grains, fruits and vegetables. In addition, these foods contain protective factors such as plant fibers (improving digestion and intestinal motility), biologically active components (medicinal ingredients in food), and vitamins and especially minerals. As the person begins to recover, it is necessary to start introducing small frequent meals, especially with the intake of protein-based dishes (dairy products, eggs, meat) along with fruits and vegetables.

During illness, the body needed more energy, because it consumes it more than usual. Likewise, the immune system needs more energy when it is active and fighting pathogens, and at the same time synthesizing new molecules, for which it needs energy. Eating plenty of high-carbohydrate foods like whole-wheat bread and pasta as well as high-protein foods like eggs, full-fat yogurt, and nuts can aid recovery. If the appetite is low, it is necessary to insist on feeding. Protein and other nutrients from eggs and fatty fish can help the body recover, even if the appetite is poor.

It is necessary to choose sometimes plant-based high-energy foods such as peanut butter, nuts and seeds. These foods are concentrated sources for healthy energy intake. The recommendation is to gradually increase the intake of healthy oils and fats with food such as fatty fish, olive oil, flaxseed, etc. Healthy fats found in olive oil and fatty fish are important for energy and the creation of new cells. Omega-3 as well as essential fatty acids cannot be produced by the body enough and must come from the diet, and they are especially useful for the immune system. Good sources of Omega-3 are blue sea fish and fish from the northern seas: sardines, mackerel, herring and salmon.

The body fights infections through the immune system. Thus, white blood cells, antibodies and other mechanisms work to destroy the invasive SARS-CoV-2 virus, as well as to repair and replace damaged cells and tissues. Proteins and amino acids, from which the elements of the defense system are built, are particularly important.

Therefore, during the infection, proteins are consumed, mainly from the muscles, breaking down into amino acids, which the immune system uses to create new protective components. Therefore, patients lose weight and notice that their muscles weaken (sarcopenia) while they are sick. During recovery, it is necessary to restore proteins, which are building and regulatory-protective substances of the body. This is especially true for patients with severe symptoms, and especially for those who were immobile in a hospital bed. Meat, milk and eggs are good sources of protein, but plants can also be excellent. Legumes (beans, peas, soybeans and lentils) and nuts are good sources. Slightly less amount of proteins can be found in common cereals. Combining different vegetable and animal foods rich in protein is the best way to ensure all the necessary amino acids [10].

There are numerous types of food that can affect the immune and other systems in the human body, and some components are almost universal. Ingredients from certain types of food are very valuable in preserving a healthy immune system, such as: colostrum, whey, young cheese, blue fish, omega-3 fatty acids, berries, leafy vegetables, legumes, bee products, mushrooms, algae, medicinal and herbs. In addition to the immune system, they also affect other systems in the body.

Bioactive components from food

Some bioactive food components known as "phytonutrients" play a positive role by maintaining and modulating immune function to prevent certain diseases. Natural products are promising in clinical therapy, because their side effects are less pronounced compared to other types of medicinal substances. Some of the important bioactive phytonutrients include: carotenoids, polyphenols, flavonoids, terpenoids, glucosinolates, phytoestrogens, phytosterols, anthocyanins. They have specific pharmacological effects in human health such as antimicrobial, antioxidant, anti-inflammatory, antiallergic, anticarcinogenic, hepatoprotective, hypolipemic, neuroprotective, analgesic, hypotensive and others [10].

Vitamins and minerals in the recommended daily amounts are also essential. They play a key role in supporting the immune system and recovery, and they include: vitamins A, D, E, C, B6, B9 and B12. It is recommended to take a vitamin D supplement in the winter months. Vitamin B12 is only found in animal products, so supplements should be taken especially by people on a vegan diet. Vitamin C is a powerful antioxidant that is specific for lung health. Foods rich in vitamin C are citrus fruits, spinach, papaya, kiwi, tomatoes, mangoes and strawberries and these are some of the good sources. Since vitamin C is soluble in water, it must be taken in adequate amounts daily. The intake of antioxidants (zinc and selenium) as well as iron, which is an integral part of hemoglobin responsible for transporting oxygen, is particularly important. Iron is also a component of enzymes critical to the function of immune cells. Zinc is a critical nutrient that supports immune health. These minerals are found in many foods, including fruits and vegetables, meat, eggs, and dairy products, and can also be taken as dietary supplements [10]. Allium compounds and quercetin from onions, capsaicins from hot peppers, lycopene from tomatoes, and especially salicylic

acid from chicory and blueberries also have an anti-inflammatory effect, because it prevents hypercoagulation, which is a frequent complication of Long-Covid.

Food should be varied, moderate and frequent. Preference is given to local and seasonal products. For the recovery of the intestinal flora, and therefore the strengthening of immunity, it is important to eat foods that contain a lot of prebiotics and probiotics from fermented products. Many lactic acid bacteria, such as lactobacilli and bifidobacteria, can compete with other pathogenic microorganisms in the colon and additionally strengthen immunity [10].

Dietary supplements and post-Covid

In pharmacies, preparations are available that can be used to strengthen the immune system and reduce the effects of post-Covid. These preparations contain: known antioxidants vitamins C and E and minerals zinc and selenium, alphalipoic acid, coenzyme Q10, and preparations based on glutathione, a powerful antioxidant. Numerous phytochemicals are offered as concentrated extracts (carotenoids such as lycopene and lutein, phenolic acids such as ferulic and ellagic, polyphenols such as quercetin, rutin, proanthocyanidins, catechins and many others). Well-known and used during and after the COVID 19 pandemic are: omega-3 fatty acids, acetylcysteine and glucosamine, beta glucan, probiotics and preparations based on fruit, vegetable, medicinal and herb extracts.

Among the nutritional supplements for the purpose of strengthening immunity for the elderly, the following are also recommended: vitamins, especially vitamin D, carnitine, green tea extracts, ginkgo biloba, curcumin and similar supplements.

Many components of the immune system have significantly reduced biosynthesis in the body after the age of 40. These are, for example: coenzyme Q_{10} and alpha lipoic acid. They can be compensated by taking preparations in the form of food supplements. During and after the disease caused by the Corona virus, it is recommended to take vitamin D in the form of food supplements. Vitamin D is lacking in more than 60% of the world's population, and staying indoors reduces its biosynthesis.

Melatonin, the main hormone of the pineal gland, affects many biological processes in the body. Studies focusing on the relationship between melatonin and aging indicate an indirect modulation of the immune response and neuroinflammation caused by SARS-CoV-2 [11]. Resveratrol and quercetin act as antioxidants, cytostatics and anti-inflammatory at the cellular level [12].

Numerous dietary products are available to strengthen the immune system. Their consumption and needs are determined based on the assessment of health and nutritional status. They can be a powerful support in strengthening the immune system as well as in the treatment of numerous diseases [10].

Loss of taste and smell. About half of all patients with Covid-19 lose their sense of smell (anosmia), and thus the ability to taste food. For most people, taste and smell return after two or three weeks, but for about 10% of patients it may take several

months. This phenomenon can have a significant impact on the feeling of lack of hunger or appetite. In this situation, it can be recommended to try foods with other sensory properties. Try food with crunchy and smooth elements or different temperatures. In this way, different sensations are obtained, which are important when the sense of taste and smell is lost.

Olfactory training can help restore the sense of smell. It involves actively smelling the same scents twice a day, with strong concentration. Olfactory training is essentially physiotherapy for the nose. Neurons are damaged and aroma therapy is a healing process. Distorted and unpleasant smells and tastes (parosmia) are also a common part of recovery from Covid-19. This can make eating very difficult, especially if some food has a repulsive taste due to parosmia. Trigger foods vary from person to person, but often include coffee, garlic, onions, bread, and baked or fried meats. This can become very disturbing and difficult to live with [4].

Coping with fatigue. Cachexia and fatigue are common consequences of POST-COVID. Food choices and nutrition for recovery can be difficult if the appetite is lost and the person feels tired and exhausted. In this case, it is necessary to minimize the loss of body weight while increasing energy intake with food and restoring muscle mass by consuming protein and necessary micronutrients. Dairy beverages such as fermented products keep the body hydrated and provide sources of energy. People with a low appetite more easily decide to consume liquid food (soups, fruit juices and milk drinks) than to face a full meal. Nutritious drinks that partially replace meals and healthy ready meals can also be beneficial.

When dealing with the problem of fatigue, it is important to use food supplements where vitamin C is especially recommended in the morning [4].

Reduced sexual abilities. A greater number of people after recovering from COVID-19 complain of reduced sexual abilities. Modern science strives to identify food ingredients with a special effect on sexual function and define the mechanisms of influence of food ingredients on sexual abilities. Different ingredients can be found in food that increase libido, affect fertility and erectile functions. Some have a dominant effect on the endocrine system, others on the circulatory system, and some on the nervous system. As food ingredients with a special effect on sexual functions the most frequently mentioned are: nuts, honey, chocolate, bananas, cherries, watermelons, pumpkin seeds, bamia, peppers, poppy seeds, ginkgo and ginseng. Antioxidants that alleviate the effects of stress, such as vitamins C and E, minerals selenium and zinc, lycopene, beta carotene, and polyphenols and flavonoids, stand out. Many are used in traditional medicine spices and herbal preparations for improving sexual functions such as Horny Goat Weed, Tribulus terrestris, Ginseng root, Ginseng, Poppy, Safran, Persimmon, Satureja khuzestanica essential oil (SKEO) and others. Preparations based on African plum, pumpkin seeds, saw palmetto, coenzyme Q10, alphalipoic acid, etc. are also used.

A prerequisite for a balanced sexual function is a balanced diet, especially in the post-COVID period. Certain ingredients in food and nutritional supplements can improve sexual function. For now, there is a lack of data on clinical trials, and the existing ones are often incomplete and methodologically flawed [4].

Conclusion

COVID-19 is a systemic disease and months after patients get over it, in many cases it leaves different consequences. There is no organ system that cannot be affected.

Nutrition can be a significant support in the treatment of the post-Covid condition. Nutrition is based on health and nutritional status and should be individualized. Especially important are proteins, vitamins, minerals and bioactive ingredients from food that strengthens immunity and has an anti-inflammatory effect.

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ZNAČAJ PREHRANE KOD POST-COVID 19 STANJA

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***Sažetak**: Post-COVID je sindrom kojeg definišemo kao kao stanje kod kojeg su prisutni simptomi i nakon 12 sedmica od preboljenja COVID 19, a da pri tome,ne mogu biti objašnjeni nekim drugim stanjem ili bolešću. Uobičajeni simptomi uključuju, umor, slabost mišića, otežano disanje, kognitivnu disfunkciju, gubitak apetita i promjene okusa/mirisa, psihički stres i općenito imaju utjecaj na svakodnevno funkcioniranje. Često je karakteriziran pothranjenošću, gubitkom tjelesne mase bez masti i upalama niskog stupnja, ali i brojnim drugim simptomima.*

Hrana i prehrana imaju ključnu ulogu u oporavku od COVID-19. Kad je u pitanju prehrana i post-COVID važna je procjena nutritivnog statusa (stepen uhranjenosti i prehrambenih navika).Tako se mogu individualizirati savjeti za prehranu. Uravnoteženje energetskog balansa je ključno u oporavku. Važna činjenica je da tokom bolesti dolazi do gubitka mišićne mase koju je potrebno nadoknaditi. Hrana bogata proteinima može pomoći u oporavku od gubitka mišićne mase. Dodavanje proteina svakom obroku ključno je za obnovu tijela. Osiromašeni unos proteina znači i smanjen imunitet.

Kod suočavanja sa simptomima značajno je primijeniti opšta načela pravilne prehrane, ali i funkcionalnu hranu i dodatke prehrani gdje su posebno preporučeni antioksidansi: vitamin C i E, minerali cink i selen, karotenoidi, polifenoli, flavonoidi i brojni drugi.

Dobro uravnotežena prehrana može pomoći u oporavljaju nakon infekcije COVID-19. Vrlo je ključno zadovoljiti povećane prehrambene potrebe jer to pomaže u obnavljanju fizičkog, mentalnog i emocionalnog blagostanja.

***Ključne riječi**: post-COVID-19 sindrom; hranjive tvari*