

Intervention Effect of Exercise and Diet on Immunity Under the Coronavirus Pandemic

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ABSTRACT

In the context of the global pandemic, enhancing immunity is an important way to defeat the virus. This article analyzes the immune system and immune function of the body and proposes to intervene in the function of the immune system through diet and various intensities of exercise. Research has shown that doing less intensive exercise can improve the impact of negative emotions, thereby enhancing the immune system. Long-term high-intensity exercise can suppress immune function. In the event of a disease outbreak, the immune system can be strengthened by providing adequate nutrition. The most important thing is that the human body should have sufficient high-quality protein. Firstly, protein is the material foundation for maintaining health. Secondly, the human body needs to consume more vitamin A. Thirdly, we mainly eat trace elements such as iron, zinc, and selenium. Fourthly, there must be more biologically active foods. At the same time, it is important to ensure sufficient sleep, a good mood, and exercise.

KEYWORDS

Exercise and Diet, Immune System, Intervention Effect

INTRODUCTION

At the end of 2019, the sudden outbreak of novel coronavirus pneumonia seriously threatened the physical and mental health of Chinese people. The consequences of the epidemic cannot be ignored (Clemente-Suárez et al., 2022). The virus cannot be cured for a period of time after infecting the human body. The virus strain can also mutate under certain factors, leading to faster transmission speed. Since moderate exercise can help the body to resist the novel coronavirus, the government has actively mobilized and adopted various ways to support daily exercise (De Frel et al., 2020). Supporting sports and anti-epidemic activities is the main content of China's national sports and health work during the epidemic, and the "anti-epidemic" movement is also an important measure for all sectors of society to encourage the participation of the whole population in sports activities during the epidemic (Laddu et al., 2021).

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Due to the impact of the epidemic, coupled with relevant departments urging the public to avoid going to centralized enclosed places or crowded public places, the proportion of public participation in fitness has decreased (Luzi & Radaelli, 2020). According to relevant surveys, before the epidemic, more people participated in sports, with 45.3% participating in more than three sports and 30.8% participating in two sports. During the epidemic, 38.5% of people exercised more than three times every week, and 25.3% exercised twice per week. The number of people participating in sports activities before and during the epidemic is shown in Figure 1.

Another link that plays an important role in immunity during the epidemic is how to eat, and this has sparked heated discussions among the public. During the epidemic, the time spent sitting and lying down significantly increased due to environmental conditions and restrictions on activity areas. And in relatively static situations, people's aerobic endurance and muscle strength both decrease to a certain extent, and these changes inevitably lead to a decrease in body function. Now, entering the stage of normalized epidemic prevention and control, citizens can scientifically adjust their exercise and diet (Alam et al., 2021).

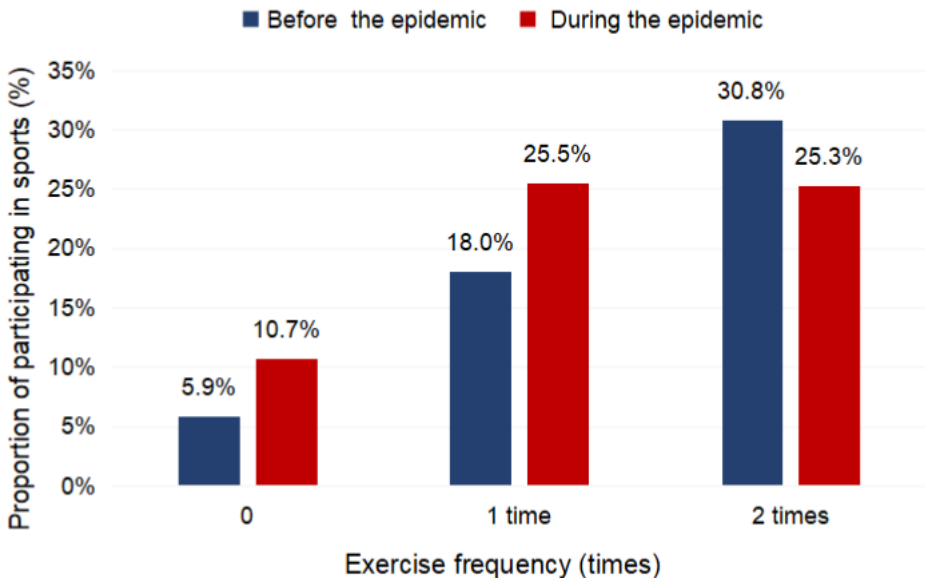
Therefore, this article analyzes the origin of human immunity, studies the impact of dietary structure on immunity, summarizes the effects of various exercise methods, and combines scientific diet with exercise. The synergistic effect of the two has important reference value for improving the body's immune system.

IMMUNE SYSTEM

Overview of the Immune System

The immune system is a complex biological defense system responsible for protecting the human body from pathogens (such as bacteria, viruses, fungi, and parasites) and foreign substances (such as foreign objects and chemicals). It is composed of a series of organs, cells, and molecules that collaborate to identify and eliminate invading pathogens and foreign substances, thereby maintaining the health and homeostasis of the body (Jayawardena et al., 2020).

Figure 1. Number of people participating in sports activities before and during the pandemic



The immune system is composed of the following parts: (1) Immune organs. Immune organs include bone marrow, thymus, lymph nodes, spleen, etc. These organs produce, mature, and store immune cells, such as T cells, B cells, and natural killer cells. (2) Immune cells. Immune cells include T cells, B cells, macrophages, dendritic cells, granulocytes, NK cells, etc. They are the main executors of the immune system and recognize and eliminate pathogens and foreign substances in different ways. (3) Immune molecules. Immune molecules include antibodies, cytokines, complements, etc. They participate in the immune response through different mechanisms, such as neutralizing pathogens, regulating inflammatory responses, activating immune cells, etc. In addition, the immune system, along with the nervous and endocrine systems, forms a neuroendocrine immune network, playing an important role in regulating the stability of the entire internal environment of the organism.

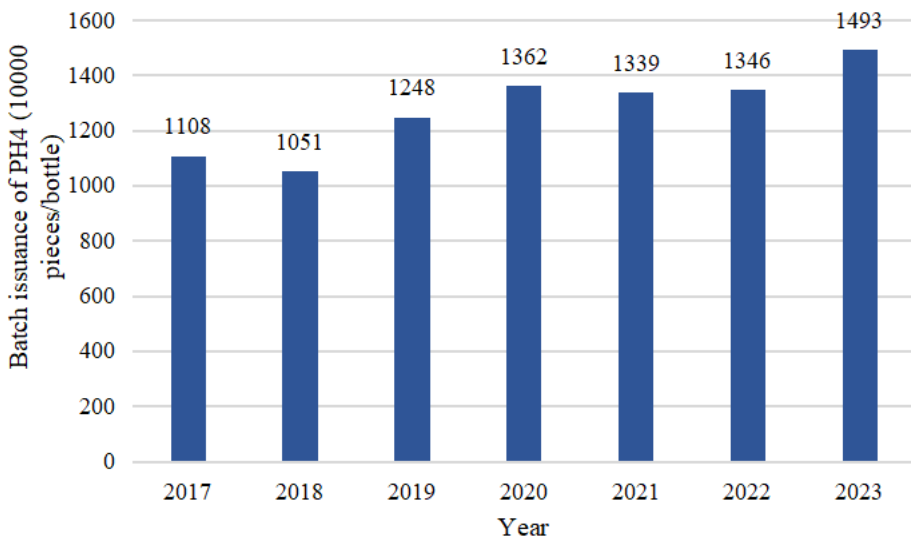
Human immunoglobulin for intravenous injection (PH4), also known as human gamma globulin, is a biological preparation extracted from human plasma and produced by the immune system after being stimulated by antigens (Kara, 2020). From 2017 to 2021, the batch issuance of intravenous immunoglobulin (IVIG) showed an upward trend, with a compound annual growth rate of 4.8%. In 2020, despite the impact of COVID-19 on plasma donations, the number of IVIG batches issued continued to grow, reaching 13.624 million tubes/bottle. It is expected that the batch issuance volume of intravenous immunoglobulin in China will reach 14.93 million tubes/bottle in 2023. The predicted trend of the batch issuance of intravenous immunoglobulin in China from 2017 to 2023 is shown in Figure 2.

IVIG is an effective drug for the treatment of primary immunodeficiency, secondary immune deficiency, and autoimmune diseases. The demand for IVIG in China has shown significant growth in recent years. The scope of clinical treatment has expanded to immune replacement therapy, anti-infection, anti-inflammatory, and immunomodulation therapy in immunology, neurology, hematology, blood oncology, dermatology, and other fields.

Main Functions of the Immune System

The main function of the immune system is to protect the body from the invasion and destruction of pathogens and abnormal cells, thereby maintaining the health and stability of the body. Its main functions are as follows: (1) Recognize pathogens and foreign substances. The immune system can

Figure 2. Prediction trend of intravenous human immunoglobulin batch issuance in China from 2017 to 2023



recognize and distinguish pathogens and abnormal cells inside and outside the body and recognize and distinguish pathogens and foreign substances through different receptors and signaling molecules, and thus initiate the corresponding immune response (Madison et al., 2021). The immune system protects physical health through the inflammatory response generated when faced with the invasions of pathogens such as bacteria, viruses, fungi, mycoplasma, chlamydia, and parasites. (2) Destroy pathogens and foreign substances. The immune system can identify pathogens and abnormal cells through different cellular and molecular mechanisms (such as phagocytosis, lysis, neutralization, cytotoxicity, etc.) and destroy these invaders through a series of responses, including the release of cytokines and the activation of phagocytes and killer cells. When a person's immune function is low, the tumor cells produced in the body cannot be cleared in a timely manner, which can evolve into terrible cancer. (3) Memory and protection. The immune system has memory, can "remember" invaders after destroying them and can remember pathogens and foreign substances that have been exposed before, so if it encounters the same invaders again, the immune system can initiate an immune response faster and more efficiently, protecting the body from disease (Shinde et al., 2020). (4) Self-protection. Normally, the immune system does not attack normal cells or tissues in the human body, and this effect is called "immune tolerance," which does not result in incorrect attacks. But when this differentiation ability is abnormal and immune regulatory function is disrupted, it can lead to the occurrence of autoimmune diseases and allergic diseases.

Take the body's antioxidant system as an example: As part of the metabolic process, reactive oxygen species (ROS) and reactive nitrogen species (RNS), the products of oxidative stress, are continuously produced in the body and maintain their homeostasis through the body's antioxidant defense system. Proper oxidative stress is necessary to maintain normal life activities of the body. ROS are small oxygen source molecules that contain unpaired electrons that can quickly bind to nearby molecules. ROS includes oxygen radicals such as peroxides, hydroxyl groups, and alkoxy groups. Some substances can be oxidized from mountain groups or easily become mountain groups, such as hypoacid, ozone, monoanion oxygen, and peroxide milk, and collar oxides such as nitric oxide, also known as reactive nitrogen RNS.

The oxidized glutathione (GSSG)/reduced glutathione (GSH) ratio can be used as an indicator of intracellular redox status. O_2 is catalyzed by NOX to rapidly produce superoxide anions, and SOD increases this rate by 10^4 and superoxide anion disproportionation into hydrogen peroxide:



The resulting hydrogen peroxide is catalyzed by catalase in the peroxisome to produce a rapid disproportionation reaction to produce water and oxygen:



Glutathione (GSH) peroxidase, found in cytosolic solutions and mitochondria, disproportionates GSH and hydrogen peroxide, producing GSSG and water:



In the face of novel coronavirus pneumonia, and most viral infections, there are few effective antiviral drugs. The body's own immune system is the main force in fighting against the virus. The essence of inflammatory response is a defensive response of the body. In the face of COVID-19, many patients will have immune system disorders; too strong or too weak inflammatory reactions

will cause bad consequences. In COVID-19 patients, low immunity or multiple organ failure caused by inflammation storm are important reasons why patients progress to severe disease or even death.

Influencing Factors of the Immune System

The immune system is an important system for the human body to resist the invasion of diseases, and the factors that affect the immune system include the following aspects: (1) Diet. Diet is an important factor affecting the immune system. A poorly nourished or inadequate diet weakens the immune system, making it difficult to respond to the invasion of pathogens. Conversely, consuming enough nutrients such as protein, vitamins, and minerals can boost the immune system. (2) Lifestyle. Lifestyle can also have an impact on the immune system (Clemente-Suárez et al., 2021). Poor lifestyles, such as lack of sleep, overwork, smoking, and drinking, can weaken the immune system. Conversely, a healthy lifestyle such as adequate sleep, proper exercise, and relaxation can boost the immune system. (3) Environmental factors. Environmental factors can also have an impact on the immune system. Exposure to harmful substances such as pollutants, chemicals, radiation, etc. weakens the immune system. On the contrary, a clean environment, a healthy climate, and proper sun exposure can strengthen the immune system. (4) Genetic factors. Genetic factors also affect the function of the immune system. Certain genes cause the immune system to malfunction, making a person susceptible to infections. Conversely, some genetic variants can boost the immune system. (5) Age and health status. Age and health status are also factors that affect the immune system (Hakeem & Sheikh, 2020). As age increases, the immune system function gradually decreases, making elderly people more susceptible to infection. In addition, some diseases or drug treatments can also have an impact on the immune system. The causes and manifestations of decreased immunity are shown in Figure 3 and Figure 4, respectively.

All in all, the factors that affect the immune system are multifaceted, from diet to the environment, from genes to age health, all of which require our attention.

Figure 3. Proportion of causes of decreased immunity

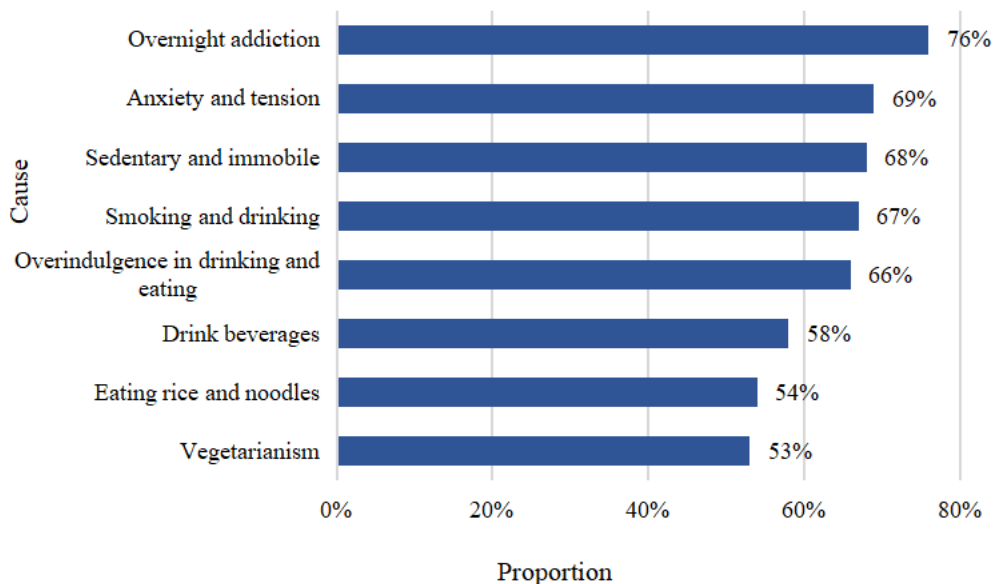
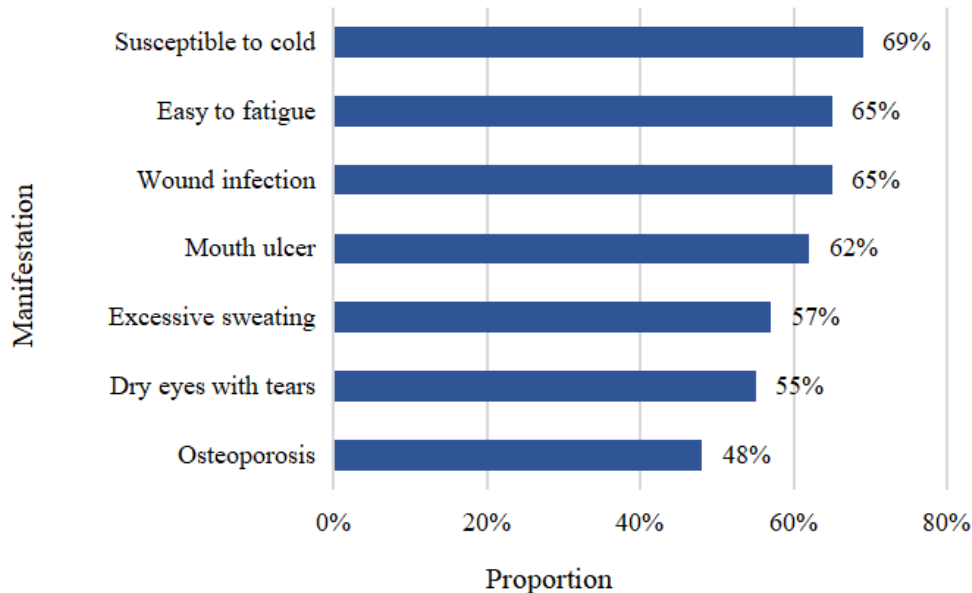


Figure 4. Manifestation of decreased immunity



INTERVENTION ROLE OF EXERCISE

Positive and Negative Effects

Exercise has multiple effects on the immune system, including beneficial and negative effects. Generally speaking, moderate exercise is beneficial to the immune system, while excessive exercise may have a negative impact on the immune system. (1) Moderate exercise can enhance the function of the immune system (Mehrsafar et al., 2020). Exercise can improve blood circulation and oxygen supply, promote the production and distribution of immune cells, and thereby enhance the immune system's ability to fight infection. In addition, exercise can also reduce weight, improve cardiovascular health, and reduce the risk of chronic diseases, all of which are beneficial for the health of the immune system. (2) Excessive exercise can reduce the function of the immune system. Excessive exercise may have a negative impact on the immune system. If excessive exercise leads to rapid weight loss or malnutrition, it can lead to a decrease in the function of the immune system. Excessive exercise can also lead to muscle damage, fatigue, and increased stress, all of which can affect the function of the immune system (Ranasinghe et al., 2020). Therefore, moderate exercise is beneficial for the immune system, but it is necessary to pay attention to the intensity and frequency of exercise to avoid the negative effects of excessive exercise on the immune system (Onagbiye et al., 2020).

Low-intensity continuous aerobic exercise (CAT) and low-intensity interval training (LIT) are commonly used by most people as a means of improving immunity. Practicing yoga, stretching, and jogging at home can all benefit the body and effectively reduce the risk of upper respiratory tract infections.

Timely moderate intensity continuous aerobic training (MICT) and moderate intensity interval training (MIT) have been proven to enhance immune function and have a certain effect on preventing upper respiratory tract infections.

Long term, extensive, or high-intensity exercise can lead to immune suppression, meaning a significant decrease in the body's immune function, forming an immune window period. Avoiding high-intensity exercise during the epidemic will prevent the body's immune system from declining.

Although high-intensity exercise cannot have a positive impact on immunity, professional athletes who participate in endurance or collective events generally have a longer lifespan than ordinary people. People who have not engaged in professional sports experiences are not suitable for high-intensity exercise, as excessive exercise under overload can lead to deterioration effects in the body.

Prevention and Treatment

Studies have shown that moderate exercise can prevent and treat viral diseases. Moderate exercise can improve the body's immunity and enhance the body's resistance to viral infections. In addition, moderate exercise can also promote the health of the body's circulatory system and enhance the function of the lungs and respiratory tract, thereby reducing the chance of virus invasion of the body (Monye & Adelowo, 2020). (1) Prevention: Moderate exercise can enhance the body's immune function and make the body more resistant to viral infections. In addition, exercise can improve cardiovascular and respiratory function, improve lung and heart health, all of which can help prevent and alleviate respiratory diseases (Morales et al., 2021). (2) Treatment: Exercise can increase the body's metabolic rate, promote blood circulation, and help the body clear the virus faster. In addition, moderate exercise can relieve symptoms of viral diseases, such as fever, fatigue, and muscle pain (Seifert et al., 2020). It should be noted that if the body is infected with the virus, strenuous exercise should be avoided so as not to increase the burden on the body (Clemente-Suárez et al., 2021). During the recovery period, the intensity and duration of exercise should be gradually increased, and excessive exercise should be avoided (Moscatelli et al., 2021). Overall, moderate exercise is one of the important ways to prevent and treat viral diseases, but it also needs to be combined with other measures such as good hygiene and vaccination.

Influence of Exercise Type and Intensity

(1) Aerobic exercise. Jogging, cycling, and swimming can increase heart rate and respiratory rate, and enhance cardiopulmonary function. Moderate aerobic exercise helps to enhance immune function and enhance the body's disease resistance. However, excessive aerobic exercise may lead to excessive stress on the immune system, making the body more susceptible to viruses and diseases (Pizano-Escalante et al., 2021). (2) High intensity interval training (HIIT). HIIT is a high-intensity aerobic exercise that typically includes short periods of high-intensity exercise followed by longer periods of low-intensity exercise or rest. HIIT training can improve cardiovascular function, burn fat, and enhance immune function (Wang et al., 2021). However, excessive HIIT training may lead to excessive stress on the immune system, making the body more susceptible to viruses and diseases (Radwan et al., 2021). (3) Resistance training. Resistance training, such as weightlifting and equipment training, can enhance muscle strength and muscle mass. Moderate resistance training can help enhance immune function and enhance the body's disease resistance (Arshad et al., 2020). However, excessive resistance training may cause damage to the immune system (Gasmi et al., 2021).

Overall, moderate exercise can enhance immune function and enhance the body's disease resistance, but excessive exercise may cause damage to the immune system. Therefore, before exercising, one should consult a doctor and choose the appropriate type and intensity of exercise based on one's physical condition and fitness level. In addition, ensuring sufficient rest and recovery time is also important to avoid the negative impact of excessive exercise on the immune system (Alkhatib, 2020).

INTERVENTION ROLE OF DIET

Effects of Diet

The effects of diet on the immune system have also been extensively studied. Studies have shown that a balanced diet can provide the nutrients the body needs to enhance the function and ability of the

immune system. For example, protein is one of the important nutrients needed by the immune system to promote the production and function of immune cells. Proteins not only participate in the formation of the basic tissues of the body, but also participate in the completion of various physiological functions, especially immune system functions. When protein is lacking, the content and activity of various enzymes, immunoglobulins, complements, etc. involved in the body's immune response are affected to varying degrees, and the body's immune system is also reduced to varying degrees. Antioxidants such as vitamins C and E protect immune cells from free radical damage, thereby improving the health of the immune system. Here are some dietary factors that affect the immune system:

Nutrient intake: The immune system needs a variety of vitamins, minerals, and nutrients to function properly, including vitamins C, E, A, D, B6, B12, folic acid, iron, zinc, copper, etc. Inadequate intake can lead to a compromised immune system and increase the risk of infection.

Healthy fats: Healthy fats can have a positive effect on immunity. Specifically, healthy fats can help maintain the normal function of the immune system, improve the body's resistance, and prevent disease. One type of healthy fat is unsaturated fatty acids, such as omega-3 fatty acids. Omega-3 fatty acids can reduce inflammation and help regulate the function of immune cells. Studies have shown that omega-3 fatty acids can reduce symptoms of certain autoimmune diseases, such as rheumatoid arthritis and inflammatory bowel disease, while also strengthening the body's resistance to bacteria and viruses. Another healthy fat is monounsaturated fatty acids, such as oleic acid found in olive oil. Oleic acid promotes healthy cell membranes and helps maintain normal cell function. It can also reduce cholesterol levels and improve cardiovascular health, thereby reducing the damage of cardiovascular disease to the immune system. Overall, healthy fats are important for both the normal functioning of the immune system and the body's immunity. It is recommended that people consume healthy fats in their diet, such as olive oil, fish, nuts, etc., to maintain the health of the body.

Dietary fiber: Dietary fiber has many positive effects on immunity. Firstly, dietary fiber can promote intestinal health. It will increase the diversity and quantity of gut microbiota, maintain a balance of gut microbiota, and reduce the growth of harmful bacteria, thereby reducing the risk of intestinal inflammation and infection, and improving gut immunity. Secondly, dietary fiber can reduce the level of chronic inflammation. Chronic inflammation is an important factor in weakened immunity. Dietary fiber can reduce chronic inflammation levels and improve immunity by regulating the activity of immune cells, increasing the intake of antioxidants, and reducing the release of inflammatory mediators. In addition, dietary fiber can promote the growth of probiotics. Probiotics are a beneficial microbiota for human health, which can help maintain a balance of gut microbiota, enhance intestinal immunity, and also help the body absorb nutrients to enhance immunity. In short, dietary fiber has many benefits for immunity. It is recommended to consume sufficient dietary fiber every day, including fruits, vegetables, whole grains, beans, and other foods, to maintain a healthy gut and immune system.

Sugar intake: Relevant studies have shown that a high sugar diet may have a negative impact on immunity. Long term high sugar diets may lead to an increase in the body's inflammatory response, causing damage to the function of immune cells, thereby reducing the body's immune system. A high sugar diet can lead to an increase in glycation end products in the body, which may damage the normal function of the immune system. Meanwhile, a high sugar diet may also lead to obesity and metabolic syndrome, which can also lower the body's immune system. A high sugar diet can inhibit the activity of white blood cells, reducing the body's resistance to infection. In addition, a high sugar diet may also lead to intestinal microbiota imbalance, further reducing the body's immune system. Therefore, in order to maintain good immunity, it is recommended to control sugar intake and avoid long-term high sugar diets as much as possible. The recommended sugar intake should be based on personal circumstances, and you can consult a dietitian or doctor.

Drinking alcohol: Drinking alcohol can have a certain impact on immunity. (1) Immune system damage. Long term alcohol consumption can lead to immune system damage, making the body susceptible to infection. (2) Reduced white blood cell count. Drinking alcohol can lead to a decrease

in white blood cell count, which is a major cell type that resists pathogen invasion. (3) Increased inflammatory response. Excessive alcohol consumption can increase the body's inflammatory response and reduce its resistance to infection. (4) Impact on certain immune responses. Research has shown that drinking alcohol can affect certain immune responses, such as cell-mediated and humoral immune responses. Overall, moderate alcohol consumption does not have a significant impact on immunity, but excessive alcohol consumption can lower immunity and increase the risk of contracting diseases. Therefore, it is recommended that everyone drink in moderation and pay attention to controlling the amount of alcohol consumed.

Preventive and Therapeutic Effects

Studies have shown that a balanced diet can prevent and treat viral diseases. Here are some suggestions. (1) Increase protein intake. Protein is an important component of the body's ability to make antibodies needed by the immune system. Increasing your intake of protein-rich foods, such as lean meats, poultry, fish, legumes, and nuts, can boost your body's immune system. (2) Eat more fruits and vegetables. Fruits and vegetables are rich in vitamins and minerals, which help improve immunity. In particular, foods containing vitamin C, such as citrus fruits, strawberries, spinach, peppers, etc., are very beneficial for strengthening the body's immunity. (3) Control sugar and salt intake. Excessive sugar and salt intake will weaken the body's immunity. Studies have shown that excessive sugar intake weakens the capacity of white blood cells, while excessive salt intake increases the risk of heart disease and high blood pressure. Therefore, sugar and salt intake should be minimized. (4) Drink enough water. Adequate water intake helps maintain good health. Water can help flush out toxins, maintain the body's normal metabolic processes, and maintain the body's water balance. (5) Avoid eating raw meat and seafood. Raw meat and seafood may carry bacteria and viruses, which can increase the risk of infection. Therefore, it is recommended to consume cooked and processed foods. In short, through a healthy diet, the body's immunity can be improved, thereby preventing and treating viral diseases.

Effects of Diet Type and Quality

Studies have shown that different kinds and qualities of diet have different effects on immunity. A balanced diet can provide the nutrients needed by the body to enhance the body's immune function and ability. Poor eating habits such as high fat, sugar, and salt will reduce the body's immunity and make the body more susceptible to infections. Therefore, developing healthy eating habits is one of the important means to improve immunity. Here are some key factors: (1) Nutrients. Various nutrients are essential for the function of the immune system. For example, nutrients such as vitamin C, vitamin D, zinc, and iron can boost the function of the immune system and help the body fight off disease. (2) Protein. Protein is an important nutrient needed by the immune system. It is recommended to consume high-quality protein foods such as lean meat, fish, shrimp, eggs, milk, soybeans, etc. daily. Try to ensure 1 egg and 300g of milk and dairy products per day to maintain a high level of immunity. (3) Food types. Dietary diversity is also very important for the function of the immune system. Consuming many types of foods can help the body get a variety of different nutrients and antioxidants, which can boost the function of the immune system. (4) Processed foods. Processed foods may reduce nutrient content, thereby reducing the function of the immune system. (5) Food quality. Food quality is also important. Pesticide-free, additive-free, and GMO-free foods may be healthier and help keep the immune system healthy.

Overall, a balanced diet and a variety of foods are key to maintaining a healthy immune system. It is recommended to eat more fruits, vegetables, whole grains, and foods rich in healthy fats, while limiting the intake of foods high in sugar, salt, and saturated fat. In addition, a proper diet plan and adequate water intake are also very important.

CONCLUSION

As a specific physiological response, the strength of the entire immune system function is particularly important during the epidemic. This article first analyzes the immune system and the immune function of the body, and then proposes to intervene in the function of the immune system through diet and various intensities of exercise. This study suggests that relying on human immunity is one of the best ways to defeat viral pathogens. In addition, improving immunity through different intensity of exercise is one of the more effective ways. Improving immunity requires moderate exercise with moderate intensity as the main focus, developing reasonable exercise duration and load, and following the principle of gradual progress. The group that has not participated in sports is based on low-intensity exercise, and then engages in moderate intensity exercise to reduce the duration of high-intensity exercise. At the same time, it is necessary to improve sleep quality, pay attention to nutrient intake, adjust the proportion of dietary structure, and increase the proportion of protein and vegetables.

DATA AVAILABILITY

The figures used to support the findings of this study are included in the article.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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