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Tipo de trabalho: TRABALHO COMPLETO (MÍNIMO 08 PÁGINAS, MÁXIMO 15 PÁGINAS)

OXIDATIVE STRESS INDUCED BY INTENSE PHYSICAL EXERCISE: A REVIEW[1]

Zenon Ratzlaff Júnior[2], Caroline Thérèse Aygadoux Martins[3], Lucas De Matos De Oliveira[4], Juliana Maria Fachinetto[5]

[1] Work developed at the Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ);
[2] Academic of the Bachelor degree in Biological Sciences of Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ), zenon.ratzlaff@gmail.com;
[3] Academic of the Bachelor degree in Biological Sciences of Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ), scholarship of the Programa de Educação Tutorial - PET Biologia/MEC/SESU;
[4] Academic of the Bachelor degree in Biological Sciences of Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ);
[5] Professor of the Dept. of Ciências da Vida (DCVida) the Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ), Research Group Biodiversidade e Meio Ambiente (AMBIO), juliana.fachinetto@unijui.edu.br.

Abstract

Oxidative Stress is characterized by the presence of free radicals reminiscent of oxidative phosphorylation, whose composition may have harmful effect to cell integrity. In Intense physical exercise, the levels of oxidative stress increase on average ten times. This study gathered references regarding the association between oxidative stress and intense physical exercise, and categorised these data by the occurrence in each area of knowledge. The descriptor was used: oxidative stress intense exercise, in the electronic bases SciELO and PubMed. In PubMed, 77 papers presented the requirements for the review, while in SciELO there were 4. The area of Biochemistry presents a greater number of studies. The practice of intense physical exercise involves enzymatic activities and naturally produces reactive oxygen species. However, it is widely accepted that the practice of the same, leads the organism to the improvement of its protection systems, thus minimizing the collateral damage.

Introduction

The generation of free radicals constitutes a continuous and physiological process, performing relevant biological functions. During the metabolic processes, these radicals act as mediators for the electrons transfer in the various biochemical reactions. Its production, in appropriate proportions, enables the generation of ATP (energy), through the electron transport chain. However, excessive production can lead to oxidative damage (FERREIRA; MATSUBARA, 1997; SHAMI; MOREIRA, 2004).

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The process of oxidative stress (OS) occurs by the existence of an imbalance between oxidant compounds and antioxidants, in favor of the excessive generation of free radicals or to the detriment of the removal efficiency of these. This process leads to the oxidation of biomolecules with consequent loss of their biological functions and/or homeostatic imbalance, whose manifestation is the potential oxidative damage against cells and tissues (HALLIWELL; WHITEMAN, 2004).

Regular moderate training promotes the production of free radicals (FRs) and other reactive species (WANG; LEE; CHOW, 2006; FISHER-WELLMAN; BLOOMER, 2009). This also results in beneficial effects, including decreased cholesterol and maintenance of healthy muscles, bones and joints. In addition, they also reduce (or help to maintain) body weight and/or body fat (WARBURTON; NICOL; BREDIN, 2006). However, all these (and more) effects can be obtained only when the reactive oxygen and nitrogen species (RONS) are in moderate amounts (SUZUKI *et al*., 1996; REID, 2001).

After an exhaustive exercise, the consequent excessive flow of oxygen promotes the production of RONS at levels much higher than the removal rate. This results in an imbalance between RONS and the complex antioxidant defense system (SJODIN; WESTING; APPLE, 1990). The consequent oxidative damage due to the oxidation of lipids, proteins and DNA, makes the physical exercise no longer benefits the body, but causes damages, making the body more susceptible to fatigue and often to lesions and diseases (DAYAN *et al*., 2005; POWERS; JACKSON, 2008).

The antioxidant supplementation can reduce the amounts of RONS, however, it is not necessarily beneficial. The antioxidant supplement can be harmful to the body because in its presence there is no need to increase the production of antioxidant enzymes (RISTOW; SCHMEISSER, 2011), besides addition to reduce the concentration of RONS below the range required for the effective functioning of the immune system and/or for intracellular signaling (GOMEZ-CABRERA, 2008; RISTOW; SCHMEISSER, 2011).

In this sense, this review to performed a bibliographic analysis of the OS under intense physical exercise, describing the most relevant conclusions of the studies found, focusing on the mechanism of protection and/or remediation solutions to the OS induced by Intense physical exercise. In addition, it was developed a categorization of the occurrence of studies in their respective areas of knowledge.

Methodology

This is a descriptive bibliographic review study, developed with the scientific production indexed in the SciELO and PubMed databases, which focus on the OS induced by intense physical exercise for several purposes.

The review explored the specific theme: oxidative stress induced by intense physical exercise. We searched for the publications developed in the last 20 years, covering the period between 1999 and 2019.

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In the electronic databases (SciELO and PubMed), the following descriptor was used: oxidative stress intense exercise. The requirements for the results to be used in the review were that the studies should present OS under intense physical exercise, besides respecting the temporal clipping.

A description of the main bibliographic analysis of the OS under intense physical exercise was performed, with a focus on the most relevant results. In addition, a categorization of the studies in thematic areas was made, such as:: Biochemistry, Cell Biology, Genetics, Phytochemistry, among others.

Results

A total of 227 articles was found, of which 81 (35%) correspond to the review criteria. These, 77 (95%) found in the PubMed electronic base and 4 (5%) in the SciELO database.

Of the 81 articles found, 35 (43%) related to the Biochemistry, 18 (22%) Cell Biology, 13 (16%) Pharmacology, 9 (11%) Phytochemistry and 6 (8%) to the Genetics area.

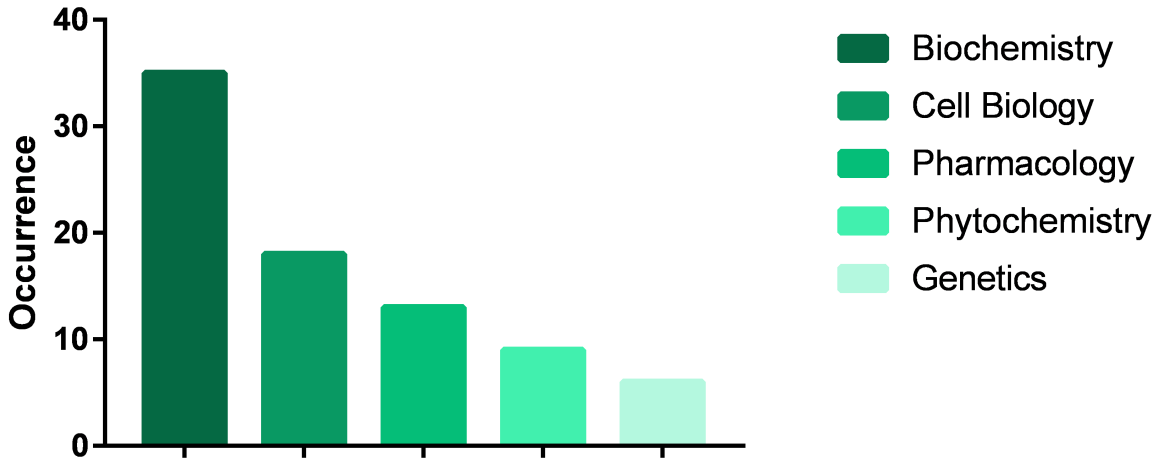

Figure 1. Occurrence of articles on oxidative stress (OS) induced by intense physical exercise indexed in the PubMed and SciELO databases, classified by thematic areas. The temporal clipping ranged from 1999 to 2019. Source: this study.

The revised articles indicate a wide variety of protocols and techniques. They present researches related to humans, rats, birds, among other experimental models. In addition, these revised studies present a great bibliographical potential.

Discussion

When exposed to situations of stress, the organisms react with a chain of events intending to

provide energy for reactions of "fight or flee". This means accelerated the metabolism enough to maintain cells working, prioritizing vital functions and responses of emergency. However, there is an overcharge: degrading levels much higher than the habit, cells aren't able to deal with waste left by chemical reactions, called free radicals, or reactive oxygen species (ROS). These are substances with at least one electron non-paired in its orbit, with huge potencial of damage to DNA, once it links easily to hydrogen of chain, removing it from its place.

In sight of ROS levels increasing, body's preventive reaction, intending self-preservation against collateral damages, is raise antioxidant substancy's production to decompose such radicals. This composes may be endogenous, or got by diet – that deficiency of antioxidants in alimentation might be a cause of raising ROS amount in body tissues.

Although its efficacy is not completely proved, antioxidants supplementation is a practice seen as preventive and likely to improve performance on physical activities, once it enhances preexistent available reducers agents on cells. By decreasing consequential degenerative process, related diseases as cancer, Alzheimer and Parkinson would suffer a huge decrease on its chances of development (KERKSICK; WILLOUGHBY, 2005).

It's logical to think, then, that an organism constantly exposed to physical efforts would need a powerful system, capable of neutralize harmful metabolic combing. In the association between physical activities and better life quality, due to higher levels and more effectiveness of antioxidants in cells, what affects since potential risks of degenerative diseases until aging general process, even tough these ones are not totally explained, and there are still many questions to be made (FINKLER; LICHTENBERG; PINCHUK, 2014).

Something observed in nature is migratory birds' capacity of, along migration time, decompose intensely the body fat reserves without lethal damages in consequence of ROS accumulation. By control of endogen production of antioxidants, the absorption of larger amounts of reducers substances between migration and during rest along the flight – this increases stock of "sacrifices molecules" to reduce ROS – or an association of both factors, what is seen is a refined preservation mechanism, which may explain how the phenomenon works in other animal species.

However, researches show that birds metabolism – and so their ROS production – even being faster than mammals', produces significantly lower levels of oxidative molecules, what by itself could elucidate, halfway, the ability of keeping a balance in redox reactions in organism, even when under extreme efforts. However this doesn't eradicates harmful consequences to animal tissues; sometimes an entire season of specific diet is needed to repair all damages caused by long flights. Even though, it's very clear the adaptation to keep under control the effects of oxidative stress in this animal class. Furthermore, in the cell membranes of birds can be found fat acids farther resistant to fat peroxidation, and their metabolisms consume lipids in metabolic ways,

resulting in higher amounts of energy, with less prejudicial sediments generation.

Free radicals levels comparison, between migrations birds during flight and after rest, shows huge damages in fat and muscular tissues caused by effort; at the same time, recovering time from most of species uses be extremely short, pointing to a coexistence of diet factors – a change in diet gives preference to antioxidants elements – and organics – alterations in metabolism to produce oxid-reducers and repair mechanisms acting together in answer to physical stress elevation, with the purpose to maintain organism integrity (COOPER-MULLIN; MCWILLIAMS, 2016).

Despite of similarities among birds and mammals, metabolic organizations and physicochemical answers to stress presents divergences, making necessary research in species genetically closer to humans, so can be understood how the events occur in *Homo sapiens* organism. Considering the injurious potential of free radicals, it is interesting have a closer look over defensive mechanisms established on mammals nervous system, notably a tissue with extreme low activities of repair and regeneration.

A study led in eight healthy men compared blood flow in brain, during rest and after exhaustive exercise loads. Results show that exercises promoted an increase in encephalic vascular permeability, without cause injuries by tissues overload with ROS, due to the good flow of antioxidants directed to the region during stress (BAILEY *et al*., 2011).

As previously mentioned, it is widely accepted that that the exercise takes organism to upgrade its protection systems; though, how does it prefiro occur and the effect of different kind of exercises an metabolism remains as a persistent ask. To elucidate at least part of this question, a research conducted by 30 male rats Wistar, at four weeks of age, in three groups: control (CON), jumping exercises (JE) and treadmill (TE). JE and TE, along eight weeks, were submitted to a “physical training” to posterior check and comparison of results.

The results show, as expected, was an intense increase in ROS levels of organisms, specially those submitted to exercises non-aerobic, more intense and less extended (JE). At the same time, TE and JE presented significant elevation also in antioxidants presence on tissues, the best balance was obtained in TE group, an indication of aerobic exercises of lower charge and more extended as most matching with desirable physical development, with the lowest collateral damages, and even upgrades of short, medium and high-term in immunological system. This occurs because lower loads are less injurious to cells, avoiding apoptosis or extreme inflammation – that happens more often in anaerobic activities and heavier works – so tissues are able to provide an influxe of antioxidants and precursors to be used in reduction of oxidative elements. The habit creates not only a larger stock of this substances, but makes easier starts its metabolisms and synthesis when necessary (LEE *et al*., 2017).

Conclusion

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Oxidative stress is usually linked to deleterious effects. The practice of intense physical exercise involves enzymatic actions and produces ROS naturally (for example, peroxide of hydrogen, hidroxil radicals and superoxide free radicals). However, an excessive production of ROS may affect the redox state of central neural system (CNS), injuring the DNA, lipids and metabolism proteins.

On the other hand, this same practice produces antioxidants, which acts since the remotion oxygen from ambient, sweeping of ROS, capitation of metal catalysts of endogenous antioxidants or even interaction from more than one mechanism. But, even immunological system answering this way in various modalities of exercise, the medium load aerobic ones are selected as more suitables to physical development, with the least collateral (oxidative) damages.

Everyway, it can be said that biochemical science is the most active in development of researches in this domain, followed by cell biology, pharmacology, phytochemistry and genetic. This classification is evidenced by biochemistry promoting of studies focused on cellular metabolism, face the answers under OS, what results in a larger amount of researches by this area.

Results show that there is an enormous interest in understanding relation between oxidative stress and intense physical exercise. Researches already published represent a good basis to continue studies using intense physical exercise as an inductor of oxidative stress. It was possible to perceive that the most of them presents new scientific hypotheses which, with its dates here collected, can be investigated more profoundly.

Beyond analyzed articles, others 146 studies utilizing the sentence were found, which can, in some way, influence and/or stimulate a new knowledge.

Keywords: exhaustive exercise, free radicals, reactive oxygen species, antioxidants, oxidative damage.

References

BAILEY, D. M. et al. Exercise-induced oxidative-nitrosative stress is associated with impaired dynamic cerebral autoregulation and blood-brain barrier leakage. **Experimental Physiology**, v. 96, n. 11, p. 1196–1207, nov. 2011.

COOPER-MULLIN, C.; MCWILLIAMS, S. R. The role of the antioxidant system during intense endurance exercise: lessons from migrating birds. **The Journal of Experimental Biology**, v. 219, n. Pt 23, p. 3684–3695, 01. 2016.

DAYAN, A. et al. Effect of a short-term graded exhaustive exercise on the susceptibility of serum lipids to oxidation. **International Journal of Sports Medicine**, v. 26:732-8. 2005.

FERREIRA, A. L. A.; MATSUBARA, L. S. Radicais livres: conceitos, doenças relacionadas, sistema de defesa e estresse oxidativo. **Revista da Associação Médica Brasileira**, v. 43(1):61-8. 1997.

FINKLER, M.; LICHTENBERG, D.; PINCHUK, I. The relationship between oxidative stress and exercise. **Journal of Basic and Clinical Physiology and Pharmacology**, v. 25, n. 1, p. 1–11, fev. 2014.

FISHER-WELLMAN, K.; BLOOMER, R. J. Acute exercise and oxidative stress: a 30 year history. **Dynamic Medicine**, v. 8:1. 2009.

GOMEZ-CABRERA, M. C. et al. Oral administration of vitamin C decreases muscle mitochondrial biogenesis and hampers training-induced adaptations in endurance performance. **The American Journal of Clinical Nutrition**, v. 87. 2008.

HALLIWELL, B.; WHITEMAN, M. Measuring reactive species and oxidative damage in vivo and in cell culture: how should you do it and what do the results mean? **British Journal of Pharmacology**, v. 142(2): pg. 231-55. 2004.

KERKSICK, C., WILLOUGHBY, D. The Antioxidant Role of Glutathione and N-Acetyl-Cysteine Supplements and Exercise-Induced Oxidative Stress. **Journal of the International Society of Sports Nutrition,** v. 2:38. 2005.

LEE, S. et al. The effects of exercise load during development on oxidative stress levels and antioxidant potential in adulthood. **Free Radical Research**, v. 51(2). pg. 176-186. 2017.

POWERS, S. K.; JACKSON, M. J. Exercise-induced oxidative stress: cellular mechanisms and impact on muscle force production. **Physiological Reviews**, v. 88. pg. 76. 2008.

REID, M. B. Invited review: redox modulation of skeletal muscle contraction: what we know and what we don't. **Journal of Applied Physiology**, v. 90. pg. 31. 2001.

RISTOW, M.; SCHMEISSER, S. Extending life span by increasing oxidative stress. **Free Radical Biology & Medicine**, v. 51. 2011.

SHAMI, N. J. I. E.; MOREIRA, E. A. M. Licopeno como agente antioxidante. **Revista Nutrição**, v. 17. pg. 36. 2004.

SOJODIN, T.; WESTING, Y.; APPLE, F. Biochemical mechanisms for oxygen free radical formation during exercise. **Sports Medicine**, v. 10. pg. 236. 1990.

SUZUKI, K. et al. Effects of exhaustive endurance exercise and its one-week daily repetition on neutrophil count and functional status in untrained men. **International Journal of Sports Medicine**, v. 17. pg, 205. 1996.

WANG, J. S.; LEE, T.; CHOW, S. E. Role of exercise intensities in oxidized low-density lipoprotein-mediated redox status of monocyte in men. **Journal of Applied Physiology**, v. 101. pg. 4. 2006.

WARBURTON, D. E.; NICOL, C. W.; BREDIN, S. S. Health benefits of physical activity: the evidence. **Canadian Medical Association Journal**, v. 174. pg. 9. 2006.