



Adaptogenic Herbs as Natural Sources of Sports Performance Enhancers

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Abstract:

Different parts of many plants, including seeds, bark, leaves, roots, fruit, stems, or flowers with known or suspected therapeutic properties are used to make herbal medications. In the past ten years, the number of athletes using herbal supplements has increased dramatically. Herbal remedies are becoming more and more popular among athletes and non-athletes as a way of improving their endurance and strength. Several diseases and impairments related to body stress are managed using herbal adaptogens; these adaptogens are also used to enhance focus, boost endurance during fatigue moments, improve physical strength/stamina, enhance energy levels, restore stress-affected cognitive function, improve sexual dysfunction, and maintain the level of cortisol. This study employed a research approach that requires the use of terms like "Herbal adaptogens, ashwagandha, endurance, athletes, turmeric, muscle strength" during a preliminary search of some of the popular databases such as Google, PubMed, Embase, ScienceDirect, OVID Medline, Google Scholar, and Web of Science. The leading herbal adaptogens on the global market (such as *ashwagandha*, *Rhodiola rosea*, astragalus, holy basil, cordyceps, and turmeric) were examined in this article based on their source. Also covered in this work are the potential negative effects of these adaptogens and how they can help athletes perform better by increasing their muscle mass, recovery, and endurance.

Keywords: Astragalus, Rhodiola rosea, Holy basil, Cordyceps, Ashwagandha, Herbal adaptogens.

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1. INTRODUCTION

Herbal medications are mostly prepared from different parts of a variety of plants with known or anticipated therapeutic properties. Herbal remedies do not need to undergo the rigorous testing that prescription drugs do in order to be sold because they are not subject to FDA regulation as pharmaceuticals [1-3]. Instead, under the Dietary Supplement Health and Education Act (DSHEA) of 1994, herbal remedies are classified as "food supplements" and subject to FDA regulations as a distinct class of foods. In the past ten years, the number of athletes using herbal supplements has increased

dramatically as herbal remedies are becoming more and more popular among athletes and non-athletes as a way of improving strength and endurance. The majority of plant-based supplements have been used in sports to improve fat burning, muscle repair, stamina, and muscle growth [4]. The global market for herbal medicines in 2021 was valued at USD 151.91B, but the market is projected to increase by 11.6%, from 165.66 to 347.50 billion USD (between 2022 and 2029). The global COVID-19 pandemic has been shocking and unexpected, and demand for herbal treatment has exceeded expectations in every region in comparison to the pre-COVID levels [5]. Numerous essential and secondary metabolites, including terpenoids,

alkaloids, and phenolic chemicals, as well as lipids, nucleic acids, and carbohydrates have been demonstrated to be found in plants. The interest in these phytochemicals is due to their biological properties that include anti-inflammatory, anti-allergic, anticarcinogenic, anti-atherogenic, antithrombotic, anti-microbial antiviral, and vasodilatory effects [6-8]. These biological properties, which are mediated by redox and antioxidant properties, are essential for stabilizing oxidative damage because they neutralize free radicals, scavenge oxygen, or break down peroxide [1]. Exercise is seen as a way athlete put their bodies under stress, and the body responds by gaining more muscle mass or endurance. Because of this, people have altered skeletal muscle phenotypes in response to exercise; among these adaptations are changes in the quantity and kind of contractile protein, metabolic enzymes, and connective tissue stiffness. The persons' age, gender, genetic-makeup, fueling, and exercise level, in addition to the duration and intensity of exercise, contribute to the phenotypic change [9].

2. THE RELEVANCE OF HERBAL MEDICINE IN SPORTS

Any sport can benefit from the application of traditional medicine, which is a multidisciplinary crossover

that is essential to the healing of exhaustion and injuries sustained during competition. It also aids in the recovery of the skeletal muscle, cardiovascular, and central nervous systems, allowing athletes to perform better during competition by reducing anxiety and nervousness before it occurs. In order to perform better during the competition, players can benefit from using herbal medicine to lessen their anxiety and uneasiness prior to games. In the Shen Nong Ben Cao Jing, which goes back more than 2,000 years, the herbal remedy Bai Shao was used to improve physical strength. Athletes typically use herbal medicines to enhance their sports performance and endurance during activities like rowing, walking, running, cycling, and mountaineering; they also use these herbal products during strength-building activities like bodybuilding, wrestling or weightlifting because 21st-century competitive sports are developing so quickly and the competition is getting more intense [10]. Herbal medicine and sports are inextricably linked and interdependent; sports have aided in the growth of herbal medicine and expanded access to pharmaceutical treatments for illnesses linked to injuries. Sports and Traditional Chinese Medicine (TCM) are closely linked, with sports influencing TCM's development and TCM benefiting greatly from sports' innovation and advancement in pharmacological treatments (Fig. 1).

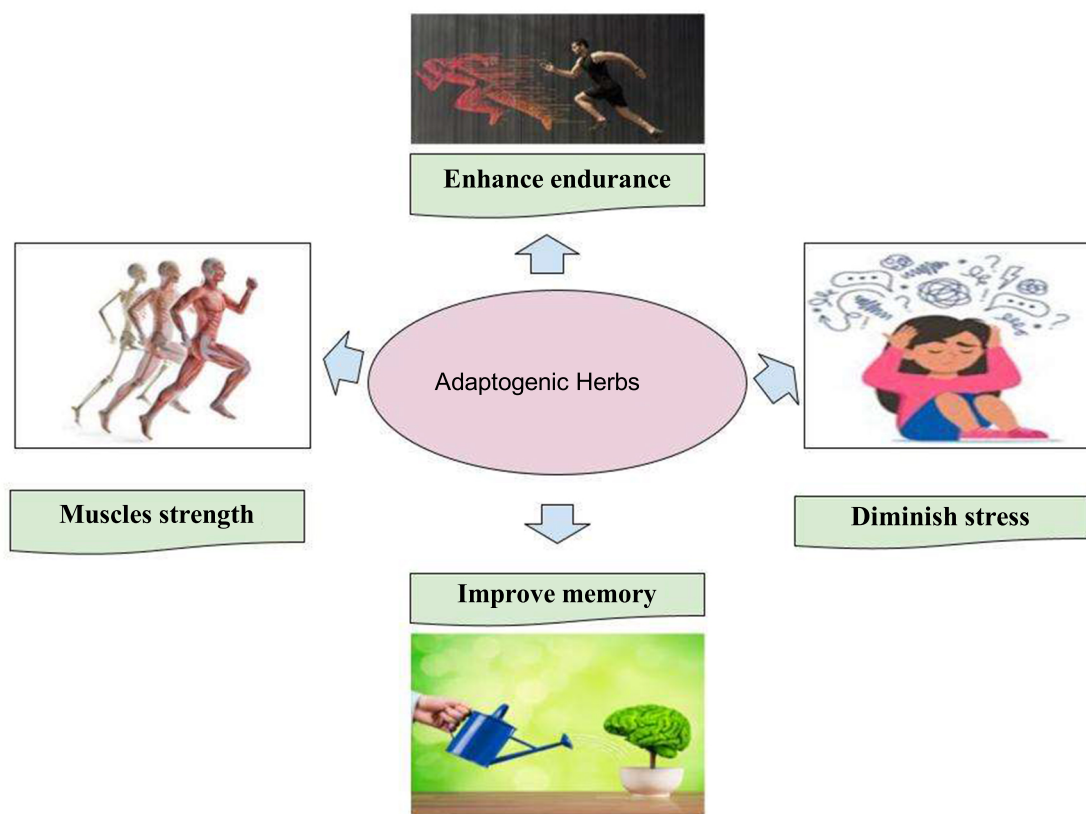


Fig. (1). Elements that adaptogens enhance.

2.1. Holy Basil

Ocimum tenuiflorum L is mostly known as holy basil or "Tulsi"; it is a member of the Lamiaceae (tribe ocimeae) family of basil plants that is endemic to the eastern tropics. Due to its many therapeutic benefits, tulsi has been a major ingredient in Ayurveda, a traditional Indian medicine for many years. This plant may have anti-diabetic, adaptogenic, radioprotective, antibacterial, and anticancer properties, according to recent studies [11]. Numerous chemical components are present in tulsi, such as elemene, caryophyllene, eugenol, linalool, carvacrol, germacrene, ursolic acid, and rosmarinic acid [12]. Maity, Mandal [13] demonstrated a CNS stimulant and/or anti-stress action of roots of *Ocimum sanctum* extracts by using a high dosage (400 mg/kg, i.p.) to improve swimming time. Moreover, it can boost vitality and enhance overall physical and mental health. Because of its many benefits, it is referred to as "the mother medicine of nature," "the incomparable one," and "the queen of herbs." As an adaptogen, it helps athletes preserve physiological homeostasis and adjust to training stimuli [14]. Athletes can benefit especially from it during muscle recovery because it also contains antioxidant properties that can help prevent muscular injury following intense training [15, 16].

2.2. Rhodiola Rosea

Rhodiola rosea L. is a Crassulaceae, also called "roseroot," "arctic root", or "golden root." For many years, *R. rosea* has been utilized for the treatment of anaemia, impotence, fatigue, depression, gastrointestinal disorders, and anomalies of the neurological system. It has also been used to increase longevity and physical endurance [17]. This plant, in addition to being found in the coastal regions of North America, also grows on sea cliffs and in the crevices of mountain rocks in the Arctic regions of Europe and Asia (mostly Siberia) [17]. Clinical therapy has made use of *Rhodiola*, a traditional medicine with strong antioxidant properties. Phytochemical research has reported the presence of phenylpropanoids, terpenoids, flavonoids, cyanogenic glycosides, and derivatives of phenyl ethanol/benzyl alcohol in this plant species. Furthermore, research has demonstrated that the bioactive chemicals effectively removed reactive oxygen species (ROS) [18]. In a placebo-controlled trial, it was reported that long-term *R. rosea* supplementation had an effect on elite athletes' redox state and physical performance during endurance training. In this study, following a 28-day period of chronic *R. rosea* supplementation, 14 trained male athletes underwent a cardiopulmonary fatigue test and had blood samples taken for checking the biochemical markers and antioxidant status. The investigation of the performance indicators showed that the use of *R. rosea* had no effect on test length, HR Max, Borg Scale level, or VO₂max following a comparison of the results to those obtained from the same athletes after they were given a placebo. While there was a substantial decrease ($p < 0.05$) in plasma creatine kinase and blood lactate levels, there was also a

significant reduction in plasma-free fatty acids. These results imply that *R. rosea* may enhance the body's ability to adapt to physical activity [19].

2.3. Astragalus

The most well-known genus in the Leguminosae family is *Astragalus* L; it is widespread in the subtropical zone, primarily North America and Asia, but it is also found in Europe and Africa [17]. This plant has over 2500 species; its root is frequently used as an immune-modulator in herbal medicine. Astragalosides, a class of saponins, flavonoids and polysaccharides, make up the majority of phytochemicals found in *Astragalus* [20]. A study [21] investigated the anti-fatigue and ergogenic aid properties of *Astragalus membranaceus* (AM) in a mouse-based study. AM and a placebo were given orally in a placebo-controlled trial. It was found that the combination of exercise training and AM administration increased the amount of glycogen stored in the muscles and liver as well as the ability for endurance activity. AM also reduced the accumulation of the exercise-induced metabolites blood lactate and ammonia after an acute exercise. Moreover, no negative consequences from AM treatment were noted; hence, AM supplementation improved exercise efficiency and decreased fatigue in mice. It might be useful as an ergogenic aid when doing exercise training [21].

2.4. Cordyceps

A genus of mushrooms known by the name Cordyceps grows on insect larvae. Around the world, more than 350 species related to Cordyceps have been identified based on fungi and/or insect hosts. However, since 1964, pharmacopoeia has only officially listed *C. sinensis* as a therapeutic herb. *C. sinensis* is well-known in herbal medicine; it is often known in China as Dongchongxiacao (winter-worm summer-grass) [22]. In the wild, cordyceps grows on caterpillars as a parasitic fungus, which makes it rare and expensive [23]. However, *C. sinensis* is a naturally occurring resource with numerous bioactivities, and several bioactive substances, such as cordycepin, polysaccharides, mannitol, ergosterol, and adenosine, have been isolated thus far [24]. Savioli *et al.* [25] recruited 30 amateur marathoners in a 12-week placebo-controlled, randomised, double-blind study conducted by using 2 g of *C. sinensis* each day. According to the study, consuming *C. sinensis* improved aerobic performance after 12 weeks and decreased heart rate to the same moderate intensity effort after 8 weeks. Scholars have suggested that supplementing with *C. sinensis* can improve the endurance capacity of amateur marathoners [25].

2.5. Ashwagandha

This is prepared from the dried bases of the stems and roots of the Solanaceae plant, *Withania somnifera* Dunal, mostly referred to as "Indian Ginseng" or "Indian Winter cherry" [26]. The physiologically-active chemical components of ashwagandha, as per studies, include steroidal lactones, alkaloids, saponins, aniferine, cuseohygrine, isopelle-tierine, and anahygrine [27]. As a xerophytic

Table 1. Summary of the effects of herbal remedies.

Adaptogen	Athletic Performance	Side Effect	References
Holy basil (<i>Ocimum sanctum</i>)	Muscle recovery	Mild nausea	[11]
<i>Rhodiola rosea</i>	Augments physical strength, endurance	Dry mouth or unrestrained saliva creation	[17]
<i>Astragalus</i> (<i>Astragalus Membranaceus</i>)	Improves muscle recovery and endurance	<i>Astragalus</i> cannot be used for those who have Autoimmune diseases	[26]
<i>Cordyceps</i> (<i>Ophiocordyceps Sinensis</i>)	Enhance endurance and energy	Diarrhea, nausea, and dry mouth	[22]
<i>Ashwagandha</i> (<i>Withania somnifera</i>)	Enhances physical stamina, strength, and life quality	constipation, reduced appetite, and rhinorrhea	[27]

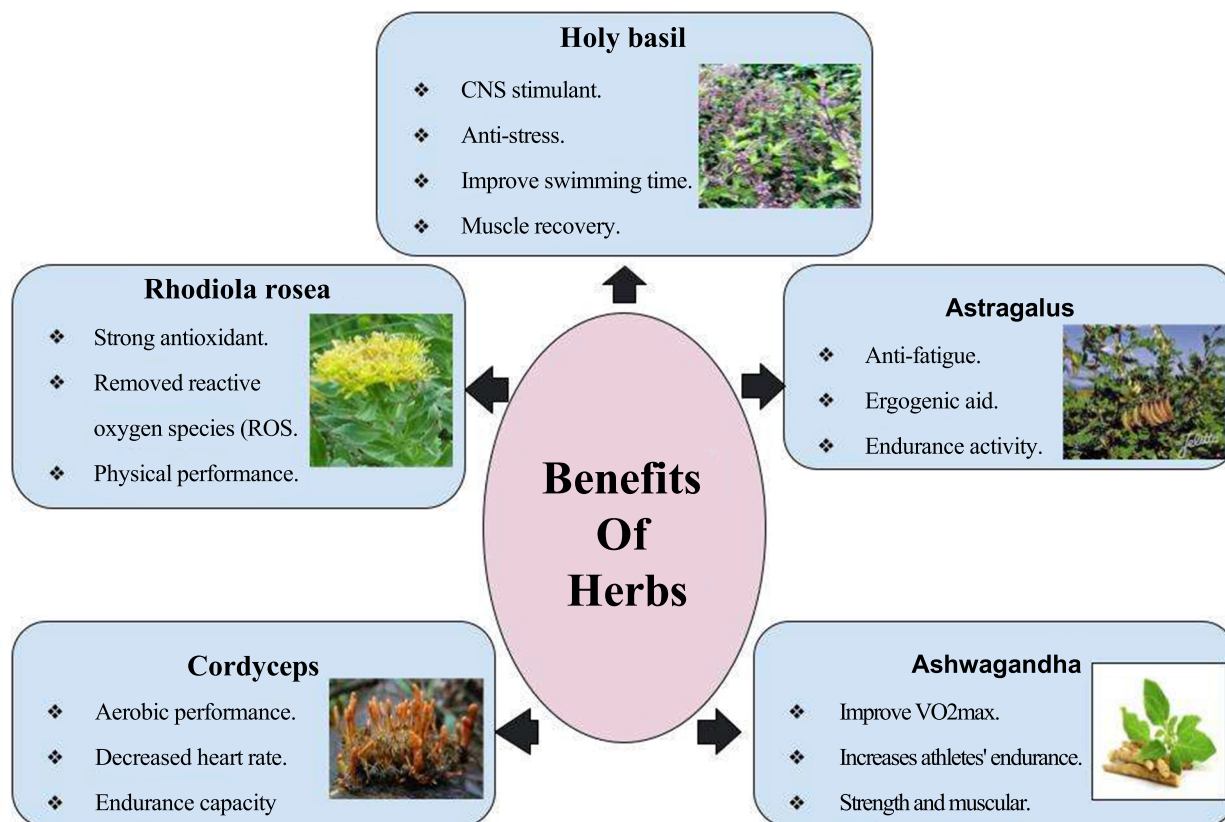


Fig. (2). Display mode of action of the studied herbs.

plant, it grows in Pakistan, Africa, India, and the Mediterranean [27]. To ascertain the effect of Ashwagandha on elite Indian cyclists' aerobic capacity, Shenoy *et al.* conducted a study in which forty elite Indian riders were randomly assigned to placebo and treatment groups. During the course of eight weeks, the treated group was placed on 0.5 g aqueous extract of the roots of Ashwagandha twice daily, while the other group (placebo group) was placed on starch-containing capsules. All measures showed a significant improvement in the treatment group, while the baseline values of the placebo

group remained unchanged. In comparison to the control (placebo) group, which showed no obvious variation in their baseline data, the treatment group showed improvement in all the studied parameters, including METS ($t = 4.483$; $p < 0.001$), VO₂max ($t = 5.356$; $p < 0.001$), and time to feel exhausted on the treadmill ($t = 4.813$; $p < 0.001$) [15]. The results of this study indicate that ashwagandha improves VO₂max, or maximum oxygen consumption, which in turn increases athletes' endurance capacity. A physiological measure called VO₂max indicates an individual's aerobic capability; it is an

indication of cardiorespiratory fitness that characterises both physical and mental well-being [28]. In a similar vein, Wankhede *et al.* investigated the possible advantages of ashwagandha root extract consumption on strength and muscular building in young, healthy males engaged in resistance training. The study was carried out using a placebo-control grouping strategy. Compared to the placebo group, the treatment group showed noticeably greater increases in muscle strength during the bench-press activity (treatment group: 46.0 kg, 95% CI, 36.6, 55.5; Placebo: 26.4 kg, 95% CI, 19.5, 33.3, $p = 0.001$) and the leg-extension exercise (treatment group: 14.5 kg, 95% CI, 10.8, 18.2; Placebo: 9.8 kg, 95% CI, 7.2, 12.3, ; $p = 0.04$); there was also more significant increase in the size of the biceps (treatment group 8.6 cm², 95% CI, 6.9, 10.8; Placebo: 5.3 cm², 95% CI, 3.3, 7.2; $p = 0.01$) as well as the size of the pectoralis muscle (treatment group: 3.3 cm, 95% CI, 2.6, 4.1; Placebo: 1.4 cm, 95% CI, 0.8, 2.0, $p < 0.001$). This study shows that taking supplements containing ashwagandha is associated with observable increases in strength and muscle size, suggesting that ashwagandha consumption in conjunction with resistance training may be advantageous [29] (Table 1 and Fig. 2).

3. CARDIOVASCULAR EFFECTS OF HERBAL MEDICINES

Herbs have a significant effect on sports cardiology. Herbal supplements can be very helpful in boosting athletes' immune systems, enhancing cardiovascular health, and improving blood flow, thereby providing athletes with more oxygen and exerting a significant impact on the regulation of the 3000 m hurdles piece of cardiovascular muscles. The effectiveness of Jianshuanyi Qi compound on athletes with high levels of swimming time was investigated. They discovered a significant decline in cortisol levels and hemoglobin, while improvements were noted in the level of the immunoglobulins (IgG, IgM) and T-cells after 4 weeks of sustained supplementation [30]. According to Parham, Bagherzadeh [31] suggests that the herb, which was prepared as capsule weighed 750 mg and contained nettle leaf 20% (w/w), berry leaf 10% (w/w), onion and garlic 20% (w/w), fenugreek seed 20% (w/w), walnut leaf 20% (w/w), and cinnamon bark 10% (w/w) all in powder, has an elevating influence on blood level and also improve the body's resistance to exhaustion by boosting immunity, encouraging anabolism, and decreasing catabolism. After conducting research on the effects of Cistanches, Epimedium, and Cuscuta on resistance to exercise-induced fatigue in rats trained in high-intensity endurance training, we concluded that these three yang tonifying herbs could boost the body's reserves of glycogen and haemoglobin, accelerate protein synthesis, decrease the breakdown of protein and amino acids, and increase resistance to fatigue. TCM improves cardiovascular function following exercise by refining the heart's blood supply capacity, increasing diastolic and cardiovascular flow, and lowering the formation of blood clots caused by cardiovascular exhaustion. It can lessen blood vessel blockage and clotting, improving cardiovascular health

and reducing the risk of developing cardiovascular diseases. It is also a useful method for recovering from post-exercise fatigue, enabling regular exercisers to tone, recover, and enhance cardiovascular function [30].

4. SKELETO-MUSCULAR EFFECTS OF HERBAL REMEDIES

During sporting activities, the skeletal muscles are affected in specific ways by herbal medicine; for instance, herbal medicine can help athletes recover more quickly from skeletal muscle fatigue in certain middle- and long-distance running events. It can also mobilise more muscle fibres for use during sports, enabling athletes to engage in prolonged, intense training sessions. Numerous fresh findings have also been made by numerous experts; for instance, Tian Shi Bin studied the relationship between skeletal muscle exercise capability and the metabolism of free radicals in rats exhibiting varying stages of post-exercise tiredness. The results of the study showed that the use of Bazhen decoction (15 g) (which contains *Paeonia lactiflora*, *Poria*, *Radix Rehmanniae*, *Radix Angelicae Sinensis*, *ginseng*, *Chuanxiong*, *Atractylodes macrocephala*, *Glycyrrhiza glabra*, plus cinnamon and bone marrow) could lengthen the exercise group's exhaustion period, significantly lower the level of malondialdehyde (MDA) in the skeletal muscle, and increase SOD activity significantly. According to the findings, the flavour of Bazhen decoction can reduce free radicals, get rid of exhaustion, boost antioxidant capacity, and help the body get better at exercising. The intake of energy-boosting substances, metabolic product accumulation, the enhancement of free radical generation, and lipid peroxidation during prolonged, intense training will result in a decrease in the cerebral cortex's and skeletal muscles' capacity to function, which will lead to exercise fatigue. Over time, this fatigue will also cause some degree of skeletal muscle damage. Herbal remedies can offer a conditioning and rehabilitation programme for tiredness and injuries sustained after exercise. Studies employing the herbal remedy "Body Fu Kang" have demonstrated that this remedy can considerably improve the skeletal muscles' energy supply and successfully reduce the structural alterations in muscle fibres brought on by exercise stress [32]. Furrer, Hawley [33] employed pressure pain, the extent of healing following exercise, and the occurrence of repeat injuries as indications of efficacy when treating skeletal muscle strain in quadriceps and hamstring injuries using herbal Huangqi and Danshen injections. According to the findings, the injection's topical application may help skeletal muscle injuries heal to some extent and reduce the risk of reinjury after treatment. In conclusion, research on herbal medicine's ability to heal skeletal muscle after strain—particularly in the context of sports training—is gradually gaining traction. Herbal medicine is used to extract the active ingredients needed to create medications that help athletes heal quickly from injuries. It is anticipated that additional findings will be made in the future to prevent injuries in some competitive athletes.

5. HERBAL MEDICINE RESEARCH TOWARD IMPROVING SPORTS INJURIES

The use of herbs to treat illnesses has long been documented, making herbal medicine a crucial kind of healthcare. The Yellow Emperor's Classic of Internal Medicine, which is considered the foundation of medical knowledge, and the Shennong Ben Cao Jing, which is supposed to be one of the four classics of medicine from the same era, contain thirteen prescriptions that list several herbal therapeutic effects and methods of treating illnesses. Through compounding and concoction, subsequent generations have continued to improve the therapeutic effects and expand the medicinal characteristics of herbal medicines, guided by the fundamental beliefs and philosophies of TCM [34]. Apart from administering herbs or formulas topically and internally to the injured sports site, it is crucial to select various dosage forms early on to optimise the therapeutic outcome. Some examples of these dosage forms include ointment, jiu-ting, powder, pill, *etc* [35]. "Injury Supplement during severe tendon damage that involves blood oozing requires mixing the holy golden knife san with the tying of the haemostatic wadding; after the blood stops, if the swelling collapses, the former medicine is removed, and the site is coated with jade red cream, outside the cover of Daoist monk cream to stop the pain and regenerate the muscle." This process explains the full course of treatment for the damaged area using various formulations of different medications. Topical herbal fumigation was selected as an efficient local injury relief method in order to minimise the harmful side effects and local targeting treatment. One significant benefit of pharmaceutical preparations is that they are mostly used at injury sites for targeted treatment [36].

6. NEGATIVE IMPACTS OF HERBAL REMEDIES ON THE BODY SYSTEM

According to a proverb, medication contains three poisons, and some of its constituent parts can affect a person's health when treating a condition. The body may experience adverse effects from large doses and prolonged use, particularly with regard to kidney and liver functions. Warming white sophora pills have been demonstrated to have distinct impacts on the metabolite profiles of healthy and kidney yang deficient mice, suggesting the toxicity of warming medications. Ephedra-containing diet tablets have been shown to have harmful effects on certain people's cardiovascular systems. Warm medications have been frequently noted to cause damage to the respiratory system and the five senses, whereas cold medications are more likely to induce adverse effects related to the digestive system, skin allergies, kidney damage, and anaemia. Huang advised consumers to use extreme caution because ephedra when used for weight loss, is hazardous to the cardiovascular system [37]. In a thorough investigation, Haung *et al.* discovered that the cooling medication Leigongteng can cause arrhythmias, tightness in the chest, palpitations, bradycardia, and, in extreme situations, potentially fatal cardiogenic shock

[37]. Zhao *et al.* [38] discovered that 88 of the 375 herbal remedies with distinct hot and cold qualities—46 of which were cold medicines and 42 of which were warm medicines—caused cardiovascular toxicity. This suggests a connection between the hot and cold characteristics of herbal remedies and their harmful side effects. It has been discovered through some publications that using herbal medicine's ingredients excessively is bad for people's health. In general, any overuse of herbal medication can harm the body; ginseng, atracylodes, astragalus, codonopsis, and licorice, which are not toxic, can all be harmful in excess. Toxic medications or those containing toxic substances used over an extended period of time can accumulate toxicity and induce negative side effects. For instance, using herbal remedies containing vermilion and stellaria over an extended period of time may harm the kidneys and liver. Consequently, it is critical to utilise herbal remedies responsibly in order to treat human illnesses and aid in the recuperation of athletes' weariness. There are few published researches on the negative impacts of using herbal remedies by athletes [38].

7. FUTURE RESEARCH TRENDS

Herbal remedies and their usage as an alternative form of treatment for internal and external health issues have become commonplace. The majority of "jamu" and other herbal drinks that are sold nowadays are used for cosmetic purposes after being thoroughly researched and manufactured for the market. Because of its health benefits, herbal drinks have the potential to be heavily advertised and consumed by the general public. Most of the herbal remedies that are now available on the market don't provide enough information regarding their pharmacology, dosage, indications, ingredients, or potential side effects. The effectiveness of herbal remedies is solely derived from ethnopharmacological findings from conventional medical practices. Scientific evidence is also missing in the majority of published data on herbal remedies, particularly when it comes to safety and efficacy. Therefore, in order to give consumers a clear understanding and assurance regarding the potential health benefits of herbal remedies, further research on the quality, pharmacological, safety, and storage characteristics of herbal remedies should be carried out. It is beneficial to identify the specific active substances in herbal medicines used by athletes that contravene the Olympic Charter and Ethical standards. These have been identified as the future research areas.

CONCLUSION

Herbal remediation is safe and has no negative side effects; nevertheless, it is important to note that there is cytotoxicity when using the proper dosage. Overall, the research literature has shown that herbal remedies may improve and regulate a patient's cardiac muscle, skeletal muscle, cardiovascular system, and central nervous system. It can also help the body return to normalcy after a period of herbal conditioning. Nevertheless, little research has been done on how conventional medicine

affects athletes. For instance, what are the long-term side effects of herbal remedies usage on athletes? How well do herbal remedies help people recover from tiredness and sports injuries? What benefits does TCM have on athletes' physiological markers? Right now, very little is understood as regards these questions. Herbal remedies are beneficial in helping athletes recover from exhaustion and sports-related injuries; they also help athletes avoid injuries during competition. However, there is currently a dearth of domestic and international research on the mechanisms of action of herbal medicine, which necessitates further investigation.

AUTHORS' CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to its submission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

LIST OF ABBREVIATIONS

- FDA = Food and Drug Administration
 DSHEA = Dietary Supplement Health and Education Act
 CNS = Central Nervous System

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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