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Review article

Therapeutic Potential of Rosemary (*Rosmarinus officinalis* L.) on Sports Injuries: a Review of Patents

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Abstract

Rosemary (*Rosmarinus officinalis* L.) has been used for its therapeutic effects since a long time ago. Most of the healing properties of rosemary might be attributed to its antinociceptive, antioxidant, and anti-inflammatory effects. The present review covers the certified patents and discoveries on medicinal, pharmaceutical, and therapeutic properties of rosemary to disclose its brilliant value on athletes' health. An extended literature review was carried out in Google Patent, US Patent, and Patentscope in the field of sports injuries, inflammation, and pain. Numerous patents uncovered the importance of rosemary to apply in various healing, pharmaceutical, and medicinal fields. These discoveries might also be used as complementary methods in sports medicine for sore muscle, muscle and ligament sprain, strain, bruise, spasm, tendinitis, tendon rupture, cartilage, and joint injuries. Due to a lack of clinical trials, the use of rosemary in the clinic has been limited to a few medicinal products. Considering the human trend to use phytocompounds rather than medications based on chemical compounds, precise attention must be devoted to linking the value of rosemary from basic science to clinical usage.

Keywords: analgesics; anti-inflammatory agents; athletic injuries; sports medicine; sprains

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Introduction

Sports injuries are very common among athletes and cause a burden on public health [1]. Sports injuries might happen during physical exercising or sports events and they could occur due to improper and poor practices or by accident. Insufficient stretching or warm-up before training sessions or sports events may possibly be another reason for such injuries. Common sports injuries include strains, sprains, tendon injuries, pulled muscles, shin splints, tendon injuries, dislocations, and fractures. There are various types of therapies for the management and treatment of sports injuries and the induced pain [2]. Beside medical treatment, prescribing herbs and phytocompounds might be helpful to provide effective and long-lasting treatment for common sports injuries and pains [3].

Since ancient times, herbs have been used to improve health and facilitate the healing process of injuries [4]. Many athletes use medicinal plants to stay alert and healthy, heal injuries, manage pain, reduce inflammation, improve their immune systems, and increase their performance [5,6]. Some well-known beneficial herbs in managing different kinds of sports injuries include arnica [7], comfrey [8], cayenne [9], ginger root [10], and ginseng [11].

Rosmarinus officinalis Linn., generally known as

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rosemary, is an evergreen herb that belongs to the Lamiaceae family [12]. This aromatic plant has 1-meter height, upright stems, white-blue flowers, dark green leaves, and it is distributed in southern Europe, Asia, and especially the Mediterranean region [13,14]. Phytochemical assessments have disclosed that rosemary contains alkaloids, flavonoids, terpenoids, and essential oil [15,16]. Furthermore, the most effective active constituents of *R. officinalis* are phenolic acids, phenolic diterpenes, and triterpenes; for instance, carnosic acid, rosmarinic acid, carnosol, rosmanol, betulinic acid, and ursolic acid [17,18] (Figure 1).

In folk medicine, rosemary has been used to manage and treat numerous ailments including stomachache, headache, dysmenorrhea, spasms, rheumatic pain, epilepsy, nervous agitation, mental and physical fatigue, depression, hysteria, and also for improvement of memory [19,20]. Lately, remarkable physio-pharmacological interest has been directed to the advantageous therapeutic effects of different types of rosemary extracts and its main constituents, including rosmarinic acid, carnosol, and carnosic acid. A great number of in vivo or in vitro investigations have revealed the wide variety of pharmacological and medicinal properties of rosemary and its components including antioxidant [21,22], anti-inflammatory [23,24], anti-apoptotic, antinociceptive [25,26], neuroprotective [27], antitoxic [28], antidepressant [29] properties and its ameliorative effect on memory and mental fatigue [30,31].

Safety of *R. officinalis* has been demonstrated in previous studies. In a study on mice receiving an intraperitoneal injection of methanolic *R. officinalis* leaves extract, the median lethal dose (LD_{50}) value of this extract was 4.125 g/kg/body weight [32]. Also, rosemary has been categorized as "generally safe" or GRAS (CFR182.10; 182.20) by the United States food and drug administration (FDA) [33].

Rosemary and its active components have insufficient clinical information for treating and managing musculoskeletal disorders, including sports injuries, which may be due to a lack of data on their clinical pharmacokinetics, toxicity, and limited economic investments. In terms of effective pharmacological properties of rosemary, the current review summarizes medicinal patents related to anti-inflammatory and antinociceptive effects in order to emphasize the importance of this herb on sports injuries and to link the significance of rosemary from basic sciences to clinical usage.

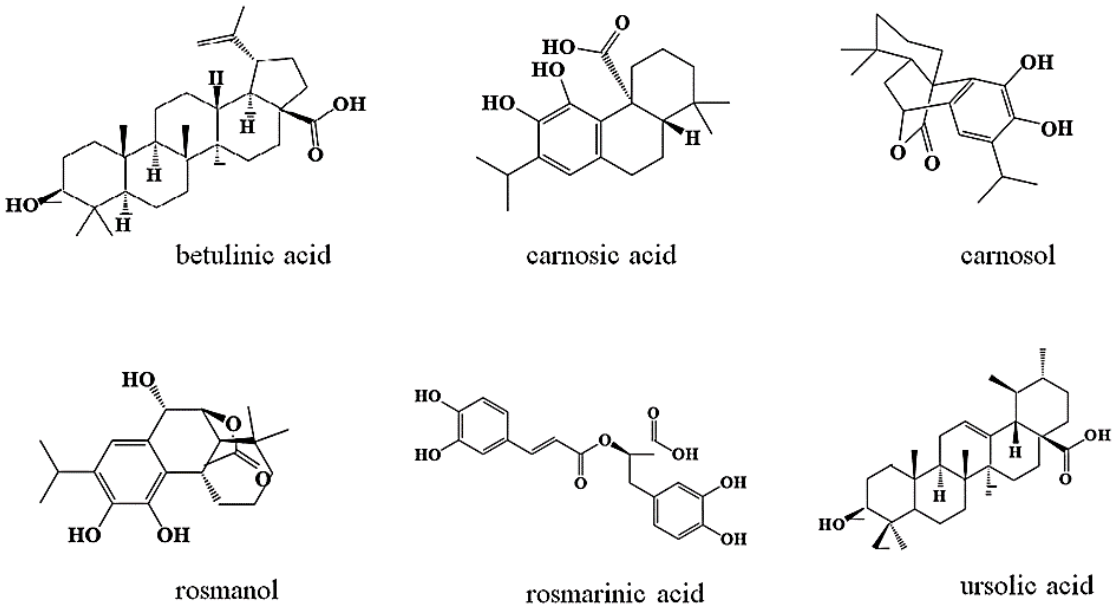

Figure 1. Chemical structure of some active constituents of rosemary

Methods

The present patent review chiefly highlights the published patents comprising the therapeutic and pharmacological effects of *Rosmarinus officinalis* on sports injuries. Patents search has been performed by searching related keywords, namely "*Rosmarinus officinalis* L.*"* or "rosemary" and "pain" or "antinociceptive" or "analgesic" and "inflammation" or "anti-inflammatory" and "antioxidant" and "muscle" or "sore muscle" or "sprain" or "strain" and "bruise" and "spasm" and "tendinopathy" or "tendinitis" or "tendon rupture" and "cartilage" and "joint" and "sports injuries", in the Google Patent, US patent, and Patentscope.

Results and Discussion

Effect of rosemary on sport injuries

Rosemary for reducing muscle injuries

Muscle injuries and muscle fibers necrosis commonly occur in sports and clinical medicine and they frequently lead to long-term physical disability and chronic pain that affect thousands of people and athletes around the world. These injuries accounts for a large proportion of all sport-related injuries [34-36]. Injured skeletal muscle might go through a spontaneous repair by regeneration. The regeneration procedure often remains incomplete since the deposition of collagen and overgrowth of extracellular matrix result in substantial fibrous scarring [37-39]. Therefore, muscle injuries commonly give rise to considerable morbidity, pain, contracture, muscle atrophy, contraction injury, as well as early functional and structural deficits [1]. In addition, muscle spasms are very common among athletes. Muscle spasms mainly happen because of the damages in the ligaments, tissues, or as a result of the pull in the muscle fiber. Also, cramps might occur in muscles due to lactic acid production through anaerobic glycolysis [40].

A previous clinical study has shown that topical application of rosemary (three times a day for 3 days) ameliorated the frequency and severity of musculoskeletal pain in 105 participants. The authors of this trial suggested that 1,8‑cineole, the main constituent of rosemary essential oil, might prevent the production of inflammatory mediators including cytokines, leukotrienes, and prostaglandins that could result in pain. Hence, the anti-inflammatory and analgesic properties of rosemary reduced pain intensities in participants [41]. In another study, the probable effect of rosemary oil on muscle spasms was assessed on 15 people. The obtained results revealed that rosemary oil was effective on muscle spasms and 9 out of 15 participants reported that rosemary oil was beneficial in reducing the spasm and cured the pain within 15 minutes [40]. The ameliorative effect of rosemary essential oil on eccentric exercise-induced delayed-onset muscle soreness was also assessed in 24 women by measuring creatine kinase (a muscle damage indicator) after eccentric leg curl exercise. Rosemary essential oil (0.25, 0.5 mL) was administered three times a day for 14 days and then the eccentric leg curl exercise was done. The supplementation of rosemary essential oil continued until 72 hours after the exercise. The findings illustrated that rosemary (0.25, 0.5 mL) was able to decrease creatine kinase in comparison with the placebo group 48 hours after exercise [42].

In this regard, a vasodilating ointment for topical application was designed that contained rosemary and eucalyptus oils, lavender, camphor, and revitalin. (Revitalin® PF boosts anaerobic glycolysis, resulting in more adenosine triphosphate (ATP) and acid. This increases mitochondrial respiration, resulting in a high ATP level) to amend muscle and joint diseases, myodynia, and rheumatism [43]. A massage oil containing a mixture of herbs including rosemary, linden, marigold, savory, juniper, horse chestnut, and lavender was prepared. This product improved venous microcirculation, relieved muscle pains, and energized users [44]. A neuroprotective composition consisting of carnosic acid, a polyphenolic antioxidant derived from the rosemary and sage, was formulated to reduce oxidative stress and prevent neuronal death. This product was helpful in reducing fatigue, muscle spasms, neuropathic and chronic pain, and for relaxing muscles, ameliorating muscle and neuromuscular junction disorders, and amending muscle weakness [45]. Also, combinations of ingredients having synergistic anti-inflammatory properties including *R. officinalis*, *Curcuma longa*, carnosol, rosmarinic acid, and fish oil were designed to ameliorate inflammation-associated disorders such as pain, neuropathic pain, strains, tennis elbow, and muscular discomfort, by reducing the formation of cyclooxygenase-2 (COX-2) and pro-inflammatory cytokines such as interleukin-1beta (IL-1β), interferon-gamma, and tumor necrosis factor-alpha (TNF-α) [46]. An organic

composition with anti-oxidant, anti-inflammatory, and antinociceptive properties comprising several extracts such as rosemary, boswellia, ginger, holy basil, turmeric, white willow, besides alpha-lipoic acid and trolamine salicylate was formulated to treat and manage pain, including chronic pain triggered by inflammation, trauma, chronic muscle pain and spasms, and acute muscle aches from a sporting injury [47]. Another product revealed composite essential oil prepared from the essential oil of rosemary, grape seed, sage, basil, and lemon that could relive muscular soreness after sports, reduce the amount of creatine kinase in serum, and attenuate the symptom of muscular soreness affected by muscle micro-injuries after sports [48]. A method was designed to use caryophyllene, a natural bicyclic sesquiterpene that is present in many essential oils, especially the essential oil of rosemary, clove oil, and *Cannabis sativa* oil, in the forms of gel, lotion, cream, or foam to provide regional neuro-affective therapy for treating muscle tension, muscle spasms, muscle weakness, peripheral neuropathic pain, acute pain, neurogenic pain, inflammation, and relaxing skeletal muscles [49]. A gel formulation containing rosemary essential oil (as an analgesic and anti-inflammatory agent) along with some other phytomedicines including aloe vera gel, menthol, and lavender essential oil has been formulated to relax muscles, relieve pain, reduce bruise, symptoms of sprains, swelling, soreness, inflammation, fibrositis, muscle strain, and muscular spasm (cramps and pulls in muscle fibers) [50]. Another formulation comprising rosemary oil, calendula oil, camellia oil, carvacrol, and leucine was designed to reduce inflammation and increase blood flow. Thus, this formulation was able to stimulate myofibrillar muscle protein synthesis and alleviate pain in the muscles [51]. A disclosure was directed to a formulation containing anti-inflammatory, antioxidant, and analgesic constituents including rosemary, cannabidiol, tetrahydrocannabinol, mint oil, peppermint, peppermint oil, piperine, and geranium to reduce muscle tension, muscle spasms, pain, and to relax muscles [52] (Table 1).

Rosemary for reducing tendon and ligament injuries

Tendon injury often happens due to direct trauma such as tendon blunt or penetrating or it might occur because of indirect tensile overload [53]. Tendon overuse is one of the major reasons for tendon injuries in recreational and competitive athletes [54]. Tendon rupture, tendinopathy, and tendinitis are some other damages that might occur in athletes [55]. Ligament injuries could occur in high-intensity sports that involve pivoting and running.

Table 1. Patents containing rosemary for reducing muscle injuries

Patent number	Patent title	Main ingredients	Reference
RU02283089	Ointment for topical application	Rosemary and eucalyptus oils, lavender, camphor, revitalin	[43]
FR2929849A1	Manufacturing of a massage oil, useful e.g. in the preparation of a composition to relax and to act against stress, comprises three successive steps for extraction carried out by slow and gentle cooking	Rosemary, linden, marigold, savory, juniper, horse chestnut, lavender	[44]
US20090042980A1	Neuroprotective compositions and methods	Carnosic acid	[45]
US20090304827A1	Combinations of ingredients having synergistic anti-inflammatory effects	*Rosmarinus officinalis*, *Curcuma longa*, carnosol, rosmarinic acid, fish oil	[46]
US8962045B2	Herbal/organic composition for the management of pain	Rosemary, boswellia, ginger, holy basil, turmeric, white willow, alpha-lipoic acid, trolamine salicylate	[47]
CN105902700	Composite essence oil capable of reliving muscular soreness after sports and preparation method thereof	Rosemary essential oil, grape seed, sage, basil, lemon	[48]
CA3034250A1	Topical regional neuro-affective therapy with caryophyllene	Rosemary essential oil, clove, and *Cannabis sativa*	[49]
WO2019195943A1	Cannabis root extract, method of manufacture, method of use	Rosemary essential oil, aloe vera gel, menthol, lavender essential oil	[50]
US20190151232A1	Topical compositions, process of manufacture and method of Use	Rosemary oil, calendula oil, camellia oil, carvacrol, leucine	[51]
CA3080468A1	Cannabinoid formulations	Rosemary, cannabidiol, tetrahydrocannabinol, mint oil, peppermint, peppermint oil, piperine, geranium	[52]

They frequently happen in the ankles and knees but they may also occur in any other joints in the body such as the neck, back, shoulder, wrist, and thumb [56]. In a clinical trial, it was observed that aromatherapy massage with a mixture of essential oils including rosemary, lavender, geranium, chamomile, and eucalyptus was effective in reducing the symptoms of peripheral neuropathy such as hypoactive deep tendon reflexes, dysesthesia, paresthesia, motor weakness, and neuropathic pain [57]. It was also reported that the rosemary leaves extract was beneficial in ameliorating tendonitis [58]. Elastase was observed to be involved in the development of chronic tendinopathy [59] and in this regard, a study has shown that rosemary extracts have anti-elastase property [60].

The homeostasis of hyaluronic acid is essential for ordinary mobility of the body and it keeps ligaments, tendons, and joints in a good condition. Therefore, hyaluronidase inhibitors are potent agents in maintaining the proper and healthy nature of connective tissues [61]. A previous in vitro investigation exhibited that rosmarinic acid has an anti-hyaluronidase property with a maximum inhibition of 44.35% [62].

Aqueous or alcoholic extracts of herbs including rosemary, arnica, thyme, male fern, capsicum, marjoram, and sage were prepared to cure neuritis, and tendinitis by massaging the injured part three times a day [63]. An herbal mixture comprising extracts from rosemary, comfrey, ginger, arnica, hypericum, witch hazel, and lavender was formulated for treating soft tissue injuries including damaged ligaments, fascia, aponeurosis, and stretched or torn tendons [64]. A nutritional supplement comprising herbal constituents such as *Rosmarinus officinalis*, *Curcuma longa*, *Salvia officinalis*, rosmarinic acid, carnosic acid, and curcuminoids was designed to ameliorate tendonitis, bursitis, strain or inflammation of tendons or ligaments by inhibiting inducible nitric oxide synthase (iNOS), reducing nitric oxide (NO) and COX-2 enzyme synthesis [46]. A therapeutic composition consisting of rosemary extract, chlorophyllin, zinc, methyl folate, and green teawas prepared to ameliorate tenosynovitis, tendonitis, and for strengthening the ligaments [65]. Other preparations presented antioxidant and anti-inflammatory compositions including the extracts of rosemary, turmeric, ginger, boswellia, white willow, holy basil, besides alpha-lipoic acid for the treatment of pain induced by tendons and ligaments disorders and tendonitis [66-68]. An herbal ointment comprising rosemary, comfrey, calendula flower, German chamomile, stinging nettle leaf, wolf's bane, Devil's claw, and turmeric was designed to relieve sports-related injuries such as damaged tendons, ligament strains, sprains, or tears, besides pains and the associated discomfort. This herbal mixture could reduce inflammation, improve the natural replacement of body cells, control bleeding, relax muscles, and could relieve spasms, and pain [69]. Another formulation containing a mixture of stilbene, isoprenyl flavonoids, flavans, curcuminoids, as well as rosmarinic acid was prepared to amend tendonitis, bursitis by decreasing inflammation and oxidative stress [70] (Table 2).

Rosemary for reducing cartilage and joint injuries

Cartilage reconstruction and tissue repair are challenging because of the cartilage inherited limited healing capacity. Articular hyaline cartilage has an inadequate potential to self-repair mainly as a result of its avascular nature and the narrow capability of matured chondrocytes to produce an adequate volume of the extracellular matrix. Therefore, damaged cartilage triggers the development of arthritis [1,71]. Articular cartilage injuries are frequently observed in athletes, particularly in sports that involve pivoting for instance soccer, basketball, and football [72]. In addition, cartilage damages of the knee joint usually lead to other serious injures including osteochondral injuries, traumatic patellar dislocation, and ligament and meniscal injuries [34].

Previous studies have shown that rosemary extract and essential oil are effective in ameliorating adjuvant-induced arthritis and in avoiding the joint architecture destruction in the osteoarthritis model in rats by their antioxidant and anti-inflammatory properties [73,74]. Moreover, it has been observed that rosmarinic acid attenuates the expression of NO and prostaglandin E_2 (PGE2) through the mitogen-activated protein kinase (MAPK) pathway in rat chondrocytes; so, rosmarinic acid might be a potent agent in treating osteoarthritis [75]. It has been reported that carnosic acid reduces cartilage degeneration by inducing heme oxygenase-1 in human articular chondrocytes [76].

Table 2. Patents containing rosemary for reducing tendons and ligaments injuries

Patent number	Patent title	Main ingredients	Reference
IT1252074	Water/alcohol extract of medicinal herbs and plants for the cure of tendinits, neuritis, sciatic pain, rheumatic, joint, and neck pains and stiff neck	Rosemary, arnica, thyme, male fern, capsicum, marjoram, sage	[63]
WO2006032091A2	Herbal composition	Rosemary, comfrey, ginger, arnica, hypericum, witch hazel, lavender	[64]
US20090304827A1	Combinations of ingredients having synergistic anti-inflammatory effects	*Rosmarinus officinalis* L., *Curcuma longa*, carnosol, rosmarinic acid, carnosic acid, and fish oil.	[46]
US20110213236A1	Therapeutic compositions, devices and methods for observing treated tissues	Rosemary extract, chlorophyllin, zinc, methyl folate, green tea	[65]
US20120082739A1	Compositions and methods for treatment and management of pain	Rosemary extracts, turmeric, ginger, boswellia, white willow, holy basil, and alpha-lipoic acid	[66]
WO2014197129A2	Compositions and methods for treatment and management of pain	Extracts of rosemary, turmeric, ginger, boswellia, white willow, holy basil, alpha-lipoic acid	[67]
US9028888B2	Compositions and methods for treatment and management of pain	Extracts of rosemary, turmeric, ginger, boswellia, white willow, holy basil, alpha-lipoic acid	[68]
US20170202898A1	Herbal ointment for musculoskeletal and joint-related conditions	Rosemary, comfrey, calendula flower, German chamomile, stinging nettle leaf, wolf's bane, Devil's claw, turmeric	[69]
TWI643631B	Composition and method for joint health	Stilbene, isoprenyl flavonoids, flavans, curcuminoids, rosmarinic acid	[70]

Also, carnosic acid can prevent the expression of pro-inflammatory cytokines (e.g. matrix metalloproteinase-3 (MMP-3), IL-1β, IL-6, IL-8, IL-17, and TNF-α) and the destruction of joint on fibroblast-like synoviocytes, osteoclasts, as well as collagen-induced arthritis rats [77]. Likewise, the findings of an investigation disclosed that carnosol can prevent catabolic mediators and pro-inflammatory factors of cartilage degeneration in human chondrocytes of osteoarthritic patients and mediate cross-talk between chondrocytes and subchondral bone osteoblasts [78]. An herbal composition was prepared from rosemary, holy basil, ginger, turmeric, *Polygonum cuspidatum* ("Hu zhang"), green tea, Chinese goldthread, and oregano barberry to reduce inflammation in joints by inhibiting COX-2, and promote healthy joint function and normal cell growth [79]. Also, a liquid massage composition containing different oils including rosemary, almond, sesame, thyme, and peppermint was designed to cure anatomic diseases such as joint hernia, joint circulation disorders, calcification, and rheumatic arthritis [80]. A pharmaceutical formulation including potent extracellular matrix-stabilizing and anti-inflammatory compounds such as different essential oils including rosemary, frankincense, thyme, turmeric, clove, and orange, besides curcuminoids was prepared to stabilize the extracellular matrix and prevent chronic inflammatory conditions such as degenerative osteoarthritis, joint pain, and cartilage degradation [81]. Another product comprising essential oils of rosemary, jojoba, lavender, chamomile, juniper berry, and pine was effective in relieving joint pain and rheumatism pain by stimulating the blood circulation and also through its analgesic and anti-inflammatory properties [82]. A homeopathic joint pain relieving formulation consisting of rosemary and animal fat was prepared to be topically applied with a massage on affected areas, including joints [83]. An herbal mixture containing rosemary, saffron, black cohosh, lemon balm, ginger, peppermint, along with a penetrating agent was formulated to ameliorate and heal joint-related disorders such as degenerative joint diseases, caused by injuries resulting from sports, falls, or accidents. This ointment could protect articular cartilage by down-regulating TNF-α and interleukins [69]. Lipid formulations including bioactive fatty acids, rosemary, green tea, cat's claw, inositol, kelp, bioflavonoids, dulse (red seaweed), nettles, maltodextrin, niacin, niacinamide, selenium, zinc, silica, and spirulina were designed to promote the growth of cartilage, ligament, tendon, bone, nerve tissue, and to heal wounds [84]. Another product contained a mixture of rosemary, lemon balm, sage, peppermint, stilbene, isoprenyl flavonoids, flavans, and curcuminoids which could amend joint stiffness, joint pain, joint inflammation, cartilage degradation and could improve mobility, flexibility, range of motion, and joint physical function by its analgesic, neuralgia reliever, and anti-inflammatory properties [70]. A medicine was formulated for treating joint, muscle, and rheumatic pain which are associated with joint diseases. It contained

different herbal extracts including rosemary, arnica, ginger, and frankincense [85]. A formulation of herbal mixture with high polyphenol concentrations comprising rosemary leaf extract, Shilajit extract, amla fruit extract, pomegranate fruit peel extract, curcumin extract, fenugreek seed extract, and piperine extract. showed antioxidant, anti-inflammatory, antiviral, and antimicrobial properties. This product could affect osteoarthritis by reducing free radical damage of the joints, preventing inflammation in joints by inhibiting COX-2, avoiding cartilage breakdown in joints and reducing joint pain [86]. Another recent formulation containing essential vitamins, minerals, amino acids, rosemary, safflower, sage, and saffron was prepared to repair articular cartilage lesions, treat or prevent osteochondral defects resulted from traumatic injury (e.g., a sports injury), restore the structure and function of several tissues of the body, and improve joint, bone, and muscle strengths in athletes [87] (Table 3).

Conclusion

Several documents indicate the superb properties of rosemary in various patent formulations in treating sports injuries including muscle, tendon, ligament, cartilage, and joint injuries. Patents of polyherbal formulations comprising rosemary have analgesic, anti-inflammatory, and antioxidant effects. It should be pointed out that in the constructions of the cited patents, rosemary most likely has synergistic effects with other ingredients in the formulated mixture, and therefore, the observed healing property is not attributed only to rosemary.

A patent is a government license or authority presenting a title or a right for an agreed period, particularly the individual right to prohibit others from selling, using, or making an invention [88]. Thus far, various patents have been publicized on phytocompounds which discloses human trends in this arena [89].

Rosemary (*Rosmarinus officinalis*) is a native herb in the Mediterranean area but nowadays it is cultivated all over the world. It might be employed in cooking, in the food industry, also as a therapeutic and ornamental plant [90]. In traditional medicine, rosemary was administered to ameliorate pain, spasms, increase blood circulation, and energize [19,20]. Scientific documents revealed that rosemary could be a beneficial agent in managing pain [25], neurodegeneration [27], depression [29], memory deficit [30], metabolic syndrome [91], cancer [92], and toxicity [28].

Table 3. Patents containing rosemary for reducing cartilage and joint injuries

Patent number	Patent title	Main ingredients	Reference
US6264995	Herbal composition for reducing inflammation and methods of using same	Rosemary, holy basil, ginger, turmeric, “Hu zhang”, green tea, Chinese goldthread, oregano barberry	[79]
WO2005004790	Liquid massage composition for the cure of acute chronic vertebral herina, diseases of joint, arthritis, calcification and for the regulation of blood circulation	Rosemary oil, almond oil, sesame oil, thyme oil, peppermint oil	[80]
WO2012142511A2	Orthomolecular compositions and their use in stabilizing the extracellular matrix patent	Rosemary essential oil, frankincense, thyme, turmeric, clove, orange, curcuminoids	[81]
CN103494876	Essential oil capable of relieving pain from caused by rheumatism	Rosemary essential oil, jojoba, lavender, chamomile, juniper berry, pine	[82]
US20140377370	Joint pain treatment composition and method of use	Rosemary and animal fat	[83]
US20170202898A1	Herbal ointment for musculoskeletal and joint-related conditions	Rosemary, saffron, black cohosh, lemon balm, ginger, peppermint, penetrating agent	[69]
WO2017091647A1	Lipid formulations containing bioactive fatty acids	Bioactive fatty acids, rosemary, green tea, cat's claw, inositol, kelp, bioflavonoids, dulse, nettles, maltodextrin, niacin, niacinamide, selenium, zinc, silica, and spirulina	[84]
CN107519465	Medicine for treating muscle and joint pain	Rosemary, arnica, ginger, frankincense extracts	[85]
US20190209634A1	Herbal nutraceutical formulation to reduce oxidative stress, viral and microbial infections, and inflammation	Rosemary leaf extract, Shilajit extract, amla fruit extract, pomegranate fruit peel extract, curcumin extract, fenugreek seed extract, piperine	[86]
WO2019140267A1	Nutraceutical products from cell conditioned medium from cells cultured under hypoxic conditions	Vitamins, minerals, amino acids, rosemary, safflower, sage, saffron	[87]

These therapeutic properties are mostly due to its antioxidant, anti-inflammatory, and antinociceptive properties [24]. However, more clinical trials are essential to assess the effects of rosemary and its main components in treating different types of sports injuries. Besides, there is no review article on the topic of therapeutic usages of formulations containing rosemary and its active constituents for handling sports injuries. In the existing review, our team tried to fill the present gap and focus on the existing inventions to draw pharmaceutical and medicinal funds in this field.

It must be noted that 'natural' does not always mean 'safe' since some documents have illustrated the adverse effects and noxiousness of some phytocompounds [93,94]. Despite the fact that rosemary has displayed to prohibit and amend numerous ailments, further scientific studies are essential to authenticate its feasible safety and toxicity extent in vulnerable individuals. Although, rosemary has been categorized as "generally safe" or GRAS (CFR182.10; 182.20) by the United States food and drug administration (FDA) [33], additional clinical trials are necessary to examine the safety of rosemary for pediatrics, geriatrics, and nursing mothers.

In the current patent review, our team gathered patents that confirmed the pharmacological and healing potential of rosemary alone or in combination with other herbs and ingredients in managing and treating sports injuries. The patents were collected from Google Patent, US Patent, and Patentscope without any time and language limitations; verifying keywords were "*Rosmarinus officinalis* L.", "rosemary", "pain", "antinociceptive", "analgesic", "inflammation", "anti-inflammatory", "antioxidant", "sore muscle", "sprain", "strain", "bruise", "muscle", "spasm", "tendinopathy", "tendinitis", "tendon rupture", "cartilage", "joint", and "sports injuries". At present, there is a growing concern in employing phytocompounds in the company of regular medicines. In immediate future, herbal medications may be used not just as complementary but as the main treatment as well. Drawing scientists' attention to formulate herbal medicines and studies in this field in addition to economical funds supporting clinical trials would be advantageous to achieve the crucial aim of researchers 'transforming basic knowledge to patient's bed'.

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None

Author contributions

Nima Nakisa and Mahboobeh Ghasemzadeh Rahbardar contributed in conceptualization, data curation, investigation, methodology, project administration, supervision writing, review and editing of the manuscript.

Declaration of interest

The authors declare that there is no conflict of interest. The authors alone are responsible for the accuracy and integrity of the paper content.

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Abbreviations

COX-2: cyclooxygenase-2; FDA: food and drug administration; IL-1β: interleukin-1beta; iNOS: inducible nitric oxide synthase; LD_{50}: median lethal dose; MAPK: mitogen-activated protein kinase; MMP-3: matrix metalloproteinase-3; NO: nitric oxide; PGE2: prostaglandin E2; TNF-α: tumor necrosis factor-alpha