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ABSTRACT

Molinos, A. (2013). Effects of adaptogen supplementation on sport performance. A recent review of published studies. *J. Hum. Sport Exerc.*, 8(4), pp.1054-1066. Objective: Adaptogens are a new class of metabolic regulators (plants from natural origin) which have been shown to increase the ability of organism to adapt environmental factors and to avoid body damage. These properties offer the possibility to utilize them to increase the performance in situations of mental and physical stress, and thus used it to improve sport performance. Methods: A literature search was conducted for articles published until December 2012 in major databases. Publications were searched without language restrictions, using combination of Keywords. Results: Latest research show that *Rhodiola rosea*, *Eleutherococcus senticosus*, *Schisandra chinensis*, *Panax ginseng* and *Erkang* offer some physical and mental benefits to use in sport nutrition. Conclusion: This review demonstrate Adaptogen supplementation can improve the sport performance, however there are not enough reliable studies to conclude this assertion as absolute in all sports, therefore we suggest further researches with any of these Adaptogens in order to ascertain this results. **Key words:** ADAPTOGENS, SPORT, SUPPLEMENTATION, EXERCISE, RHODIOLA ROSEA, ELEUTHEROCOCCUS SENTICOSUS, SCHISANDRA CHINENSIS, PANAX GINSENG.

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INTRODUCTION

Adaptogens were initially studied by the Russians during World War II, with the aim to get organic oils and acids (Lebedev, 1967). These same Researchers were the first to officially recognize the effects of these plants to develop Physical abilities and recovery (Lupandin, 1990; Panossian & Wikman, 2009) also homeostatic functions to regulate and balance the physiological mechanisms (Panossian, 2003). The term Adaptogen was originally named by N.V. Lazarev in 1947, a USSR pharmacologist, who described the unexpected effects of Dibazol (2-benzylbenzimidazol) (Panossian et al., 1999), an arterial dilator developed in France. Dibazol was found to improve the body resistance to stress (Lazarer, 1962). Brekhman and Dardimov showed in 1969 some basic principles which every adaptogen plant must follow (Lupandin, 1990); 1) Adaptogens must reduce stress-induced damage, thus presenting stress-protective effects such as anti-fatigue, anti-infectious, anti-depressant and restorative activities, 2) Adaptogens must exhibit stimulating effects, both after single and multiple administration, leading to increased working capacity and mental performance against a back-ground of fatigue and stress, 3) the stimulating effect of Adaptogens must be different from those of conventional stimulants and anabolics that deplete the energetic and plastic resources of the organism and give rise to negative side effects such as drug withdrawal syndrome, 4) Adaptogens must be innocuous and must not perturb body functions from their normal levels but rather exert a normalizing influence on a pathological state, independent of the nature of that state.

Many Adaptogens have been studied with the aims to improve the Physical performance, but only some of them have been defined to use as stimulant to recover after intense efforts and with anti-fatigue effects (Moriyama, 2007). The Adaptogens which have shown positive results in scientific studies, with the purpose of improving Physical performance, were: *Rhodiola rosea* (Brekman & Dardymov, 1969; Perfumi & Mattioli, 2007; Saratikov et al., 1968; Saratikov & Krasnov, 2004; Qian et al., 2012; Parisi, 2010; De Bock et al., 2004; Lee et al., 2009), *Eleutherococcus senticosus* (Brekman & Dardymov, 1969; Kimura & Sumiyoshi, 2004; Huan & Rose, 2001) *Schizandra chinensis* (Hurnovicz et al., 1960; Panossian & Wikman, 2008), *Panax ginseng* (Brekman & Dardymov, 1969; Saito et al., 1974; Ferrando et al., 1999; Pieralisi et al., 1991).

Other plants with similar effects and which could be included in a sub-group of Adaptogens are *Rubus coreanus* (Jung et al., 2007), *Pseudosasa japonica* (You et al., 2006; You et al., 2010), *Chines bamboo* (Zhang et al., 2006), *Anoectochilus formosanus* (Ikeuchi et al., 2005), *Camelli sinensis* (Murase et al., 2006) y *Allium sativum* (Moriyama et al., 2007; Marihara et al., 2006).

Extracts from these plants and several Adaptogens Complexes, as Erkang (Wu et al., 1998), also showed improvements in mental resistance and greater concentration and physical development (Panossian & Wikman, 2008; Olsson et al., 2009; Panossian, 2003).

Nowadays there are not enough studies with trained humans and Adaptogens supplementation, so is opened a new way to possible and future researches, which analyzed the real possibilities to improve the physical and mental sport performance in different sports.

This study presents a review of recent published studies (from 1967 to December 2012) on Adaptogens and the capacity to enhance athletic performance. Therefore, the search is carried out based on researches, which from Adaptogen supplementation, with animals and humans, results were showed that they could be applied to improve sport performance.

MATERIAL AND METHODS

We conducted a literature search in major databases of health sciences (PubMed, Food Sciences & Technology Abstracts (FSTA), Medline, IME, Biomedicine (CSCI), Cochrane Library Plus, Gale Virtual Library Referent, Informa Healthcare, PsycArticle (CSA) and SpringerLink), of all published articles about Adaptogens to December 2012, which provide us valid information and results to improve the physical and mental sport performance. The terms on which we focused our search were “Adaptogens”, “sport”, “supplementation”, “exercise”, “performance”, “*Rhodiola rosea*”, “*Eleutherococcus senticosus*”, “*Schisandra chinensis*” and “*Panax ginseng*”.

Publications were searched without language restrictions.

RESULTS

Adaptogen concept

The Adaptogens, thus defined, constitute a new class of metabolic regulators (of a natural origin) which have been shown to increase ability of the organism to adapt to environmental factors and to avoid damage from such factors. The concept has developed since early researches, when drugs and methods to stimulate the body were found to maintain Physical and mental abilities as stable as possible (Lazarev, 1962).

Based on what we previously discussed, we would do the following question, what are the differences between Adaptogens and other metabolic regulators, such as the stimulants? As Hancke (1994 y 1996) shows, in studies with racehorses, supplementation with stimulants, such as amphetamines, improves the strength capacity in a short time. However, after this initial period of high boost, comes a decrease work capacity. Adaptogens as *Acatopanax* (also called *Eleutherococcus senticosus* or Siberian Ginseng) and *Rhodiola rosea* show a constant performance, and after reaching its maximum is not followed by a corresponding minimum of the average work capacity (Hancke et al., 1996; Hancke et al., 1994).

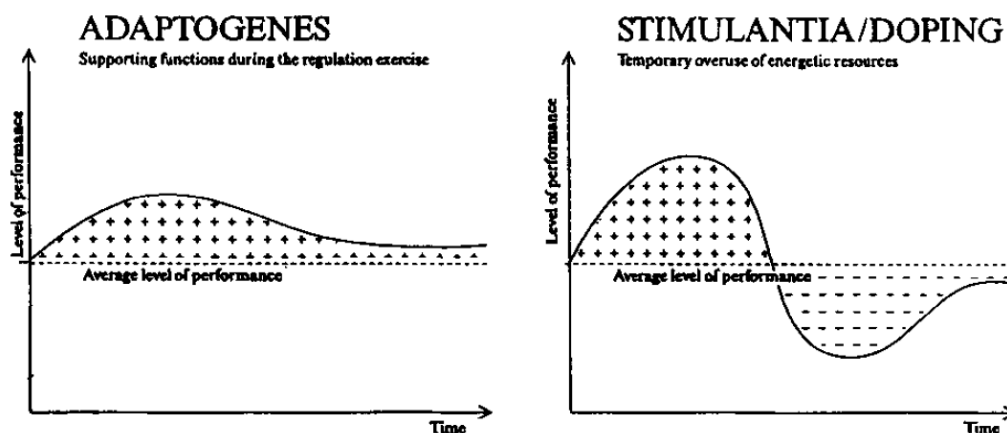


Figure 1. Difference between Adaptogens and stimulants (qualitative pictures). Panossian A, Wikman G, Wagner H. (1999). Plant adaptogens III. Earlier and more recent aspects and concepts on their mode of action. *Phytomedicine*, Vol. 6(4), pp.287– 300.

In order to classify these plants, Brekhman y Dardimov made these postulates about what they called new substances with increased nonspecific resistance (Brekhman, 1969).

- Adaptogens must reduce stress-induced damage, thus presenting stress-protective effects such as anti-fatigue, anti-infectious, anti-depressant and restorative activities;
 - Adaptogens must exhibit stimulating effects, both after single and multiple administration, leading to increased working capacity and mental performance against a background of fatigue and stress;
 - The stimulating effect of Adaptogens must be different from conventional stimulants and anabolics that deplete the energetic and plastic resources of the organism and give rise to negative side effects such as drug withdrawal syndrome;
 - Adaptogens must be innocuous and must not perturb body functions from their normal levels but rather exert a normalizing influence on a pathological state, independent of the nature of that state.
- About this last postulate, the dose will be really important for greater performance (Huang et al., 2011).

Mechanisms of action

The ability to increase work capacity with Adaptogen supplementation, has been studied both human and animals.

These plants allow us to reduce fatigue and increase mental and Physical resistance, thus increasing attention, precision, hard work and stress resistance (Brekhman & Dardymov, 1969). Theses anti-fatigue abilities from Adaptogens are associated with its effect on:

- Mediators of stress and particularly cortisol, nitric oxide (NO), protein kinase (p-SAPK), c-Jun N-Terminal protein kinase (p-JNK) and Forkhead Box O proteins, such as DAF-16 (Panossian et al., 1996 & Wiegant et al., 2009).
- Adaptogens activate formation of NO and cortisone in the plasma and saliva, in order to adapt the body to heavy workloads (Panossian et al., 1999).
- The expression of Heat Shock proteins Hsp70 y Hsp16 (Wiegant, 2008).

In addition, other studies have shown Adaptogens actions of these plants on energy mechanisms:

- The biosynthesis of ATP, thus inducing an alternation in energy source (Panossian et al., 1999).
- Energy regulation during stress, increasing the formation of glucose-6-phosphate and thus affecting the metabolism of carbohydrates and energy supplies, as well as DNA and protein synthesis (Panossian et al., 1999).
- Potent antioxidant properties (especially with Schisandra chinensis) (Panossian et al., 1999).

The mechanisms of action of Adaptogens are mainly associated with the mechanism of stress and involve in the regulation (activation and inhibition) of the system. Thus, theses plants help the body achieve optimal balance due to its capacity of bidirectional action.

Possible applications of adaptogens on sport performance

From all Adaptogens researched and evaluated in recent years, just four of them have given results that may be apply and transferable to sport to improve the physical performance (Panossian & Wikman, 2009) (*Rhodiola rosea*, *Eleutherococcus senticosus*, *Schisandra chinensis* and *Panax ginseng*) and one formula created with several of these plants (called Erkang), are which we focused our review.

Rhodiola rosea (RR)

Unfortunately, most of the scientific evidence in the current literature have shown using animals, only a few studies, with conflicting results (Panossian et al., 2010; Walker & Robergs, 2006; Walker et al., 2007), were developed on human. Parisi et al, in 2010, showed one of the few studies published with trained humans. This study evaluated physical performance parameters such as heart rate max, Borg Scale, maximal oxygen uptake (VO₂ max), duration of the test and blood glucose levels, without improvement between Placebo and RR group. On the other hand interesting results were obtained, as the reduction in muscle damage and lower levels of lactate. Furthermore, this supplementation shows increase fatty acid consumption. These data confirm that the intake of this plant could improve the adaptogen ability to physical exercise resistance (Parisi et al., 2010).

De Bock et al got an improvement in the resistance with young people who had taken daily RR, during 4 weeks (De Bock et al., 2004). Similarly, Lee et al observed in mice, supplemented with RR, an increment in the swimming time, with a later exhaustion (Lee et al., 2009).

Qian et al in 2012 studied the active ingredient of RR, salidroside (2 (hydroxyphenyl) ethyl β -D-glucopyranoside). This is a protective agent of human red blood cells against oxidative stress and may be a good Adaptogen for stress resistance and fatigue (Qian et al., 2012).

In 2007 Perfumi and Mattioli, researched about the effects of supplementation with RR in a single oral dose in rats. The results showed antidepressant, adaptogen ability, anxiolytics and stimulants effects, without differences between amount of doses (10, 15 y 20 mg/Kg). This study proved for the first time the anxiolytic and antidepressant potential of this plant (Perfumi & Mattioli, 2007).

All these studies showed an improvement in physical and mental performance on resistance efforts, but RR has also demonstrated anti-inflammatory effects, reducing levels of C-reactive protein and protecting the muscle tissue during exercise, reducing the among of Creatinine Kinase (CK) [1]. Zhu et al (2004) showed that RR could reduce the activity of CK in mice exposed to stress (Zhu et al., 2004).

Researchers suggest that supplementation with RR can be used in sport, especially those of resistance, due to their ability to stimulate metabolism, stimulate the use of fatty acids, lower blood lactate levels, minimize damage muscle after intense efforts, to help a better and faster muscle recovery, as well as for its potential antidepressant and anxiolytic. Future researches could focus on trained athletes assessing supplementation with different amounts of RR, in order to test the physical and mental performance and the appropriate dose.

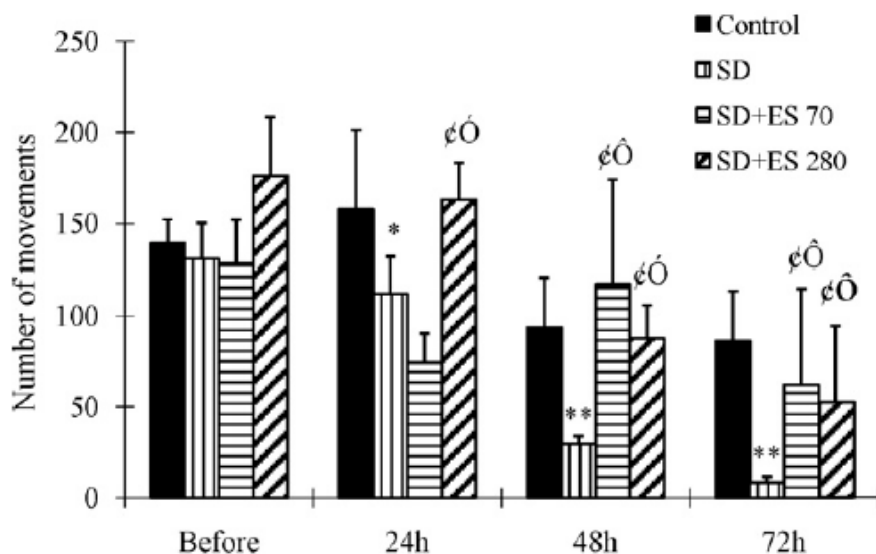


Figure 2. The effect of ES on locomotor activity before and after sleep deprivation (SD) in mice. Mice were treated with ES (70 and 280 mg/kg, i.g.), during 9 days, and, on the seventh day of treatment, were submitted to 72 h of sleep deprivation or maintained in home cages as control. Values are expressed as mean S.E.M. * $P < 0.05$, ** $P < 0.01$ represent the difference between SD and control. $\phi\hat{O}P < 0.05$, $\phi\hat{O}P < 0.01$ represent the difference between ES and SD group. Huang LZ, Huang BK, Yea Q, Qina LP. (2011). Bioactivity-guided fractionation for anti-fatigue property of *Acanthopanax senticosus* Journal of Ethnopharmacology 133, pp.213–219.

Eleutherococcus senticosus (ES)

Eleutherococcus senticosus, also called Acanthopanax or Siberian ginseng, has been named in recent years in a number of scientific researches with interesting results to take into account for the sport community.

Kimura y Sumiyoshi (2004) used types of ES root to demonstrate that supplementation in rats got prolong swimming. They suggested that ES had anti-fatigue action, reducing recovery of NK cells (immune system) and inhibition of cortisol rise, induced by stress (Kimura & Sumiyoshi, 2004). Previously Nishibe et al. (1990) reported that the ES bark extract prolonged time in rats forced with a swimming test (Nishibe et al., 1990).

One of more recent studies, carry out by Huang et al. (2011), shows eleven groups of mice, divided according to the supplementation type; one control and ten with treatment (with different doses of ethanol eluate and ES). The test was conducted with animals, swimming with different weight loads, different supplementation and sleep deprivation. Results of theses test suggest that ES supplementation can relieve mental and physical fatigue (Figure 2). In addition, they showed decreased triglycerides, thus increasing the utilization of fat as an energy source, delayed accumulation of blood urea nitrogen (BUN), and increasing lactate dehydrogenase (LDH) to reduce the accumulation of lactic acid in muscle, which brings a reduction of pH in blood and muscle fibers, thereby protecting the muscle (Huang et al., 2011). All these results shown a significant extends in the swimming time to exhaustion.

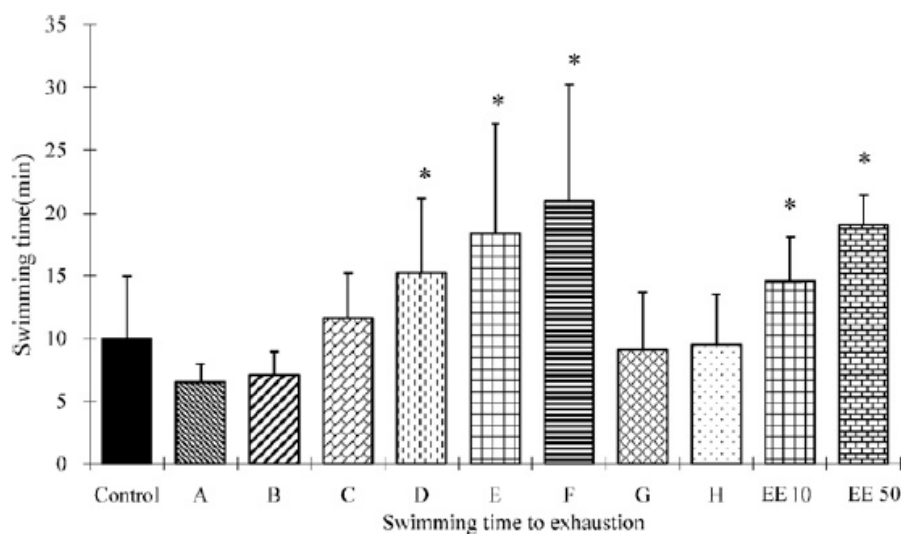


Figure 3. Effects of the fractions of *n*-butanol on the swimming time to exhaustion of weight-loaded mice. A: low dose of water eluate, B: high dose of water eluate, C: low dose of 20% ethanol eluate, D: high dose of 20% ethanol eluate, E: low dose of 60% ethanol eluate, F: high dose of 60% ethanol eluate, G: low dose of 100% ethanol eluate, H: high dose of 100% ethanol eluate. Those fractions were collected from D101 macroporous resin. Low dose means 70 mg/kg, high dose means 280 mg/kg for every mouse. EE 10 and EE 50 mean that animals were treated with eleutheroside E 10 mg/kg and 50 mg/kg. Values are means \pm S.E.M. of mice per group. (*) Significantly different from control group ($P < 0.05$). Huang LZ, Huang BK, Yea Q, Qina LP. (2011). Bioactivity-guided fractionation for anti-fatigue property of *Acanthopanax senticosus* Journal of Ethnopharmacology 133, pp.213–219

Schisandra Chinensis (SC)

During World War II, USSR began studying *Schisandra chinensis* with purpose to obtain organic acids, ether oils and tonic substances. Extensive research revealed, however, that extracts of SC had significant stimulatory effects. Although Chinese folklore previously used this plant as a sexual stimulant, anti-pollution, gonorrhea, dysentery, sweating, cough, asthma, fatigue, diabetes, etc. (Panossian & Wikman, 2008).

Panossian y Wikman (2008) showed a review of studies with SC of Russian origin. The most of them have been tested, both animal and human, improved endurance, precision of movement, higher physical work capacity and mental development. Short exercise, like gymnastic and sprint racers showed a decrease in workability and ever worse coordination of movements, after supplementation with SC (Panossian & Wikman, 2008).

Adaptogenic capacity of SC has been demonstrated by Panossian et al (1999) with elite athletes and untrained subjects. These plants have the ability to suppress (NO) or activate (cortisone) neuroendocrine system as the stress level of the subjects. Thus, with SC supplementation before competition, the values of NO are raised, in order to adapt the body to high physical intensities (Panossian et al., 1999).

Panax Ginseng (PG)

The tonic effect of Ginseng root was described in an ancient text, of the 1st century BC in China. PG has been used for over 2000 years in China to increase qi and vital energy (Huan & Rose, 2001).

One of the most standardized extracts from PG is the G115, which contains 4% Ginsenoside. Many studies have been made with this extract from PG, but the effectiveness of this plant still needs to be proven, due to the large number of investigations have not shown any effect in increasing physical performance with

humans (Scaglione et al., 2005). Fernando et al (1999) showed in their research a raise in capillary density and muscle mitochondrial content of mice, suggesting that prolonged treatment with G115 (50mg/kg for 12 weeks) improve the aerobic output and therefore the physical performance (Ferrando et al., 1999). Research such as Engels et al (2001), executed with double-blind trials (placebo group and G115 group) with active women, showed no significant changes in peak anaerobic power, anaerobic power average, fatigue and post-exercise recovery after supplementation (Engels et al., 2001).

Other studies differ from these results, Pieralisi et al (1991) noted that a supplementation with Ginseng, as well as Dimetiletanilamina, minerals and vitamins, increased workload and oxygen consumption. In contrast, plasma lactate levels, ventilation, carbon dioxide production and heart rate decreased after supplementation with Ginseng. These results were greatest in subjects with Maximal oxygen consumptions levels under 60 ml/kg/min than those with levels over 60 ml/kg/min (Pieralisi et al., 1991).

Erkang

Special mention deserve the traditional Chinese herbal medicine formula Shi-Quan-Da-Bu-Tang (also known as Juzentaiho-to, YJ-48), which has traditionally been used to increase vital energy, and strengthen health and immunity. Erkang capsule, introduced by the Harbin Medical University, China, is a modified formula of Shi-Quan-Da-Bu-Tang, with the addition of four other herbs. Although Erkang only have two of the Adaptogens, above mentioned, this formula has been shown to increase the adaptogenic and ergogenic skills.

In 1998, Wu et al, conducted a study supplementing mice with Erkang. The swimming test was performed in which animal were forced to swim until exhaustion. There were two groups; the control group ate chow pellets without any herbal medicine and the treatment group ate chow pellets containing 0,5% Erkang compound. This research indicated how mice with this formula supplementation could swim for a longer time to exhaustion, in warm water ($25,5 \pm 0,5^{\circ}\text{C}$) and cold water ($9,5 \pm 0,5^{\circ}\text{C}$) (Wu et al., 1998).

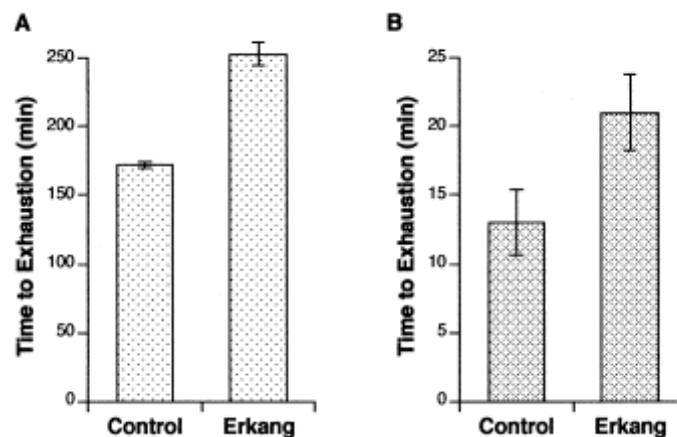


Figure 5. Time to exhaustion in swimming tests in two different water temperatures ($n = 10$ per group). (A) Time to exhaustion during room temperature ($25.5 \pm 0.5^{\circ}\text{C}$) water swimming test. (B) Time to exhaustion during cold ($9.5 \pm 0.5^{\circ}\text{C}$) water swimming test. There were significant differences in the time to exhaustion between the control groups and Erkang treatment groups in both temperature swimming tests. Brackets indicate the mean \pm S.E.M. Note different time scales in (A) and (B). Wu Y, Zhang Y, Wu JA, Lowell T, Gu M, Yuan CS. Effects of Erkang, a modified formulation of Chinese folk medicine Shi-Quan-Da-Bu-Tang, on mice. (1998) *Journal of Ethnopharmacology* 61, pp.153–159

The same research proved as the treatment group (supplementation with 300mg/kg Erkang for 7 consecutive days), had a significant weight increase, compared with the control group. In addition, at 11 months after the start of the experiment, the mortality for the control group was 94,4% and average median mortality of $297 \pm 22,9$ days, and that for the treatment group was 50% and $387 \pm 32,1$ days (Wu et al., 1998).

DISCUSSION

The mode of action of Adaptogens is mainly associated with stress and can regulate the body in different directions (inhibition or activation, as required). During intense physical activity, our body must make continuous adjustments in order to maintain a good health and to continue with the physical processes which are required during exercise. Therefore, Adaptogens regulate the internal environment and tend to maintain the body stable, what is called as Homeostasis, and thus, achieve greater athletic performance to physical and mental stress.

Adaptogens Plants; *Rhodiola rosea*, *Eleutherococcus senticosus*, *Schizandra chinensis*, *Panax ginseng* and Erkang formula, have shown, in most of studies, encouraging results in improved physical performance, to be applied to sportsmen. In the latest research with these plants, remarkable physiological improvements were found (Figure 5), but we must keep in mind that due to the lack of research with different supplementation doses, physical test, Adaptogenic extracts and also different study subjects, as we have seen, there are results and scientific articles that have not found any improvement in athletic performance.

Therefore, for future studies on Adaptogens, we recommend make researches supplementing trained athletes, with different types and doses of these plants, in order to check what kind of supplementation is achieved to maximize results. In addition, it would also be interesting to note which physical and mental abilities can get most benefit and athletic performance, and get to know the most interesting sports to perform such supplementations techniques.

Thus, we suggest further research with any of these Adaptogens, as well as formulas and compounds with Erkang or several of these plants, in order to test if the combination enhances athletic performance. Sporting test used by the international scientific community would also be interesting to give more reliability and to compare results between Adaptogens and other sports supplements.

CONCLUSIONS

The mode of action of Adaptogens is mainly associated with stress and can regulate the body in different directions (inhibition or activation, as required). During intense physical activity, our body must make continuous adjustments in order to maintain a good health and to continue with the physical processes which are required during exercise. Therefore, Adaptogens regulate the internal environment and tend to maintain the body stable, what is called as Homeostasis, and thus, achieve greater athletic performance to physical and mental stress.

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different supplementation doses, physical test, adaptogenic extracts and also different study subjects, as we have seen, there are results and scientific articles that have not found any improvement in athletic performance.

Table 1. A summary of all actions shown in the latest research with Adaptogens and formulas from these plants

Demonstrated mechanisms of action in research	<i>Rhodiola rosea</i>	<i>Eleutherococcus senticosus</i>	<i>Schizandra chinensis</i>	<i>Panax Ginseng</i>	<i>Erkang</i>
Reduce muscle damage ^[12, 17]	X	X			
Lower lactate levels ^[12, 17, 22]	X	X		X*	
Increased consumption of fatty acids ^[12, 17]	X	X			
Increased Physical activity time to exhaustion ^[13, 14, 16, 17, 19, 22, 35, 47]	X	X	X	X*	X
Protectors of erythrocytes against oxidative stress ^[11]	X				
Anxiolytic and antidepressant effects ^[8]	X				
Reduction of CK activity in stressful situations ^[45, 46]	X				
Anti-inflammatory effects, reducing levels of C-reactive protein ^[45]	X				
Reducing recovery of NK cells ^[16]		X			
Inhibition of cortisone rise, induced by stress ^[16]		X			
Relieve mental and Physical fatigue ^[17]		X			
Delayed accumulation of BUN ^[17]		X			
LDH increase ^[17]		X			
Reduced pH in blood and muscle fibers ^[17]		X			
Improved precision of movement ^[19]			X		
Increased endurance and mental development ^[19]			X		
Activate formation of NO and cortisone, in order to adapt the body ^[19]			X		
Rise in density increase ^[21]				X	
Rise in muscle mitochondrial content ^[21]				X	
Increase aerobic power ^[21]				X*	
Decreased heart rate ^[22]				X*	
Decreased mortality ^[35]					X
Weight gain in rats ^[35]					X

*There are researches showing opposite data

Therefore, for future studies on Adaptogens, we recommend make researches supplementing trained athletes, with different types and doses of these plants, in order to check what kind of supplementation is achieved to maximize results. In addition, it would also be interesting to note which physical and mental

abilities can get most benefit and athletic performance, and get to know the most interesting sports to perform such supplementations techniques.

Thus, we suggest further research with any of these Adaptogens, as well as formulas and compounds with Er kang or several of these plants, in order to test if the combination enhances athletic performance. Sporting test used by the international scientific community would also be interesting to give more reliability and to compare results between Adaptogens and other sports supplements.

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