The effect of Ginseng on physical activity

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ABSTRACT

The practice of physical activity causes an increase in the production of free radicals, which can lead to the destruction of cellular macromolecules causing fatigue and muscular injuries. In this sense, Ginseng is exemplified - an herb derived from East Asia and commonly used as a tonic that prepares the body for stressful situations by improving energy levels and blood circulation. It was realized a review on the databases: PubMed; EMBASE, Web of Science. Thus, 338 articles were found, of which 69 were selected for the study. The intake of Ginseng exerted effects on the immune system, increasing the mRNA expression, of mitochondrial biogenesis factors, mitochondrial DNA content, and plasma concentrations of PCR and IL-6. In addition, it increased the activity of enzymes such as lactate dehydrogenase, creatine kinase, citrate synthase and antioxidant enzymes, and decreased urea nitrogen, lactic acid, hepatic glycogen reserves, lipid peroxidation and protein oxidation. Exceeding the effects already mentioned, the phytotherapics increased the resistance to the physical exercise, improved the motor capacity in practice, as well as induced fatigue. The Ginseng, as phytotherapics, exerted positive effects on the body submitted to physical activity, however, it is emphasized the importance of conducting studies on humans, regular practitioners of physical activity.

Key words: Ginseng, physical activity, supplementation, exercise.

INTRODUCTION

Sedentary behavior has been pointed as a determinant factor to the installation and development of rheumatics and even oncologic diseases. In contrast, the regular practice of physical activity is beneficial because it has protective health effects due to its inductive capacity of anti-inflammatory and anti-atherogenic effects (Antunes et al., 2017; Meneguci et al., 2016; Cardoso et al., 2016; Paschoal and Naves, 2016).

However, the practice of high intensity and long term physical activity may suppress the immune system and cause cellular damage (Antunes et al., 2017). Athletes in high intensity training program, particularly involved in resistance events, seem to be more susceptible to infections resulting from the reduction of their immunocompetence. The magnitude of the infectious process is related to several factors, such as duration and intensity of the training, macro and/or micronutrient deficiencies, high oxidative stress generated by increased production of reactive oxygen and nitrogen species, and reduction of intra and extracellular antioxidant systems (Paschoal and Naves,
The benefits of physical exercises are directly associated with the miocinas production (such as myostatin, IL-6, IL-7, IL-8, IL-10, IL-15, LIF) and activate the immune system cells (monocytes/macrophages, neutrophils) in order to direct the satellite cells to the site of muscle damage with the objective of initiating the remodeling process and repair. To initiate the whole process, neutrophils are the first cells to be installed in the skeletal muscle by increasing the release of reactive oxygen species (ROS) or by favoring the recruitment of monocytes for phagocytic action and/or increase cytokine secretion in an attempt to recruit a larger number of defense cells (Antunes et al., 2017). After infiltrate on the target tissue, the monocytes become macrophages, which increase the production of cytokines in the interstitial spaces, attracting new monocytes chemo attractant molecules, which will induce phagocytosis of apoptotic and necrotic muscle cells. The first macrophages to accumulate at the onset of inflammation are characterized as M1; when they become active in the tissue recovery process, mediated by cytokines such as IL-10 and tumor growth factors (TGFβ1), increasing proliferation of myoblasts and myofibrillar growth, are polarized in the antiflammatory macrophages (M2). M2 macrophages also have the ability to produce insulin-like growth factor 1 (IGF-1) and vascular endothelial growth (VEGF), increasing the number of blood vessels, blood flow and, again, inducing proliferation of myoblasts and differentiation of satellite cells, which result in the formation of new myofibrils (Figure 1) (Antunes et al., 2017).

Furthermore, the manipulation of the variables in the physical exercise, such as the type of stimulus (aerobic or anaerobic), frequency of stimulus (acute or chronic), intensity and volume, eccentric or concentric contraction and recovery intervals, can influence (positively or negatively) the process of recruitment of cells of the immune system (Antunes et al., 2017). Besides, it is important to also emphasize the valorization of the metabolic response in situations of practice of intense physical exercise, since the function of the immune system of athletes is closely related to the energy metabolism.

The energetic metabolism of the immune system cells is extremely refined, using mostly glucose, glutamine, fatty acids and ketone bodies (Antunes et al., 2017). Proteins, lipids and carbohydrates are possible sources of muscle fuel. The glycolytic pathway is restricted to glucose, which may originate from the carbohydrate in diet or may be synthesized from the carbon skeletons of certain amino acids through the gluconeogenesis process. The Krebs cycle is fed by two carbon fragments of fatty acids and carbon skeletons of specific amino acids, especially alanine. All of these substrates are mostly used throughout the exercise. However, the duration and intensity of the exercise determine the relative rates of substrate utilization (Possebon and Oliveira, 2006).

In this sense, it is also stated that, the fuels that support physical activity are glucose, fatty acids and, to a small extent, amino acids. The body use several fuel mixtures in different moments, depending on the intensity and the duration of the activities and also, previous training. Usually, the body uses nutrients according to the type,
duration and intensity of physical activity. Stored glucose from muscle glycogen, for example, is an important fuel for physical activity. Muscle glycogen provides most of the energy that the muscles use to get into action for a short time, and as the activity continues, messenger molecules, including the hormone epinephrine, flow into the bloodstream in order to signal the liver and adipose cells to release their stored energy nutrients, especially glucose and fatty acids. So, the hormones are organized to release energy to the muscles and they use the fuels that are passing in the blood (Possebon and Oliveira, 2006).

The hormonal factors are also closely related to the immunometabolic response. The adrenalin and cortisol are two examples of hormones that respond to physical exercise at the same time that they modulate the lymphocyte metabolism, besides being dependent on the intensity and duration of the stimulus. The adrenaline can stimulate the lymphocyte proliferation and increase the glucose and glutamine consumption being that high intensity exercises can generate effects of immunosuppression, reducing the activity of key enzymes that impair the metabolism of glucose and glutamine. Cortisol, in turn, is considered an immunosuppressive hormone, especially also in high-intensity exercise, impairing proliferative capacity of lymphocytes between 30 min to two hours after physical exertion (Antunes et al., 2017).

Physical exercise causes an increase in oxygen consumption, causing an increase in the production of free radicals, which can lead to the destruction of cellular macromolecules such as lipids, proteins and nucleic acids, causing muscular fatigue and muscular injuries, potentiating oxidative stress, decreasing physical performance and may even lead to overtraining. Thus oxidative equilibrium, through antioxidant nutrition, becomes essential to counterbalance the effects of excessive free radical production and avoid organic imbalances that may compromise performance, such as frequent repetitive muscle injuries, tendinitis, bursitis, among others (Paschoal and Naves, 2014).

In this sense, it is important to emphasize the use of herbal medicines because they play an important role among physical activity practitioners, especially athletes, in terms of maintaining health and fitness (Possebon and Oliveira, 2006).

The consumption of herbal medicines is a therapy characterized by the use of medicinal plants in their different pharmaceutical forms without the use of isolated substances, although of vegetal origin. One of the justifications for using it is the desire for a more natural way of life and there is a growing belief that every natural product is healthy and safe. And what have put these herbal medicines in the spotlight are advances in the scientific and technical knowledge of quality, safety and efficacy characteristics (Oliveira and Cordeiro, 2013).

Thus, the properties of Ginseng, a traditional herb derived from East Asian countries, have been emphasized (Palaniyandi et al., 2017). The physical appearance of the herbal remedy is similar to radish. In addition, it has slow growth, which takes at least six years of cultivation. The traditional use of Ginseng is like a tonic that help the body deal with stress of all kinds and also, widely used to improve energy levels and increase blood circulation (Maham et al., 2005).

The main bioactive components of Ginseng are steroid saponins called ginsenosides (Palaniyandi; Suh; Yang, 2017). Ginsenosides consist of a type of glycoside constituted by triterpenesaponins, to which one or more monosaccharaides are bound; it also confers physical resistance, since it eliminates the free radicals of oxygen and unsaturated fatty acids responsible for the destabilization of the cellular membrane through lipid peroxidation, which increase during physical exercise (Lima et al., 2015).

The use of nutritional supplements as ergogenic resources is employed through dietary manipulations capable of delaying the onset of fatigue and increasing the contractile power of skeletal and/or cardiac muscle, thus enhancing the ability to perform physical work, that is, the athletic performance (Possebon and Oliveira, 2006).

Therefore, considering that physical activity and sports practice are responsible for much of the consumption of supplements, this review sought to demonstrate scientifically the biochemical impacts of Ginseng supplementation on physical exercise practice.

MATERIALS AND METHODS

Research strategy

It was conducted a review through the selection of articles based on already published randomized controlled clinical trials. The study language was limited to English and Portuguese with no restrictions for the status and/or year of publication, and the research was realized at July 2017.

Electronic researches

Electronic researches was realized at PubMed (1996-2017), EMBASE (1974-2017), and Web of Science (2000-2016). For searches, key words, such as Ginseng and Exercise, were used with filter application for Clinical Trials. Consequently, 338 articles were found.

Study types

For the construction of this review, we focused on studies
that had practitioners of physical activity who used or participated in an experiment with Ginseng and / or its components.

Participants

There were included athletes and practitioners of physical activity who exercised for professional and/or health reasons. The sample presented in the studies could not deal with some diseases. The included studies were clinical trials on humans of both sexes and also animals.

Interventions

In the analysis of the studies, it was observed, the use of Ginseng in the sample in the form of capsules, roots and as topical use. The phytotherapeutic has been reported in numerous studies as being used in isolation. In other studies, its consumption has been presented to be associated with supplements and other herbs. Also, its saponins, Ginsenosides and other compounds that are constituted in it were administered in isolation in many studies. In observations, it was noted that the herb is commonly used in combination with hormone replacement therapy.

Among the interventions mentioned, the most frequents are as follows:

- Ginseng associated to fish oil and valerian;
- Ginseng, protopanaxadiol and protopanaxatriol;
- Ginseng associated to testosterone hormone replacement therapy;
- Ginsenosides Rb1;
- Capsules de Rg1;
- Steroids of Dammarane (chemical compounds present in the Ginseng);
- Red Ginseng;
- IH901 (intestinal metabolite of Ginseng);
- Wild Ginseng;
- Ginsenosides Rh2;
- Extract of Ginseng;
- Chinese, Koreans and Americans Ginsengs;
- Ginsengsaponins complex;
- Panaxnotoginseng (PNG).

Study selection

Titles, abstracts, and keywords were reviewed for all records retrieved from searches of the databases mentioned above to determine if the studies would meet the inclusion criteria. For the divergent cases, there was a discussion to reach a consensus.

Data extraction

For the analysis of the studies, a Data Extraction Table was set up, in which information were collected as: study objective, intervention and model used, association of phytotherapy with drug, food and / or supplement, dosage administered by the sample, level of evidence, type and purpose of the practice of physical exercise and outcomes related to the metabolism and immune system.

Quality evaluation

To assess the quality of the selected studies, the Amstar Protocol - a measurement tool to evaluate systematic reviews, was used to create decision-making opportunities in precise, succinct, credible, comprehensive and comprehensible summaries of the best evidence available, minimizing error and bias.

The studies selected in this review received Amstar score 8 in 11 points, which in percentage terms represents 73%. Because it is a protocol with excellent reliability, it is possible to judge that the selected studies are good scientific sources. Thus, considering the databases, 69 articles were included in this review, which had a complete analysis of the text (Figure 2).
Table 1: Main immunological outcomes observed in selected studies.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Intervention Dosage</th>
<th>Model (n)</th>
<th>Type of exercise</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bao et al., 2016)</td>
<td>Oligopeptide of <em>Ginseng</em> (125, 250 and 500 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>↑ mRNA expression ↑ factors of mitochondrial biogenesis and mitochondrial DNA content in skeletal muscles.</td>
</tr>
<tr>
<td>(Lin et al., 2016)</td>
<td><em>Panax ginseng</em> and <em>Salvia miltiorrhiza</em></td>
<td>Humans (23)</td>
<td>Cycling (Downhill)</td>
<td>↑ plasma concentrations of C-reactive protein and IL-6.</td>
</tr>
<tr>
<td>(Hou et al., 2015)</td>
<td>Capsules of Rg1 (5 mg/kg)</td>
<td>Humans</td>
<td>Ergometric exercise</td>
<td>Suppressed exercise-induced increases in the reactive substance of thiobarbituric acids; reversed the increase of TNF-alpha; ↓ the IL-10 mRNA of the quadriceps muscle against exercise challenge; did not affect PGC-1 alpha and GLUT4 mRNA of exercised muscle, ↑ of pro-inflammatory change.</td>
</tr>
<tr>
<td>(Estaki and Noble, 2015)</td>
<td>Aqueous and alcoholic extract of Ginseng (300 mg/kg)</td>
<td>Animals</td>
<td>Downhill run</td>
<td>↓ levels of infiltrating neutrophils in the soleus muscle and ↓ of damage and inflammation induced by eccentric exercise.</td>
</tr>
<tr>
<td>(Yu et al., 2014)</td>
<td>Steroids of Dammarane (20, 60, 120 mg/kg)</td>
<td>Animals</td>
<td>Downhill run</td>
<td>↑ signaling of NFkB, TNF-alpha and IL-6 mRNA, 3-nitrotyrosine, glutathione peroxidase and glutamylocysteinesynthetase in skeletal muscle. There were no detectable increases in necrotic muscle fibers or CD68 + M1 macrophages. ↑ muscle strength, centronucleation, IL-10 mRNA expression and number of CD163 + M2 macrophages. Potentiation of baseline inflammation and production of anti-inflammatory effects on skeletal muscle after exercise.</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Immunological Aspects

Among athletes and coaches, there is a common perception that high training loads and competitions, applied in a chronic way, with inadequate nutritional control and/or recovery periods, can reduce immunologic resistance, increasing predisposition to infection episodes. Exercise may lead to an immunosuppressive condition, if it is performed intensively and/or for prolonged periods that outweigh the physical limitations of the athletes or when the recovery period is insufficient. This overload in the immune system is related to increases in neutrophil counts and decrease in circulating lymphocytes, reduction of lymphocyte proliferation and the cytotoxicity of Natural Killers (NK) cells, increase in lymphocytes apoptosis, reduction of mucosa immunity due to the decreasing serum concentrations of specific antibodies, specially IgA immunoglobulin and the increasing serum concentrations of proinflammatory cytokines, specially IL-1β interleukin, IL-6 and tumor necrosis factor TNF-α (Dias et al., 2017).

As a result, it is important to emphasize the effect of herbal medicines, such as Ginseng, on the immune system. In this sense, there is an increase in mRNA expression, mitochondrial biogenesis factors and mitochondrial DNA content in swimmers who ingested Ginseng Oligopeptides (Bao et al., 2016). Besides that, the intake of the supplement is capable of increasing the plasma concentrations of C-reactive protein and IL-6 (Lin et al., 2016; Hou et al., 2015; Yu et al., 2014). Physical activity associated with proper diet and regular physical activity habits synergistically improves health by enhancing immune function (Romeo et al., 2010), as shown in Table 1.

Metabolic aspects

The use of Ginseng and/or its compounds also exerted metabolic effects on the sample in several selected studies. With ingestion, it was possible to observe an increase in the activity of enzymes such as lactate dehydrogenase, creatine kinase, citrate synthase and antioxidant enzymes (Bao et al., 2016; Lin et al., 2016; Hou et al., 2015; Lee et al., 2013; Voces et al., 2004). Although a number of studies found an increase, in another study, it was observed a decrease in the activity of creatine kinase and citrate synthase enzymes (Lee et al., 2013). There was also a decrease in urea nitrogen, lactic acid, hepatic glycogen reserves, lipid peroxidation and protein oxidation (Bao et al., 2016;
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<tr>
<td>(Yu et al., 2014)</td>
<td>Red Ginseng</td>
<td>Animals</td>
<td>-</td>
<td>Regulation of mRNA expression above Cu / Zn-SOD and the muscle regulating factor.</td>
</tr>
<tr>
<td>(He et al., 2013)</td>
<td>Blood sample</td>
<td>Humans (236)</td>
<td>-</td>
<td>Previous coinfection with cytomegalovirus or Epstein Barr virus promotes protective immune surveillance to reduce the risk of upper respiratory tract infections.</td>
</tr>
<tr>
<td>(Lee et al., 2013)</td>
<td>IH901 (25, 50 and 100 mg/kg)</td>
<td>Animals (8)</td>
<td>Eccentric exercise</td>
<td>Beneficial effects on anti-inflammatory activities through down regulation of pro-inflammatory mediators.</td>
</tr>
<tr>
<td>(Jiang et al., 2012)</td>
<td>Rg1</td>
<td>Animals</td>
<td>Swimming</td>
<td>↑ density of the dendritic column and neurogenesis of the hippocampus. There was no effect on the monoaminergic system.</td>
</tr>
<tr>
<td>(Estaki and Noble, 2012)</td>
<td>North American Ginseng extract (300 mg/kg)</td>
<td>Animals</td>
<td>Acute exercise</td>
<td>↓ levels of creatine kinase and ↓ membrane rupture. Immunosuppressive actions of polysaccharides attenuate leukocyte activation.</td>
</tr>
<tr>
<td>(Megna et al., 2012)</td>
<td>Herbs supplements (Echinacea, Rhodiola, Ginseng)</td>
<td>-</td>
<td>-</td>
<td>Improved exercise-induced stress tolerance related to enhancement of the entire immune system and reduction of oxidative damage.</td>
</tr>
<tr>
<td>(Jung et al., 2017)</td>
<td>Extract of Panax ginseng (20 g/day)</td>
<td>Humans (18)</td>
<td>Running</td>
<td>↓ on exercise-induced muscle damage and inflammatory responses, resulting in improvements in insulin sensitivity.</td>
</tr>
<tr>
<td>(Romeo et al., 2010)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Physical activity ↑ immune function. Although proper diet and regular physical activity habits can improve synergistic health, clinical trials in athletes using nutritional supplements to counteract immune suppression have not been conclusive.</td>
</tr>
<tr>
<td>(Thomas et al., 2009)</td>
<td>Ergometric tests (Sprints of 6 × 8s with breaks of 30s)</td>
<td>Humans (17)</td>
<td>Cycling</td>
<td>There were significant changes in salivary cortisol and testosterone concentrations, but there were no changes for IgA. The results confirm that high intensity exercise produces hormonal responses, but does not affect immune function.</td>
</tr>
<tr>
<td>(Biondo et al., 2008)</td>
<td>North American Ginseng extract (<em>Panax quinquefolius</em>) (1125mg)</td>
<td>Humans (10)</td>
<td>Moderate exercise</td>
<td>↓ the peripheral blood concentration of CD8 + T cells and ↑ the production of T cells stimulated by mitogens of interleukin-2. Ginseng had no effect on total white blood cell count, neutrophil concentrations, monocytes or lymphocytes (CD3 +, CD4 +, CD16 +, CD20 +). The effect is limited on the immune response to an acute exercise protocol.</td>
</tr>
<tr>
<td>(Wei, 2008)</td>
<td>Ginseng G115</td>
<td>Animals</td>
<td>Eccentric exercise</td>
<td>Positive detection of antidesmina and anti-vimentin antibodies. ↓ percentage of negative cells. The anti-vimentin immune reaction was raised at each post-exercise time point. ↓ expression of desmin and vimentin.</td>
</tr>
<tr>
<td>(Hwang et al., 2007)</td>
<td>Ginseng</td>
<td>Animals (36)</td>
<td>Swimming</td>
<td>↓ of the mitogenic activities of splenocytes in response to the exhaustive exercise stress, ↓ of the proliferative activity of lymphocytes in concanavalin A or lipopolysaccharide after exhaustive stress. ↓ of peritoneal ROS responses and levels of lymphocyte DNA damage after exhaustive exercise.</td>
</tr>
</tbody>
</table>
Table 1 Contd: Main immunological outcomes observed in selected studies.

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</thead>
<tbody>
<tr>
<td>(Pannacci et al., 2006)</td>
<td>Panax Ginseng G115 (25 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>↑ expression of TLR4 and the release of cytokines.</td>
</tr>
<tr>
<td>(Engels et al., 2003)</td>
<td>Ginseng G115 (400 mg)</td>
<td>Humans (38)</td>
<td>Bodybuilding</td>
<td>There was no improvement in physical performance and heart rate recovery.</td>
</tr>
<tr>
<td>(Ferrando et al., 1999)</td>
<td>Ginseng extract</td>
<td>Animals</td>
<td>Aerobic exercise</td>
<td>↑ in hematological parameters, a and production of the effects obtained after the long-term exercise.</td>
</tr>
</tbody>
</table>

Table 2: Main metabolic outcomes observed in selected studies.

<table>
<thead>
<tr>
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<th>Model (n)</th>
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<th>Outcomes</th>
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</thead>
<tbody>
<tr>
<td>(Ma et al., 2017)</td>
<td>Changbai Mountain Ginseng (4, 5 or 25 mg / kg / day)</td>
<td>Animals (24)</td>
<td>Swimming</td>
<td>↑ strength of grip and time of resistance in swimming; ↓ levels of serum lactate, ammonia, creatine kinase and blood urea, nitrogen and glucose levels after the practice of acute exercise. ↑ of glycoprotein in the gastrocnemius muscle. ↑ protein, total glucose and muscle mass. There was improvement in physical performance and ↓ of fatigue.</td>
</tr>
<tr>
<td>(Takamura et al., 2016)</td>
<td>Panaxatriol (0.2 g/kg)</td>
<td>Animals</td>
<td>Resistance exercise</td>
<td>↑ at the phosphorylation levels of Akt, p70S6K and ERK1 / 2. ↑ muscle protein synthesis through mTORC1 signaling in skeletal muscle.</td>
</tr>
<tr>
<td>(Lee et al., 2016)</td>
<td>UGO712 (500 and 100 mg/d)</td>
<td>Humans (117)</td>
<td>Resistance and aerobic training</td>
<td>↑ significant in VO2 and muscle strength during physical training. There were no defined changes in lactic acid levels over time. There was no difference in muscle strength during physical training.</td>
</tr>
<tr>
<td>(Bao et al., 2016)</td>
<td>Oligopeptide of Ginseng (125, 250 and 500 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>↑ lactate dehydrogenase activity and levels of hepatic glycoprotein; ↓ the accumulation of serum urea nitrogen and blood lactate acid.</td>
</tr>
<tr>
<td>(Lin et al., 2016)</td>
<td>Panax ginseng and Salvia miltiorrhiza</td>
<td>Humans (23)</td>
<td>Cycling (Downhill)</td>
<td>↑ plasma creatine kinase concentration and ↑ arterial stiffness.</td>
</tr>
<tr>
<td>(Oh et al., 2015)</td>
<td>Ginseng, protopanaxadiol and protopanaxatriol (50 and 100 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>Inhibition of corticosterone, lactate and creatinine levels.</td>
</tr>
<tr>
<td>(Hou et al., 2015)</td>
<td>Capsules of Rg1 (5 mg/kg)</td>
<td>Humans</td>
<td>Ergometric exercise</td>
<td>↑ post-exercise glycogen replenishment and ↑ the activity of the enzyme citrate synthase in skeletal muscle</td>
</tr>
</tbody>
</table>

Hwang et al., 2007; Lee et al., 2013) (Table 2).

Other aspects

Besides the influence on the metabolic and immune systems, the intake of Ginseng associated with physical activity, in general, increased the resistance to the exercise, improved the motor skills in practice, as well the induced fatigue. Furthermore, it caused a decrease in lipid peroxidation, improved blood circulation, increased resistance to aerobic exercise, and increased body muscle strength. In addition, a number of other effects were exerted, as shown in Table 3.

Due to the effects of several exercises, were selected studies that addressed the use of Ginseng associated with physical activity which did not influence in any aspect, making the physical capacity and body function
<table>
<thead>
<tr>
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</thead>
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<tr>
<td>(Estaki and Noble, 2015)</td>
<td>Alcoholic and aqueous extract of Ginseng (300 mg/kg)</td>
<td>Animals</td>
<td>Downhill run</td>
<td>↓ levels of plasma creatine kinase</td>
</tr>
<tr>
<td>(Hwang et al., 2014)</td>
<td>Red Ginseng (1 g/kg)</td>
<td>Animals (42)</td>
<td>-</td>
<td>Promotion of fat oxidation and glycogen sparing effect during exercise. This can lead to a delay in peripheral fatigue during the performance of resistance exercise.</td>
</tr>
<tr>
<td>(Yu et al., 2014)</td>
<td>Red Ginseng</td>
<td>Animals</td>
<td>-</td>
<td>↓ glutamic oxaloacetic transaminase levels and glutamic pyruvic transaminases, hepatic malondialdehyde; ↑ levels of muscle glycogen, glucose-6-phosphate dehydrogenase and lactate dehydrogenase activities. Protection against oxidative stress induced by exercise, as well as improved exercise and performance capacity.</td>
</tr>
<tr>
<td>(Yu et al., 2013)</td>
<td>Red Ginseng</td>
<td>Animals</td>
<td>-</td>
<td>↓ levels of glutamic oxaloacetic transaminase, glutamic pyruvic transaminase and MDA. ↑ in muscle glycogen levels, G6PDH activity and lactate dehydrogenase activity. Regulation of SOD and MRF4 gene expression.</td>
</tr>
<tr>
<td>(Lee et al., 2013)</td>
<td>IH901 (25, 50 and 100 mg/kg)</td>
<td>Animals (8)</td>
<td>Eccentric exercise</td>
<td>↑ significant resistance to exercise and ↓ plasma levels of creatine kinase and lactate dehydrogenase. ↑ citrate synthase and antioxidant enzymes and ↓ lipid peroxidation and protein oxidation.</td>
</tr>
<tr>
<td>(Jiang et al., 2012)</td>
<td>Rg1</td>
<td>Animals</td>
<td>Swimming</td>
<td>It regulated the BDNF signaling pathway in the hippocampus and in the corticosterone level in the regulated serum.</td>
</tr>
<tr>
<td>(Korivi et al., 2012)</td>
<td>Panagin DS-1227 (60 mg/kg)</td>
<td>Animals (120)</td>
<td>Induced exercise</td>
<td>↓ elevated levels of exercise-induced malondialdehyde and levels of carbonyl protein. ↑ the activity of the enzyme xanthine oxidase. ↓ activity of glutamate-cysteine ligase. No change in Catalase enzyme activity. Protects the liver against oxidative stress induced by exhaustive exercise.</td>
</tr>
<tr>
<td>(Jung et al., 2011)</td>
<td>Extract of Panax ginseng (20 g/day)</td>
<td>Humans (18)</td>
<td>Running</td>
<td>↓ levels of plasma CK and IL-6. ↓ glucose and insulin.</td>
</tr>
<tr>
<td>(Dong et al., 2011)</td>
<td>Age LOC (0.4 or 0.8 g/kg)</td>
<td>Animals</td>
<td>Resistance exercise</td>
<td>↑ the capacity of resistance exercises; improved metabolism of mitochondria bioenergy and attenuation of the increase induced by the exercise of lactic acid in the blood.</td>
</tr>
<tr>
<td>(Yeh et al., 2011)</td>
<td>Saponin complex of Ginseng (4 capsules - 2 g each)</td>
<td>Humans (14)</td>
<td>Cross Over</td>
<td>Supplementation was effective in promoting the use of free fatty acids and in improving the exhaustive performance of the cycling test in humans.</td>
</tr>
<tr>
<td>(Yang et al., 2011)</td>
<td>LOC Vitality (0.4 or 0.8 g/kg)</td>
<td>Animals</td>
<td>-</td>
<td>↑ in swimming time, cellular glycogen levels and antioxidant capacity after exercise. It improves the exercise abilities of resistance and attenuation of functional and biochemical changes due to muscular aging.</td>
</tr>
<tr>
<td>(Lau et al., 2010)</td>
<td>Panax notoginseng (3 g)</td>
<td>Humans (53)</td>
<td>Aerobic exercise</td>
<td>↓ acute postprandial glycemia in non-diabetic men.</td>
</tr>
</tbody>
</table>
### Table 2 Contd: Main metabolic outcomes observed in selected studies.

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<tr>
<td>(Hsu et al., 2005)</td>
<td>American Ginseng (Panax quinquefolium)</td>
<td>Humans (13)</td>
<td>Running</td>
<td>↓ production of plasma creatine kinase during exercise. It did not increase the capacity of aerobic work.</td>
</tr>
<tr>
<td>(Kim et al., 2005)</td>
<td>Extract of Panax ginseng (2g (3x/day))</td>
<td>Humans (7)</td>
<td>Treadmill running</td>
<td>↑ of the duration of the exercise. ↑ malondialdehyde and the activities of catalase and superoxide dismutase enzymes.</td>
</tr>
<tr>
<td>(Liang et al., 2005)</td>
<td>Panax notoginseng (1.350 mg/day)</td>
<td>Humans (29)</td>
<td>-</td>
<td>Supplementation improved the duration of resistance to exhaustion and reduced blood pressure levels and Vo2 during endurance exercise.</td>
</tr>
<tr>
<td>(Voces et al., 2004)</td>
<td>Extract of Ginseng (3, 10, 100 or 500 mg/kg)</td>
<td>Animals (8)</td>
<td>-</td>
<td>The administration of Ginseng extract was able to protect the muscle against oxidative stress induced by exercise, regardless of the type of fiber. They showed the membrane stabilizing ability of the extract, since mitochondrial function measured on the basis of citrate synthase and the activities of 3-hydroxyacyl-CoA dehydrogenase was reduced. Lipid peroxidation, measured on the basis of malondialdehyde levels, was significantly higher in all muscles after exercise.</td>
</tr>
<tr>
<td>(Min et al., 2003)</td>
<td>Red Ginseng</td>
<td>Animals</td>
<td>Treadmill running</td>
<td>↑ of the time of exhaustion for the operation of the conveyor. Inhibition of exercise-induced increases in 5-hydroxytryptamine synthesis and tryptophan hydroxylase expression.</td>
</tr>
<tr>
<td>(Voces et al., 1999)</td>
<td>Panax ginseng G115</td>
<td>Animals</td>
<td>-</td>
<td>↑ of the time of exhaustion for the operation of the conveyor. Inhibition of exercise-induced increases in 5-hydroxytryptamine synthesis and tryptophan hydroxylase expression.</td>
</tr>
</tbody>
</table>

### Table 3: Main outcomes observed in selected studies.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Intervention Dosage</th>
<th>Model (n)</th>
<th>Type of exercise</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bao et al., 2016)</td>
<td>Ginseng oligopeptide (125, 250 and 500 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>It improves fatigue-induced changes in biomarkers of oxidative stress and antioxidant enzymes.</td>
</tr>
<tr>
<td>(Zaheri and Marandi, 2016)</td>
<td>Ginseng (2 capsules for 4 weeks)</td>
<td>Humans (24)</td>
<td>Resistance training</td>
<td>Improvement of blood circulation during exercise; ↓ peripheral vascular resistance; helps in releasing oxygen to activate the muscles; influences the recovery of blood pressure after weightlifting.</td>
</tr>
<tr>
<td>(Lee et al., 2016)</td>
<td>UG0712 (500 and 100 mg/d)</td>
<td>Humans (117)</td>
<td>Resistance and aerobic training</td>
<td>↑ improvement of aerobic capacity by physical training</td>
</tr>
<tr>
<td>(Yan et al., 2015)</td>
<td>Sanyuansan supplement (30 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>Improved ability to feel pleasure. There was no change in spontaneous motor activity.</td>
</tr>
<tr>
<td>(Oh et al., 2015)</td>
<td>Ginseng, protopanaxadiol and protopanaxatriol (50 e 100 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>The anti-fatigue effect of Ginseng can be attributed to its saponins, in particular to protopanaxatriol and not to its polysaccharides.</td>
</tr>
</tbody>
</table>
Table 3 Contd: Main outcomes observed in selected studies.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Intervention Dosage</th>
<th>Model (n)</th>
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</thead>
<tbody>
<tr>
<td>(Hou et al., 2015)</td>
<td>Capsules of Rg1 (5 mg/kg)</td>
<td>Humans</td>
<td>Ergometric exercise</td>
<td>↓ The unwanted lipid peroxidation of human skeletal muscle.</td>
</tr>
<tr>
<td>(Yu et al., 2013)</td>
<td>Red Ginseng</td>
<td>Animals</td>
<td>High intensity exercise</td>
<td>Inhibition of oxidative stress and ↑ the ability to exercise.</td>
</tr>
<tr>
<td>(Lassiter et al., 2012)</td>
<td>Energetic drink of caffeine and Ginseng</td>
<td>Humans (15)</td>
<td>Cycling</td>
<td>Improvement in cycling time performance and possibly the simple aspects of cognitive function even with high levels of caffeine in the basal blood.</td>
</tr>
<tr>
<td>(Jiang et al., 2012)</td>
<td>Rg1</td>
<td>Animals</td>
<td>Swimming</td>
<td>Antidepressant activity via activation of the BDNF signaling pathway and regulation of hippocampal neurogenesis without affecting locomotor activity.</td>
</tr>
<tr>
<td>(Lee et al., 2011)</td>
<td>Wild Ginseng (50, 100 or 200 mg/kg)</td>
<td>Animals</td>
<td>Swimming</td>
<td>↓ Anxiety and depression behavior; stimulation of NPY expression in the hypothalamus. Wild Ginseng extract may be effective in inhibiting anxiety and depression responses due to withdrawal of morphine.</td>
</tr>
<tr>
<td>(Yang et al., 2009)</td>
<td>Ginsenoside Rh2</td>
<td>Animals</td>
<td>-</td>
<td>Reversed memory impairment by improving learning deficits.</td>
</tr>
<tr>
<td>(Wei, 2008)</td>
<td>Ginseng G115</td>
<td>Animals (72)</td>
<td>Eccentric exercise</td>
<td>After eccentric exercise, microculture and ultrastructure of the skeletal muscles were altered.</td>
</tr>
<tr>
<td>(Cabral de Oliveira et al., 2005)</td>
<td>Ginseng (100mg/kg)</td>
<td>-</td>
<td>Eccentric exercise</td>
<td>Protection of muscles against injuries from eccentric exercises. It was effective in preserving the mitochondrial membrane integrity and ↓ the concentration of nitrates and carbonyl content.</td>
</tr>
<tr>
<td>(Bucci, 2000)</td>
<td>Ginseng (several species)</td>
<td>-</td>
<td>-</td>
<td>Asian ginseng improved exercise performance. Siberian Ginseng showed mixed results.</td>
</tr>
<tr>
<td>(Ziemba et al., 1999)</td>
<td>Ginseng (350 mg)</td>
<td>Humans (15)</td>
<td>Football players</td>
<td>Improvement in psychomotor performance without affecting exercise capacity.</td>
</tr>
</tbody>
</table>

remained intact even after the experiments were performed (Table 4)

**Conclusion**

The Ginseng, as phytoterapeutic, exert positive effects on the body. According to the studies, it was observed proinflammatory changes, acting on the expression of mRNA, the plasma concentrations of C-reactive protein and IL-6 and IL-10, the cytokines liberation and decrease of blood cells T CD8. Moreover, it has the potential to increase levels of enzymatic activities that act on the immune and metabolic system. Thus, the herb has been shown to be beneficial in increasing glycogen replenishment, besides saving its reserves after physical activity and has demonstrated the potential of fat oxidation, increase in strength, adherence strength, improve psychomotor development and aided to improve the fatigue-induced changes of biomarkers of oxidative stress and antioxidant enzymes.

In the studies, the capsule Ginseng was mostly administrated through oral route. The kinds of herbs most cited were the consumption of its extract, its Oligopeptide,
Ginsenosides and its saponins, red Ginseng, North American and Korean ginseng, Panax ginseng and among others. To exert positive effects as described, the dosage varies between 1 mg/kg and 20 g.

In this study, among the most cited physical activity practices were swimming, running, walking, cycling, eccentric and acute exercise. However, although there are many studies on humans, the prevalence remains of studies conducted and tested on animals. The use of Ginseng associated with a healthy diet and the regular practice of physical activity is one of the strategies to improve the quality of life, being also a differential that can be used by the Nutritionist for patients under nutritional treatment.

In associating the two fields explored in this study, the studies carried out on humans aimed at a significant sample of healthy patients, active practitioners and those who underwent nutritional treatment, with a balanced diet in nutrients, vitamins and minerals. This intervention is associated with the use of herbal medicines such as Ginseng, which is able to act in stress situations and improve the biochemical responses of the organism.

REFERENCES


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