


## The importance of nutrition in the modulation of metabolic oxidative stress in cadets

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### ABSTRACT

The objective of this article is to discuss the importance of food in the modulation of metabolic oxidative stress in cadets. Stress is a natural response of the body when we are faced with a dangerous situation, thus causing physical and psychological changes. Cadets experience high levels of stress due to the physical and mental demands of military life. Both chronic stress and intense training lead to a greater generation of reactive oxygen species (ROS), requiring the action of antioxidant agents to neutralize ROS, avoiding metabolic oxidative stress (EOM). The stress level and strenuous training of cadets can lead to an imbalance of the redox system, due to the accumulation of reactive oxygen species and the depletion of antioxidants, causing oxidative stress. Diet can act by modulating EOM through nutrients such as vitamins C, E and A, zinc, selenium, flavonoids and carotenoids.

**Keywords:** Food, Antioxidants, Cadets, Oxidative stress.

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## INTRODUCTION

Since prehistoric times, there has been a recognition that man suffered exhaustion after work, fear, exposure to heat and cold, hunger, thirst, blood loss, or disease. Such situations triggered a series of biological and psychological outcomes, known today as stress<sup>1</sup>. However, it is important to understand how the concept of stress has evolved over the years, as social, historical, and cultural conditions influence the construction of the body of knowledge.

According to Kakasato; Carmona<sup>2</sup> stress is a wear and tear of the body in general, caused by a series of physiological adaptations of the organism, this expression was the object of study for the first time by Hans Selye, who through observation, noticed a series of identical symptoms in the same group of people. Such symptoms were: skin irritation, joint pain, enlarged liver, digestive disorders. Therefore, factors that cause physiological changes in the body are a lever that generates stress.

Stress is the biological attitude necessary for the organism to adapt to a new situation<sup>3</sup>. It is a natural response of the body when we are faced with a dangerous situation, in which this mechanism puts us in a state of alert, thus causing physical and emotional changes, so it is understood as a complete physiological event.

The concept of stress refers to a state that arises from the perception of stimuli that cause emotional tension and triggers adaptive processes through changes in homeostasis, which is characterized by an increase in adrenaline secretion that gives rise to a variety of systemic manifestations with physical impairment and psychological changes<sup>4</sup>.

According to Chiavenato<sup>5</sup>, stress is a complex of mental, chemical and physical reactions of a given individual to environmental stimuli. In this way, stress is a set of reactions that occur in an individual due to undesirable stimuli that exist in the environment. It characterizes the sum of organic and psychic disturbances caused by various aggressor agents, such as trauma, strong emotions, fatigue, exposure and conflicting situations.

Early medical research on stress examined a number of organic changes in the body when faced with an aggressive situation, situations often experienced by cadets during training and missions. The studies of Claude Bernard, a French physiologist, established the existence of specific mechanisms for protection against hunger, thirst, hemorrhage, and agents that could alter the normal parameters of body temperature, blood pH, blood glucose, proteins, fats, and calcium<sup>1</sup>.

The evolution of stress occurs through phases, each of which corresponds to different reactions. The first is the alert phase, in which the individual comes into contact with the stress-causing agent. The second is the resistance phase, when the body enters the process of homeostasis, being able to adapt to the problem or eliminate it. And finally, the exhaustion phase, where various physical impairments may arise in the form of a disease, such as gastrointestinal changes<sup>3</sup>.



The symptoms of each phase arise as a result of the body's neuroendocrine response to the stressor and involve two main axes, namely: hypothalamus-pituitary- cortex of the adrenal gland and hypothalamus-pituitary- sympathetic nervous system – medulla of the adrenal gland. Causing a series of hormonal releases such as Corticotropin Release Hormone (CRH), which stimulates the pituitary gland to increase the production of Adrenocorticotrophic hormone (ACTH), acting directly on the cortex of the adrenal glands stimulate the increase in the synthesis of corticoids (cortisol and aldosterone) and in the adrenal medulla, releasing catecholamines, adrenaline and noradrenaline into the bloodstream. The increase in these hormones will cause some symptoms such as changes in body weight, behavioral disorders, increased susceptibility to infections, hypertension, gastrointestinal changes, pupil dilation; increased sweating, heart rate and myocardial contractile force, among others<sup>1</sup>.

Health can be affected by the presence of aggressive factors (risk factors, overload factors), as well as by the absence of environmental factors (underload factors, lack of sufficient muscle activity, lack of communication with other individuals, lack of diversification of activities performed at work). Consequently, some stress is important for the performance of any activity and its total absence or excess can have repercussions on a pathological condition, causing transient disorders or serious pathologies such as occupational stress<sup>6</sup>.

According to Kings; Fernandes; According to Gomes<sup>7</sup>, stress has multiple etiologies and different models have been developed and validated to explain its causes, there is currently a growing attention to psychosocial factors at work, in which several studies point to ongoing changes in the work environment that lead to changes in the psychosocial environment that lead to illness.

Another point that deserves to be highlighted is the diet, because during stress, the body loses many vitamins and nutrients and, to compensate for this loss, it is recommended that they have a diet rich in B vitamins, vitamin C, magnesium, manganese and calcium, thus ensuring a good functioning of the body, as they are essential vitamins and nutrients mainly for the digestive and immune systems<sup>3</sup>.

Stressful life experiences are accompanied by a set of psychological and physiological responses that arise in the face of events or circumstances that are threatening, harmful, or challenging. Since the stress response system is an important adaptive mechanism designed to restore the body's lost balance, promoting defenses<sup>8</sup>.

Selye<sup>9</sup> in his studies identified that different organisms behave similarly when tested in sensory or psychological experiences. Sensory stressors are those that have a direct contact with the body, such as daily activities, running, climbing obstacles, temperature changes, adventure practices. Psychological stressors, on the other hand, are directly related to the mind, that is, the central nervous



system is stimulated through cognitive mechanisms, such as fights, public speaking, grief, environmental changes, dealing with sick people.

Another stressor that directly affects humans is the infection factor, caused by viruses, bacteria, parasites and fungi, which causes our body to release substances specialized in the destruction of unwanted invaders and that causes damage to our health, these substances are cytokines and white blood cells<sup>10</sup>.

Physiological stress is related to two systems of our body, the nervous and the endocrine, in which the natural process has its origin in the sense receptors, interconnected to each other through feedback mechanisms, thus ending up in the periphery of the body. Thus, the production of hormones is stimulated and regulated by parts of the brain, and it has an important connection with the endocrine glands, which will directly influence the effector organs, through hormones through the bloodstream<sup>11</sup>.

## CADETS' QUALITY OF LIFE VS. OXIDATIVE STRESS

Stress has been associated with perceptions of discomfort. These unpleasant sensations are perceptible by people in general, increasing the number of individuals affected by the symptomatic disease<sup>12</sup>.

Stress can come from both external and internal sources. Internal sources are linked to the individual's way of being, their personality type, reaction to the way of life, certainly sometimes an event itself is not the reason that constitutes stress, but the way it is interpreted by the individual. External stressors are related to certain demands of the individual's daily life, as well as work, social, family problems, death or illness of a family member, professional failure, frustration of unachieved goals, financial conditions, assault, violence, threats, among others<sup>13</sup>.

According to France; According to Rodrigues<sup>14</sup>, the actions generated by the phenomenon of stress are interconnected with the body's work to achieve adaptation. The author also points out that if the stressful trigger is too intense or long-lasting, it will lead to the development and appearance of diseases, because stress can leave the body fragile and open to diseases.

Among the diseases developed as a consequence of exposure to stressful factors, the following stand out: obesity, heart diseases such as hypertension and arrhythmias, diabetes, allergies, infections, asthma, bronchitis, migraine. Stress can also trigger problems such as depression, cognitive impairment, memory loss, among others<sup>15</sup>.

The gastrointestinal system is sensitive to the stimulus of a stressor. Studies conducted by Cabral *et al.*<sup>16</sup>, demonstrated that people who are under stressful actions produce a high demand of peptic digestive hormones in the urinary canal, thus, it is attested that stressful hormones are responsible for the increase in the production of peptic enzymes, which may favor the formation of



ulcers. In other words, these stomach lesions result from the increased demand for the flow of acidic juices, triggered by emotional afflictions that affect the stomach, which is weakened and unprotected by the mucus responsible for protecting the stomach walls. In addition, mucus is only produced when the body is in a state of homeostasis, under the command of the parasympathetic autonomic system.

The cadet faces a space with its own norms, academic tasks in which new study skills are required, and high levels of involvement, autonomy, and organization. Responsibilities and opportunities to explore experiments are added, with the possibility of building new projects, friendships and relationships<sup>17</sup>.

Military culture promotes the notion of strength and emotional control that fuels the desire to stand out from one's peers, especially in relation to mental health<sup>18</sup>. The peculiarities of military life and various situations that cadets encounter in their routine, such as overload in studies, anxiety related to psychological functions during the year, and some administrative disturbances during the day, cause excess stress and reduce the quality of life of cadets<sup>19</sup>.

The daily activities of cadets are already stressful in many areas since the beginning of the Training for career combatant officers of the army, with the performance of various theoretical and practical activities or even in environmental conditions, resulting in a strenuous routine. And that this stress produces a feeling of mild tension in some people and more accentuated in others, and this difference is due to biological factors inherent to each organism, as well as to the individual himself, who decides how to respond to the stress factor<sup>20</sup>.

Cadets are an important group to consider when associated with gastrointestinal health, as they undergo intensive training. Their lifestyle can significantly affect the health of the gastrointestinal tract and, consequently, its ability to perform its functions effectively<sup>21</sup>. Stress levels can vary depending on the stage of training they are in and the pressures they face in their personal and professional lives. However, it is common for them to experience high levels of stress due to the physical and mental demands of military life.

According to Teixeira:

Long workloads, distance from family and homes, strenuous physical activities, labor rights that differ from the universal nature and, in some situations, life-threatening, are some examples of what can make the profession more stressful<sup>21</sup>.

According to Rodrigues *et al.*<sup>22</sup>, Military Physical Training (TFM) is defined as the regular practice of Physical Education in the military environment. Such training aims to develop physical, cognitive, psychological, and social skills and prepare to participate in eventual missions, such as close confrontations and war. In view of this, it is necessary to search for better muscular endurance and intense musculoskeletal development in view of the high demands required in Military



Organizations (OM). However, these same service members are in a situation of vulnerability due to insufficient rest and stress.

Such factors can compromise performance in the long term and cause the onset of chronic musculoskeletal injuries. These injuries occur due to inappropriate training or poor physical fitness for the practice, i.e., anthropometric aspects, excessive training and incorrect execution of the movement are their main causes<sup>23</sup>.

The TFM was developed to train its service members, both from the army and from other forces, in order to strengthen their cardiopulmonary and neuromuscular systems, favoring the gain of muscle mass. In addition, the promotion of quality of life and health involves encouraging the practice of regular physical exercise as a way to combat sedentary lifestyle, a condition that is directly related to risk factors, such as cardiovascular diseases<sup>24</sup>.

When the individual is in a chronic state of stress, cortisol levels are soon elevated, which provide greater energy outputs. For this reason, a higher production of ATP (Adenosine triphosphate) is required. However, the fact of increasing the ROS index will not necessarily cause an increase in the levels of antioxidant enzymes or facilitate the entry of these molecules into the cell. Thus, it is understood that chronic stress has psychosocial influences, it is linked to stress with oxidative damage<sup>25</sup>.

In certain training sessions, it is necessary to obtain energy in the aerobic and anaerobic form from various energy supply systems, taking into account the duration and intensity, favoring the production of oxidative free radicals (RLOs) in a significant way, having an adequate recovery system through antioxidant agents, the RLOs are quickly neutralized, avoiding a picture of metabolic oxidative stress<sup>26</sup>.

During exercise, there is a significant increase in the demand for O<sub>2</sub>, which is 10 and 15 times higher than the expenditure at rest. As a result, there is a greater production of free radicals, which can be the cause of the origin of some muscle injuries or the aggravation of others. According to Turrens<sup>27</sup>, metabolic oxidative stress (EOM) resulting from the practice of high-intensity physical exercise is probably caused by the invasion of leukocytes in the damaged muscle areas.

During exercise, there is an increase in the plasma concentration of antioxidants, giving rise to a defense mechanism mediated by vitamins E and C, beta-carotene, coenzyme Q10 and selenium with the intention of neutralizing ROS. In other words, it can be stated that both competitive exercise and daily physical activity aiming at a better quality of life increase the production of ROS, while stimulating antioxidant defense mechanisms, and the final balance will be positive. Concomitantly, a balanced nutrition, as part of a healthy lifestyle, provides the exogenous supply of antioxidant agents through food and supplements containing antioxidants, which reduces the possibility of EOM<sup>26</sup>.





Oxidative stress is characterized by the intracellular accumulation of oxygen and nitrogen-reactive compounds called nitrogen ROS (ERN), and usually occurs in cells as a consequence of an imbalance of the redox system, due to excess ROS accumulation, and antioxidant depletion (AOX) or both<sup>28</sup>.

Human metabolism contains a detailed antioxidant defense system, with defensive triggers ready to counterattack free radicals, which are formed respectively in the normal cell organism from pathological factors, but when free radicals become excessive, they can provide the oxidation of biological molecules. Therefore, it is at this moment that the imbalance between oxidative damage and the defensive capacity of the body's antioxidants occurs, which is called oxidative stress<sup>29</sup>.

The occurrence of this chronic imbalance has direct implications for the appearance of numerous pathologies, such as chronic non-communicable diseases, including atherosclerosis, diabetes, obesity, neurodegenerative disorders and cancer<sup>30</sup>. Ferrari's study<sup>31</sup> reaffirms that the production of free radicals triggers pathological events that, in turn, are involved in cardiovascular, carcinogenic and neurodegenerative processes.

It is necessary to have a balance between the intensity of training and the rest time for the different stages of training, as well as a balanced diet and healthy lifestyle habits, such as sleeping eight hours a day, not using tobacco and not drinking alcoholic beverages, this will allow the body to have an adequate system of antioxidant production and not accumulate free radicals. If these factors are not taken into account, it will lead to a significant accumulation of ROS, which can result in injuries, decreased performance, and the onset of chronic fatigue<sup>26</sup>.

## ANTIOXIDANTS IN FOOD AS A MODULATING FACTOR OF OXIDATIVE STRESS

Food is one of the most important environmental factors that humans are exposed to on a daily basis. The type and quality of food consumed are extremely important not only for their nutritional value, but also for the ability of nutrients and bioactive compounds to interact with the genome<sup>32</sup>.

The study by Pasiakos *et al.*<sup>33</sup> demonstrated the adoption of unhealthy eating habits by young soldiers, revealing a high intake of foods with high caloric density, rich in saturated fats and sugars, on the other hand, a reduced consumption of fruits, vegetables, legumes and, consequently, dietary fiber and antioxidants. This survey, conducted with 209 young U.S. military personnel, found that all of them did not meet the recommendations regarding the ideal consumption of total and saturated fat, fiber, fruits and vegetables.

Similar results were found in a study conducted with male military personnel of the Brazilian Air Force (FAB) in São Paulo, in which low fiber intake was present. Only 2.3% of the study population reported consuming foods that were sources of fiber as recommended<sup>34</sup>. In addition, the



food intake of the cadets of the Brazilian Air Force Academy (AFA) showed a profile of inadequate eating habits, with high consumption of fatty foods and low fiber sources<sup>35</sup>.

Healthy eating refers to the intake of foods that are sources of vitamins, minerals, and fibers<sup>36</sup>. Many studies have demonstrated the existence of several chemical compounds with biological activity in foods, evidencing the presence of compounds with antioxidant and anti-inflammatory properties in foods such as fruits, vegetables, nuts, and fish<sup>37</sup>, compounds that are capable of neutralizing the harmful effects triggered by metabolic oxidative stress<sup>38</sup>.

An antioxidant is responsible for slowing down or inhibiting the oxidation of a substrate. Due to its stability, it donates an electron to the free radical, neutralizing it. Thus, the antioxidant defense system minimizes the levels of free radicals, allowing essential functions of the body to continue unharmed<sup>39</sup>.

The antioxidant defence system acts by sacrificing its own molecular integrity in order to prevent the molecules from undergoing changes<sup>40</sup>. Antioxidants are substances that, when present, are able to slow or inhibit oxidation rates.

Antioxidant agents regulate and keep the body in full function by fighting the action of free radicals. When there is a production of radicals that exceeds the production of antioxidant agents, cellular integrity is degenerated, shaking the functional structure of the organism, thus, the influence of free radicals requires a balance between the production and inactivation of these molecules by means of cells and tissues<sup>41</sup>.

Therefore, studies on bioactive compounds, antioxidants and anti-inflammatories, and the Nrf2/Keap1 pathway, have shown that they act indirectly on oxidative stress, thus showing the numerous benefits of foods rich in phytochemicals naturally present in food. In the group of these bioactive compounds are the polyphenols that are present in plant foods, such as curcumin present in turmeric, resveratrol found in grapes and peanuts, sulforaphane in cabbage and broccoli, epigallocatechinagalate (EGCG) present in green tea, and phenolics that, like polyphenols, are also secondary metabolics, acting as a potent modulator of signaling pathways in the process of oxidative stress<sup>32</sup>.

According to Bianchi; According to Antunes<sup>42</sup>, antioxidants act at different levels in the protection of organisms. The first defense mechanism against free radicals is to prevent their formation, mainly by inhibiting chain reactions with iron and copper. Antioxidants are able to intercept free radicals produced by cellular metabolism or exogenous sources, preventing the attack on lipids, amino acids of proteins, double bonding of polyunsaturated fatty acids and DNA bases (deoxyribonucleic acid), preventing the formation of lesions and loss of cellular integrity. Antioxidants achieved in the diet, such as vitamins C, E and A, flavonoids and carotenoids, are extremely important in intercepting free radicals. Another protective mechanism is to repair the





damage caused by free radicals. This process is related to the removal of DNA molecule damage and reconstitution of damaged cell membranes

Vitamin E is a cell signaling molecule and stands out for its antioxidant properties. Its main sources are vegetable oils rich in polyunsaturated fatty acids, seeds, nuts, and whole grains, asparagus, avocados, berries, green leafy vegetables, and tomatoes<sup>43</sup>.

Flavonoids are part of a class of natural compounds in which important biological activities have been reported, acting against allergies, viruses, inflammation, vasodilation and especially their antioxidant activity. Among the flavonoids, anthocyanins stand out, which are a group of natural pigments that are found in the composition of many red fruits and dark vegetables, with a high concentration in the skins of dark grapes<sup>44</sup>.

Vitamin C or ascorbic acid has a reducing capacity, in addition, this vitamin can also reduce ROS. Its main function is to participate in various reactions, as a cofactor, which require reduced copper and iron as water-soluble antioxidants that act in intra- and extracellular environments. Its main sources are vegetables, citrus fruits, and legumes<sup>43</sup>.

Zinc is a component of many enzymes (approximately 300 enzymes), participating in numerous enzymatic reactions. It is also necessary for the action of various hormones. Oysters are one of the main food sources, with a good concentration of zinc, as well as seafood, fish, liver and red meat, poultry, whole grains, legumes, brewer's yeast, corn and some vegetables. Selenium, on the other hand, stands out for its antioxidant capacity, for participating in the conversion of T4 (thyroxine) into T3 (triiodothyronine), and for providing protection against the action of heavy metals and biotic xeno, in addition, it contributes to reducing the risk of chronic non-communicable diseases and strengthening the immune system<sup>43</sup>.

Carotenoids are involved in the production of vitamins, which is related to a decreased risk of macular degeneration, cataracts, and chronic non-communicable diseases (NCDs). In addition, it prevents neoplastic diseases and protects DNA against oxidative stress, due to its antioxidant action<sup>45</sup>. Foods such as carrots, pumpkins and spinach are examples of abundant sources of carotenoids, precursors of vitamin A.

Thus, the concept of nutrition is understood as a biological process in which organisms, using food, assimilate nutrients to carry out their vital functions. And when it comes to the cadets' diet, it is of utmost importance that they are well nourished, as they are going through intense and rigorous training that demands a lot from their bodies. A balanced and healthy diet is essential to provide energy, maintain physical and mental health, as well as ensure good performance during training<sup>46</sup>.



## CONCLUSION

It is common for cadets to experience high levels of stress due to the physical and mental demands of military life, putting their health in a situation of vulnerability. Lifestyle, stress level, unbalanced diet and strenuous training are some of the factors that can cause the imbalance of the redox system, due to the accumulation of reactive oxygen species and the depletion of antioxidants, causing metabolic oxidative stress.

Therefore, it is necessary for cadets to take extra care with their diet, prioritizing the consumption of vegetables, fruits and vegetables in general, which have a range of antioxidants and nutrients in their composition, including vitamins C, E and A, zinc, selenium, flavonoids and carotenoids. These components contribute to the homeostasis of the body by neutralizing the damage caused by oxidative stress, such as the emergence of chronic non-communicable diseases, such as cancer, obesity, diabetes, cardiovascular diseases, neurodegenerative diseases and others.



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