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Nutritional and dietary interventions for the treatment of Chronic Fatigue Syndrome

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Abstract

Background: Chronic fatigue syndrome is an increasingly frequent disorder characterized by prolonged fatigue and few specific symptoms. He favors prolonged stress and life in a constant hurry. The main symptoms of chronic fatigue include: headache, throat, myalgia, joint pain, short-term memory impairment, sleep disorders, malaise occurring after physical exertion and lasting over 24 hours, and painful lymph nodes. The possibility of chronic fatigue syndrome should be considered in patients with the above symptoms, if they persist for more than 6 months. In this review, we wanted to focus on the possibilities to minimize the symptoms of chronic fatigue syndrome through nutritional and dietary intervention.

Materials and methods: Analysis of articles in the EBSCO and Google Scholar database using keywords: Chronic Fatique Syndrome, nutritional, dietary interventions, treatment.

Results: Patients with chronic fatigue syndrome suffer from chronic fatigue and not specific symptoms, which makes diagnosis difficult. The analysis of articles shows that dietary and nutritional

interventions tailored to the patient reduce the feeling of fatigue, which is the main problem among patients with chronic fatigue syndrome. Positive effects in the form of alleviation of symptoms have been observed while using, inter alia: polyphenols, L-carnitine, probiotics, CoQ10 and NADH and GAA.

Conclusions: Dietary and nutritional intervention has a positive effect on intestinal microflora, intestinal mucosa, oxidative stress and proper functioning of mitochondria, thanks to which it reduces symptoms of chronic fatigue syndrome. Individual and appropriate supplementation depending on the etiology of the syndrome can lead to relief of symptoms.

Key words: Chronic Fatigue Syndrome, nutritional, dietary interventions, treatment

Introduction:

Chronic Fatigue Syndrome, also known as a myalgic encephalomyelitis (CFS/ME) [1], is a disabling illness characterized by unexplained, persistent and debilitating fatigue and a combination of accompanying symptoms [2]. There is no medical test available to confirm a diagnosis of CFS, but it is important to reach the diagnosis as early as possible so that appropriate advice and treatment can be started early on. A positive diagnosis of CFS is made in patients who have chronic fatigue of at least 6 months duration (which cannot be explained by any other disease) and who meet presented Table 1. Centres for Disease Control and Prevention (CDC) criteria for CFS, also known as Fukuda criteria from 1994 [2, 3]. Seven key symptoms for making an appropriate diagnosis of CFS are: post-exertional malaise or symptom exacerbation (CFS symptoms are worsening after any activity - physical or mental), exercise-induces muscle fatigue or muscle pain, cognitive dysfunction (commonly including problems with short-term memory and working memory), persistent or difficult to control pain, sleep disturbance, a general feeling of 'being unwell' accompanied by on- going, flu-like malaise (with sore throat, tender lymph glands and problems with temperature control - feeling feverish, sweating episodes) [3]. Along with the ongoing fatigue, it has also been reported that 97% of CFS patients report neuropsychological disturbances. Their symptoms are often part of anxiety and depressive disorders, including dizziness, lightheadedness, heart palpitations, appetite changes and shortness of breath [4]. Clinically, CFS is a heterogeneous, multifactorial and complex disorder that does not have a disease-specific biomarker. Research into the possible etiology and pathogenesis have shown a few different possible causes of this syndrome, but any of is not fully proved yet [3]. Some research show that patients with CFS have somatic disorders, IBS-like symptoms (irritable bowel syndrome) and intestinal microbial flora alterations [4]. That is why in this article we want to show possible ways of treatment CFS by dietary and nutritional interventions.

Table 1.

1994 Centers for Disease Control and Prevention case definition for CFS	
1.	The individual has severe chronic fatigue for 6 or more consecutive months that is not due to ongoing exertion or other medical conditions associated with fatigue (these other conditions need to be ruled out by a doctor after diagnostic tests have been conducted).
2.	the fatigue significantly interferes with a daily activities and work.
3.	The individual has four or more of the following symptoms: ● post-exertion malaise lasting more than 24 hours ● unrefreshing sleep ● significant impairment of short-term memory or concentration ● muscle pain ● pain in the joints without swelling or redness ● headaches of a new type, pattern ora severity ● tender lymph nodes in the neck or armpit ● a sore throat that is frequent or recurring
These symptoms persisted or recurred during 6 or more consecutive months of illness and they cannot have first appeared before the fatigue.	

Material and methods:

Articles in the EBSCO and the Google Scholar database have been analyzed. The available literature was subjectively selected due to its usefulness in showing potential benefits of nutritional and dietary interventions for CFS treatment. Moreover, literature which reveals inconsistency in results was shown as well. Finally 22 researches were analyzed in this review paper.

Results:

1. **Etiology of CFS**

Chronic Fatigue Syndrome is the pathology of unknown etiology and incompletely understood pathogenesis [1]. Although precise etiology of CFS is not fully elucidated and proved yet, but we have already strong suggests in researches that it can be cause by such a mechanisms like potentially viral infection, endotoxemia and immunological system activation, alterations in the gut microbiota, disruptions of intestinal mucosal barrier, chronic bowel inflammatory, oxidative stress and coenzyme Q10 deficiency or mitochondrial failure [2].

Etiology of CFS is multifactorial and it is impossible to found only one correct CFS trigger. The potential CFS causes, which are possible to treat by dietary and nutritional interventions, are gut microbiota alterations, mucosal barrier dysfunctions, gut inflammatory, brain-gut axis disturbances, oxidative stress and mitochondrial failure. So, proper, individual supplementation can lead to relieve in Chronic Fatigue Syndrome apart of its exactly etiology and seems to be unique and strongly expected alleviation for patients.

2. Supplementation of CoQ10 and NADH

NADH is a coenzyme that stimulates energy production by replenishing ATP cellular stores. The NAD / NADH ratio plays a ubiquitous role in regulating the metabolic state of the cell. Bearing in mind the role of these dinucleotides in maintaining normal cellular homeostasis during inflammation, subsequent studies of these compounds may improve understanding of the mechanisms underlying CFS [5].

Clinical trial design

Initially, 113 patients were enrolled in the CTS Clinical Unit (Vall d'Hebron Hospital, Barcelona, Spain) in the period from January to December 2013. There were 33 patients who did not meet the 1994 CDC Fukuda criteria [5].

8-week, randomized, double-blind, placebo-controlled experiments were performed. The benefits of CoQ10 (200 mg / day) plus NADH (20 mg / day) were evaluated. 73 patients met the CFS criteria and also met the Fukuda CDC criteria from 1994. The exclusion criteria from the study were:

-even infectious diseases in the last 4 weeks,

-pre-current or current neurological diseases,

- (depression / anxiety),

-metabolic, auto- immune, allergic, skin diseases, or chronic inflammatory disorders,

- habits like smoking, alcohol abuse,

- oral cavity diseases,

- medical conditions that required the use of glucocorticoids,

statins or antidepressants / anxiolytics,

-late or current breastfeeding [5].

Seventy-three women with CFS qualified for the study were randomly assigned to the CoQ10 plus NADH or placebo groups. After 8 weeks of CoQ10 plus NADH supplementation, a significant reduction in fatigue was observed in patients with CFS compared to placebo. It was allowed to use a simple analgesic NSAID, aspirin COX-2 inhibitors, two patients benefited. Thirty-nine people with CFS received oral CoQ10 Q10 (200 mg / day) plus NADH (20 mg / day).) Thirty-four patients with CFS received placebo. Adverse reactions have been reported according to the Medical Dictionary for Regulatory Aivity terminology. After 8 weeks of CoQ10 plus NADH supplementation, a significant reduction in fatigue was observed in patients with CFS compared to placebo. The role of NAD / NADH in the pathogenesis of CFS is not sufficiently documented. .73 patients with CFS in the stable phase were clinically treated with CoQ10 plus NADH and placebo. The NAD / NADH level was tested in blood mononuclear cells (BMCs). All patients were in a clinically stable phase. After 8 weeks, patients treated with CoQ10 plus NADH had a lower level of NAD compared to placebo. Moreover, in patients treated with CoQ 10plus NADH, the NADH level was higher and the NAD / NADH ratio was lower compared to placebo. It is likely that NADH has therapeutic significance in CFS because NAD / NADH levels are associated with impairment of mitochondrial function and hence disturbance of the bioenergetic state of the cell [5].

The results of the study indicate the relationship between BMCs levels NADH and NADH in CFS. The dysfunction of the pyridine nucleotide metabolism may result from impaired mitochondrial respiratory function. The reason for this may be the increased NAD / NADH ratio inducing the production of free radicals. The pyridine nucleotide is likely to be important in CFS due to the role that NAD plays in the metabolism of mitochondria and the integrity of the genome [5].

CoQ10 deficiency has been associated with a number of human disorders, some of which are caused by a direct defect in CoQ10 biosynthesis genes or a secondary consequence of other diseases (9). Since CoQ10 levels were suggested to be potentially a useful biological marker of mitochondrial dysfunction, we measured CoQ10 levels in BMC from patients with CFS treated versus placebo. A significant increase in CoQ10 levels was observed in patients treated with the CoQ10 plus NADH combination compared to the placebo group. CoQ10 plus NADH causes significant changes in mitochondrial function in CFS patients. All CFS patients measured total ATP levels in BMC. ATP was taken into account as an indicator of the bioenergetic level of the cell. CFS patients treated with CoQ10 plus NADH were shown to have significantly higher ATP levels than the placebo group. In addition, a significant increase in citrate synthase activity was demonstrated in patients treated with

patients compared to placebo. CFS function and mass of mitochondria has been shown to improve in patients with CFS after 8 weeks of CoQ10 and NADH treatment. The combination of these two cofactors weakens damage caused by oxidation. This is done by reducing lipoperoxides in people with CFS. What's more, CoQ10 and NADH have been proven to play the role of an antioxidant. To determine this, lipoperoxides in BMC were analyzed in patients with CFS compared to placebo. Treatment patients showed much lower levels of lipid peroxidation than placebo [5].

3. Supplementation of GAA

Cross-clinical clinical trials involving the study of GGA efficacy in the treatment of CFS were carried out in 1994 on a group of people over 18 years of age meeting the criteria of Centers for Disease Control and Prevention of Diseases. Exclusion criteria included:

- coexistence of mental illness,
- the use of any dietary supplement within four weeks before the start of the trial,
- unwillingness to return to further analysis,
-pregnancy [6].

Participants were divided according to the generated randomisation list and received GAA (2.4 g per day) or placebo by oral administration. The patients completed a Multidimensional Fatigue Inventory (MIF), a questionnaire containing 20 items in which global, physical and mental fatigue and reduction of activity and motivation are described. The results were in the range from a minimum of four to a maximum of 20, the higher the result, the greater the fatigue. The study included: locomotive pain measured using a visual analog scale (VAS), health-related quality of life (HRQL) was assessed using the SF-36 questionnaire. The level of participants' activity was monitored daily by means of actigraphy. The intensity, daily time of physical activity and active energy expenditure were examined, the values of which were processed by computer. Muscle efficiency, maximum blood pressure was analyzed using an isometric dynamometer. Endurance capacity was assessed using the incremental walk or run performed on the treadmill. The heart rate (HR) was recorded using the HR monitor. The serum and urine GAA serum creatine and creatinine were measured by HPLC with fluorimetric detection The total amount of serum homocysteine, blood count, glucose, total cholesterol, serum sodium, potassium and calcium levels, urine protein, blood, glucose were also analyzed [6].

The results indicated that general fatigue and musculoskeletal pain were not affected by three months of GAA supplementation in adult women with chronic fatigue syndrome. However, a daily intake of 2.4 grams of GAA for three months improved muscle and oxygen strength, while intervention did not affect to the aspects of physical exercise. GAA intervention was ineffective in increasing the daily duration of physical activity and active energy expenditure, according to the artistic evaluation. Supplementary GAA can be a real benefit for the CFS population to deal with daily physical activities. No side effects were reported during the study. The significant effect of using GAA for three months (2.4g per day) on muscle pain and fatigue in patients with CFS has not been reported. However, GAA reduced physical and mental fatigue and had a positive effect on the increase in muscle strength and maximum oxygen uptake [6].

4. Supplementation of pollen and pistil extract

In the treatment of Chronic Fatigue Syndrome an attention to pollen and pistil extract, which are easily available on the market in the form of tablets (Polbax), is also needed. The starting point of this reasoning was the study conducted by Krotkiewski et al., which proved the very high antioxidant activity of the extract [7]. Bearing in mind that antioxidant activity may significantly influence the treatment of CFS [8], an attempt was made to include the discussed preparation in ill persons. The research was conducted by Öckerman et al., and twenty-two patients took part in it, with a significant dominance of women (19). The study, consisting in administering pollen and pistil extract, was randomized, double-blind, crossed-over, and lasted three months. According to the results of the study, the use of this preparation has improved statistically significantly 7 relevant clinical symptoms, which are CFS components: fatigue, fatigability, sleep problems, depression, intestinal problems, cold hands and feet, and hypersensitivity to smoke and odors [9]. Therefore, the use of pollen and pistil extract seems to have a positive effect on the treatment of people suffering from Chronic Fatigue Syndrome, therefore further research should be conducted, confirming current observations.

5. High cocoa and low cocoa chocolate

Chocolate, especially its dark variety, rich in cocoa, and therefore with a high content of polyphenols, affects many metabolic processes in the body. It has a particular influence on the functioning of the nervous system, because, as it was proved in the research conducted by Di Tomaso et al., it increases the production and secretion of neurotransmitters, such as phenyl ethylamine, serotonin or anandamine in the brain [10]. On the other hand, there have been newer reports that some neurotransmitters, including the aforementioned serotonin, may affect the course of chronic fatigue

syndrome [11]. Bearing in mind the two presented facts, it was concluded that dark chocolate, rich in polyphenols, but also milk chocolate, but to a lesser extent (due to the lower content of cocoa and thus polyphenols) can have a positive effect on CFS treatment, by beneficial secretion of essential neurotransmitters in the course of the disease. Sathyapalan et al. conducted a study to confirm the assumption. The experiment was attended by 10 people (6 women and 4 men) suffering from CFS, and it consisted in serving chocolate rich in cocoa, and then measuring how such intervention affects the course of their disease. The study was randomized, double-blind and crossed-over. After 8 weeks of study, it was noticed that chocolate rich in polyphenols had a positive effect on the course of the disease, as determined using the Chalder Fatigue Scale. In turn, chocolate poor in polyphenols not only did not have a positive effect on the treatment process, but even had a negative effect [12]. The presented results confirm the positive influence of chocolate on CFS treatment, however, they emphasize that it is necessary to use chocolate rich in cocoa, and therefore with a high content of polyphenols. We should keep this in mind when creating a diet for people suffering from the discussed syndrome.

6. Supplementation of probiotics

Probiotics are cultures of bacteria or yeasts whose role is beneficial in the human digestive tract. They have the task of immunomodulating intestinal microflora, regulating the functioning of the gastrointestinal tract, and supply energy and vitamins to the intestinal epithelial layer, and consequently have beneficial effects on the health of the host [13]. Amount of bacteria present in the intestine depends on many factors, among them we distinguish: age, diet, medication, physical activity and stress. The group particularly exposed to disorders in the intestinal ecosystem are athletes. The most common problems in this group include food hypersensitivity, infection or chronic fatigue. The causes of these disorders are found in the disturbed intestinal ecosystem, the so-called intestinal dysbiosis [14,15]. To prevent this disorder, probiotics supplementation is used, the purpose of which is to restore the natural composition of intestinal microbiota, and thus increase the efficiency of the organism and reduce the incidence of infection [16,17]. In recent scientific research, you can read about the influence of intestinal pathogens on emotions. Researchers have hypothesized the therapeutic properties of probiotic bacteria in the context of mood disorders [18]. In their study, Benton et al., 132 subjects administered Lactobacillus casei Shirota or placebo. The results they received indicated that patients who at the beginning of the study had a lower level of probiotic bacteria, showed a significant improvement in mood after taking the probiotic, compared to the group that received placebo [19]. In 2009, the same bacterial strain was used by Rao et al. They studied people with chronic fatigue syndrome, and after 8 weeks of treatment they observed a reduction in aggression in people undergoing treatment [20]. Other strains were taken up by Messaoudi et al. They

studied supplementation with Lactobacillus helveticus R0052 and Bifidobacterium longum R0175 strains for the concentration of free cortisol and the severity of anxiety and depression symptoms measured by questionnaire methods. After 30 days of therapy, a 30-person study group showed a decrease in the level of anxiety and intensity of depressive behavior and a decrease in plasma cortisol [21]. Clarke pointed out that the probiotic strain Bifidobacterium longum 1714 exhibits memory-enhancing properties and reduces the symptoms of stress. The results of his research indicate that patients supplemented with the probiotic strain had significantly lower salivary cortisol concentrations. It was also noticed that the intensity of stress assessed by the Cohen self-assessment questionnaire was lower in volunteers receiving Bifidobacterium longum 1714. Moreover, the subjects from the study group achieved higher scores in cognitive tests compared to the placebo group [22]. It was confirmed that the brain bioelectric activity of people supplemented with probiotic was clinically better. Kato-Kataoka et al. Conducted his research on medical students. He used supplementation with fermented milk. He received results that illustrated a higher level of aggression, as well as cortisol in saliva, on the eve of exams, compared to people who took probiotics. In addition, he observed an increase in serotonin concentration in the group taking supplements as well as stress reduction [23].

In recent years, correlations between neuropsychiatry and gastroenterology have evolved into a new discipline, the so-called intestinal neurology. Studies have shown that intestinal bacteria can communicate with the central nervous system using vagus nerve fibers and a peripheral immune system. Experimental studies have shown that even small doses of microbes in the gastrointestinal tract that do not trigger an immune response are capable of affecting the neurotransmission in the pericellular palatal region, the central nucleus of the amygdala and the nucleus in the bed of the larynx end. All three regions are involved in the processing of emotions. All three regions are involved in the processing of emotions related to anxiety and mood. It is also true that quantitative changes in the composition of the intestinal microflora are a consequence of states of stress and fear or anxiety [24].

7. Supplementation of acetylo-L-carnitine and propionylo-L-carnitine

The most important function performed by carnitine (B-hydroxy-γ-trimethylammonium butyrate) is the transport of free fatty acids into the mitochondrial matrix in order to oxidize them in the b-oxidation process [25]. As demonstrated by acetyl L-carnitine (ALC) and propionyl L- carnitine (PLC) studies, they are important in eliminating clinical symptoms in chronic fatigue syndrome (CFS) [26]. This study was conducted on 90 patients with CFS according to the Centers for Disease Control and Prevention criteria (CDC) in a randomized controlled trial. These were polyclinic patients at the CFS Research Center Amsterdam. After randomization, patients were divided into three groups. The ALC group then received 2g of acetyl L-carnitine daily, the PLC group received 2g propionyl L-

carnitine and the third ALC + PLC group received 2g ALC and 2g PLC. In this study, the drugs were administered twice a day, after breakfast and supper for a period of 24 weeks. Due to side effects, 8 patients were excluded from the study (3 in the ALC group, 2 in the PLC group and 3 in the ALC+PLC group), because they experienced excessive excitability and insomnia. Then 8 patients were excluded in whom no therapeutic effect was demonstrated (4 in the ALC group, 1 in the PLC group and 3 in the ALC + PLC group). Finally, 2 patients were excluded for reasons not related to the treatment. The results of these studies were monitored after 8 weeks without treatment, and then after 8, 16 and 24 weeks of treatment, which present a clinical global impression of change.There was an improvement after 24 weeks of treatment in the ALC group in 59% of patients, in the PLC group in 63% of patients and in the ALC + PLC group in only 37% of patients. However, 10% in the ALC group, 3% in the PLC group and 16% in the ALC + PLC group felt worse. After the 24th week, treatment was discontinued, the table shows that after 2 weeks of discontinuation of treatment, 52% of patients in the ALC group deteriorated, in the PLC group in 50% of patients and in the ALC + PLC group in 40% of patients. In the ALC group and PLC there was a clinical global impression of change, while the ALC group showed a significant improvement in attention and mental fatigue. The PLC group showed an improvement in general and physical fatigue, but a little less concentration. The last ALC + PLC group has improved for general fatigue, but also to a lesser extent in the ALC + PLC group. physical and mental fatigue. The pain was not significantly affected by any of the drugs.

8. Natural antioxidative substances (NAIOSs) supplementation

The purpose of antioxidants is to defend the body against the harmful effects of reactive oxygen species. It turns out that natural antioxidants such as glutamine, N-acetyl-L-cystine or zinc (NAIOS) can be of great use in the treatment of chronic fatigue syndrome (CFS) [27]. Michael Maes and Jean-Claude Leunis conducted a study on the concentration of IgA and IgM in LPS gram-negative enterobacteria in patients suffering from CFS before and after taking NAIOS with a leaky gut diet during 10-14 months. Immunological changes and Fatigue Team Fatigue Scale were measured in 41 patients with CFS before and 10-14 months after NAIOS. Studies show that consumption of certain NAIOS weakens the IgM and IgA responses to LPS - NAIOS may be considered to reduce NAIOS intestinal inflammation (glutamine, NAC, zinc) are suitable for the treatment of increased intestinal permeability. Glutamine has the properties of alleviating intestinal damage. The studies proved that glutamine reduces the frequency of pancreatic infections, reduces the flow of mannitol through the epithelium and, above all, increases resistance to mucous membranes. Glutamine also stops bacterial translocations. Zinc removes permeability problems and improves intestinal barrier functions. NAC eliminates inflammation that comes from the gastrointestinal tract due to increased intestinal barrier function. Other NAIOS that have been used in the study: carnitine,

lipoic acid, coenzyme Q10 can stop the formation of oxygen free radicals or protect tissues along with mitochondria. NAC and lipoic acid reduce the oxidative stress that is the result of zinc deficiency. It can therefore be concluded that NAIOS, in the company of a leaky gut diet, may strengthen the weakened barrier in CFS. NAIOS given to patients had the ability to restore the holes of the connection barrier, accompanied by a decrease in activation of IO and NS resulting in a reduction in CFS annoyance. Natural antioxidants may have clinical applications in the fight against CFS because they weaken the pathways of IO and NS while restoring the intestinal barrier.

Conclusions

Based on studies, some dietary and nutritional supplements might be useful in Chronic Fatigue Syndrome treatment. CoQ10 and NADH supplementation has been shown to reduce CFS, although the role of NAD / NADH in the pathogenesis of CFS is not yet sufficiently documented. It is likely that NADH has very good therapeutic significance in CFS, which is due to the fact that NAD / NADH levels are associated with impaired mitochondrial function, which further relates to the disruption of the bioenergetic state of the cell. The results of the tests carried out for this purpose may indicate a relationship between the BMC levels of NADH and NADH in CFS.

In other studies, it was noticed that GAA supplementation does not affect general fatigue and musculoskeletal pain in a group of adult women with CFS. It affects the strength of muscles and oxygen. This supplementation is ineffective in increasing the daily duration of physical activity and active energy efforts, but using it as a supplement can bring benefits in dealing with daily physical activity. It was also noted that GAA reduced physical and mental fatigue and had a positive effect on the increase in muscle strength and maximum oxygen uptake.

The treatment of CFS should also pay attention to the pollen and pistill extract due to their very high antioxidant activity. The use of this preparation allows to improve 7 significant clinical symptoms that are components of CFS, i.e. fatigue, fatigability, sleep problems, depression, intestinal problems, cold hands and feet, and hypersensitivity to smoke and odors. It seems that the use of pollen and pistill extract has a positive effect on the treatment of people suffering from chronic fatigue syndrome, therefore it is believed that further research should be carried out for this purpose.

Further studies of chronic fatigue syndrome have found that dark chocolate, which is rich in polyphenols, as well as milk chocolate (though to a lesser extent) can have a positive effect in the treatment of CFS by favorably securing the necessary neurotransmitters in the course of the disease, as noted that serotonin, which is contained in chocolate, can affect CFS.

Supplementation with probiotics in CFS is designed to restore the natural composition of the intestinal microflora, thus increasing the efficiency of the body and reducing the incidence of infections, which is especially important in sportsmen. The obtained results indicate that patients with a lower pro-biotic level at the beginning of the study showed a significant improvement in mood after taking the probiotic compared to the placebo group. It was also noticed that patients using probiotics showed less stress, their brain bioelectric activity was better and they controlled their emotions more.

Other studies have shown that supplementation with acetyl L-carnitine and propionyl L-carnitine is important in the elimination of clinical symptoms. ALC affects a significant improvement in attention and mental fatigue, and the use of PLC improves overall and physical fatigue, but it has a lower impact on concentration than the use of ALC. It was also noticed that the mix of ALC and PLC also improves general fatigue, but to a much lesser extent than separately applying them.

It also appears that natural antioxidants such as glutamine, N-acetyl-L-cystine or zinc (NAIOS) can be very useful in the treatment of chronic fatigue syndrome due to the fact that natural antioxidants weaken the pathways of IO and NS, restoring the intestinal barrier. because a leaky intestinal diet affects the weakening of the barrier in CFS.

Discussion

Chronic fatigue syndrome is a complex disease that consists of many factors and its pathogenesis is not fully understood. Currently, there is no diagnostic test that could facilitate the diagnosis of this disease. Due to prolonged diagnostics, patients for many years do not know what they are suffering from, and this is associated with a number of costs spent by them on additional research and a significant reduction in their quality of life [28]. However, there are studies that indicate that supplementation of certain nutrients and modification of the patient's previous diet with CFS can positively affect his health. The aim of this study was to characterize the current results of CFS treatment using dietary and nutritional interventions.

Fatigue is often characterized as lack of energy, mental or physical fatigue, or reduced endurance. Literature indicates that there is a connection between the functioning of the mitochondrion in human cells and the occurrence of a condition such as CFS. One of the mitochondrial markers that has an effect on fatigue is CoQ10 [29]. This thesis is confirmed by the results of the study analyzed in this article, which was conducted in 2013, in which patients were supplemented with CoQ10 and NADH for 8 weeks. It was demonstrated that fatigue in people with CFS decreased as a result of using CoQ10 and NADH, compared to placebo [5]. However, further

research is still required, which will allow a more detailed exploration of the problem [29,5].

GAA supplementation showed no effect on muscle pain in patients with CFS, but resulted in increased muscle strength and maximum oxygen compared to the control group [6]. A similar effect of the improvement of physical activity performance after GAA was obtained in previous studies of 48 healthy people aged 22.3 to 23.8 years, in whom GAA was used at a dose of 1.2g / day and 4.8g / day. At that time, the tests were carried out for 6 weeks, and the results were evaluated on the basis of hand pressure measurements and extrinsic exercises, and also in this case the muscle endurance of people using GAA was higher compared to those in the placebo group [30]. Both examples of studies show that GAA supplementation has the effect of increasing muscle strength, but its use in the treatment of CFS should be investigated further.

In connection with the use of pollen and pistil extract as well as high coca and low cocoa chocolate in CFS therapy, it can be concluded that compounds with antioxidant activity help to alleviate the symptoms of CFS [9,12]. Such an effect of these substances may be the result of the fact that in a disease that is CFS there is a disturbance of the balance between prooxidants and antioxidants and there is an increase in oxidative stress, which is set at a higher level than in healthy people. In addition, damage to lipid and protein structures also occurs [31].

Currently, more and more scientific studies show the influence of intestinal microflora on human behavior. Disorders in its sphere and the presence of pathogenic microorganisms that secrete endotoxins may impair cognitive abilities and affect human mood [32]. Also in people with CFS, it was observed that the increase in the probiotic level by means of supplementation influenced better self-control and mood improvement than those not using probiotics or natural antioxidants [24,27]. In turn, the Supplementation of acetyl-L-carnitine and propionyl-L-carnitine, which was used in one of the studies on CFS, improved the concentration of patients compared to the placebo group. People who used these substances in this experiment also experienced a positive change in the reduction of mental fatigue. The best results were obtained with the use of acetyl-L-carnitine, and the weakest at the combination of acetyl-L-carnitine and propionyl-L-carnitine [26].

Currently, there are various studies showing the positive impact of certain nutrients and diet on improving the quality of life of people with chronic fatigue syndrome. However, these experiments are relatively small, which requires further research on this subject. With more data it will be possible to construct a specific treatment plan for people struggling with chronic fatigue, which will be based on scientific evidence and the most effective methods of therapy for patients for whom everyday life will become easier.

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