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REVIEW ARTICLE

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State of the art and major clinical outcomes of the use of essential oils in the performance of athletes: a systematic review

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Abstract

Introduction: Essential oils (EOs) has been around for years and studies show that they are useful in treating various diseases and improving health. According to the United States OEs Handbook, OEs are a vital part of complementary and alternative medicine and the positive findings of OEs are now becoming a trend in sports performance research for athletes. **Objective:** It was to list the main scientific findings of clinical studies on the effectiveness of essential oils in improving the health and sports performance of athletes**. Methods:** A total of 195 articles were found involving clinical studies of the influence of essential oils on human health. After this process, 42 articles were included and 32 were discussed in this study. The present study was prepared following the systematic review guidelines – PRISMA. **Results and Conclusion:** Essential oils have been used in medicine for decades and have been proven to eliminate toxins from the body. They are also shown to improve the body's ability to absorb essential vitamins and nutrients. In this sense, the application of these oils not only helps to prevent and heal sports injuries but also to stimulate and relax the mind and body, leading to higher levels of fitness. Because of these inherent properties of EOs, there is growing interest in using them to tone the body and mind in a variety of ways, such as musculoskeletal preparation, injury prevention, and improving mood and performance to achieve a higher success rate in sports. sports and fitness, as well as post-exertion recovery. They can be used as an aid to make recovery faster, reducing the effect of fatigue and raising the energy level of the mind and body.

Keywords: Essential oils. Aromatherapy. Athletes. Sports. Performance.

Introduction

Essential oils (EOs) have been around for years and studies show that they are useful in treating various ailments and improving health **[1, 2]**. According to the United States EOs Handbook, EOs are a vital part of alternative and complementary medicine and the positive findings of EOs are now becoming a trend in sports performance research for athletes **[3]**.

In this context, EOs have been used in medicine for decades and have been proven to eliminate toxins from the body. They are also shown to improve the body's ability to absorb essential vitamins and nutrients. EO can enter the body through application to the skin, ingestion or inhalation (aromatherapy) **[4]**.

Also, EOs inhalation positively affects the olfactory and limbic systems of the body. The olfactory system is related to all the organs that contribute to our sense of smell. The limbic system, also known as the emotional brain, directly affects our heart rate, blood pressure, stress levels, hormones, breathing, and memory. It is said that the active ingredients of some EOs, when inhaled, reach the lungs and improve the respiratory system **[5]**.

Furthermore, EOs can improve anxiety, depression and stimulate neurological function. Other studies have shown that athletes who used peppermint oil before an event had a significant improvement in lung function **[4]**. When applied to the skin, the EOs are absorbed and the active principles are used by the body for specific therapeutic treatments. For example, applying an essential oil blend containing ginger reduces arthritis pain and increases flexibility **[5]**.

Other research has indicated that the inhaled form of citrus essential oil promotes relaxation and peppermint oil acts as a bronchodilator. These findings spurred further research into how citrus and peppermint

EOs may benefit athletic performance [5].

In addition, there may be the synergistic effects of different vegetable oils on the energy of the body and mind, facilitating excellence in sports and fitness. There are well over a hundred different natural EOs with antiseptic, anti-inflammatory, analgesic, antidepressant and even expectorant properties. In this sense, the application of these oils not only helps to prevent and heal sports injuries, but also to stimulate and relax the mind and body, leading to higher levels of fitness. Because of these inherent properties of EOs, there is growing interest in using them to tone the body and mind in a variety of ways, such as musculoskeletal preparation, injury prevention, and improving mood and performance to achieve a higher success rate in sports. sports and fitness, as well as postexertion recovery. They can be used as an aid to make recovery faster, reducing the effect of fatigue and raising the energy level of the mind and body [4, 5].

Added to this, EOs can clean cellular receptor sites of drugs and other disruptors of intercellular communication and can act as chelators of heavy metals and other toxins, helping to remove and eliminate them through the kidneys, lungs, sweat, colon and liver. In this way, EOs increases the body's ability to absorb nutrients and vitamins [6-8].

Besides, many of the EOs are used in the pharmaceutical industry as an active ingredient in pharmaceutical formulations such as eucalyptus, peppermint, thyme, fennel and many others or they are used in the pharmaceutical industry as excipients as well as most of flavoring agents that are used to improve the odor and taste of medicines isolated from various plants containing EOs [9-12].

Over the past thirty years, a number of studies have been conducted to assess the inhalational effects of EOs on behaviors, creativity, mood, and many other psychological and physiological effects [13-17]. Therefore, the present systematic review study aimed to list the main scientific findings of clinical studies on the effectiveness of essential oils in improving the health and sports performance of athletes.

Methods

Study Design

The present study was prepared in accordance with the systematic review guidelines - PRISMA (Transparent reporting of systematic reviews and meta-analysIshttp://www.prisma-statement.org/).

Data Sources and Research Strategy

The databases as PubMed, Scopus, Web of Science, Embase, OVID and Google Scholar databases were searched using scientific articles from 1980 to 2022. The search lasted 2 months. Initially, the descriptors were determined through a search in the DeCS tool and later verified and validated by the MeSH Terms System (US National Library of Medicine), using the descriptors (MeSH Terms): *Essential oils. Aromatherapy. athletes. Sports. Performance*, and using the Booleans "and" between the MeSH terms and "or" between the historical findings.

Study Quality and Risk of Bias

Quality was rated as high, moderate, low or very low for risk of bias, clarity of comparisons, precision and consistency of analyses. The most evident highlight was for systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument through the analysis of the Funnel Plot (Cohen test (d)).

Results and discussion

A total of 195 articles were found involving clinical studies of the influence of essential oils on human health. Initially, the existing exclusion title and duplications were carried out following the interest described in this work, which was about the influence of essential oils on the performance of athletes. After this process, 42 articles were included and 32 were fully analyzed and described in the results of the systematic review **(Figure 1)**. Most studies showed homogeneity in their results, with I2 =98.9% >50%.

Figure 1. Flowchart of the article selection process.

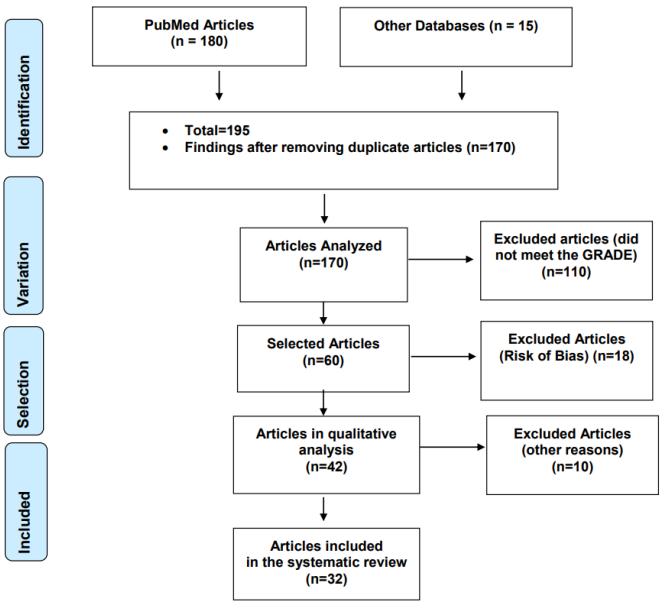
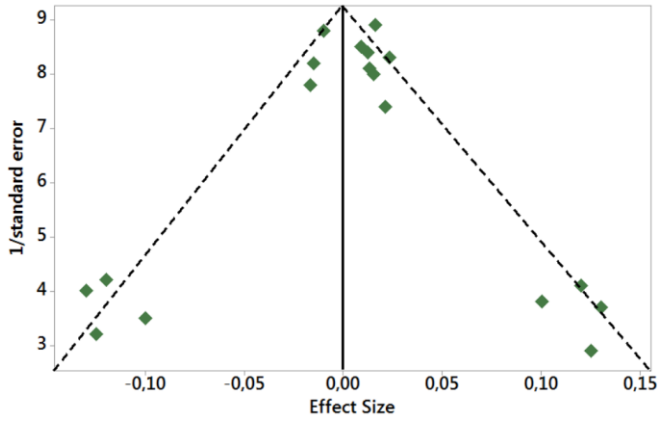


Figure 2 presents the results of the analysis of the risk of bias of the studies using the Funnel Plot (magnitude of the difference versus sample size), using the Cohen test (d). The result showed a symmetrical behavior, not suggesting a significant risk of bias, both between studies with a small sample size (lower precision), which are shown at the bottom of the graph, and in studies with a large sample size, which are presented in the upper region.

Figure 2. The symmetrical funnel plot suggests no risk of bias between the small sample size studies that are shown at the bottom of the plot. High confidence and high recommendation studies are shown above the graph (NTotal=32 studies evaluated in full in the systematic review).



In the context of the action of essential oils (EOs) for therapeutic and curative purposes, the inhalation of some fragrances has been used to correct sympathetic dysfunction associated with various lifestyle-related disorders such as hypertension and obesity **[1-4]**. In addition, several studies have found that EOs used in aromatherapy for stress relief can reduce the risk of cardiovascular disease **[4, 5]**. The reason is that shortterm exposure to fragrance has a beneficial effect on heart rate and blood pressure **[6, 7]**.

Previous studies have shown that some fragrances have inhibitory effects on brain and autonomic nerve functions **[7,8]**. In this regard, one study investigated the effects of fragrance inhalation on sympathetic activity in normal adult subjects, using both power spectral analysis of blood pressure fluctuations and measurement of plasma catecholamine levels. Inhalation of EOs fragrances such as pepper oil, tarragon oil, fennel oil, or orange oil resulted in a 1.5- to 2.5-fold increase in relative sympathetic activity, representing low-frequency amplitude of the EOs systolic blood pressure compared to inhalation of an odorless solvent, triethyl citrate ($p<0.05$). In contrast, inhalation of rose oil fragrance or patchouli oil caused a 40% decrease in relative sympathetic activity ($p<0.01$, each). Inhalation of pepper oil fragrance induced a 1.7-fold increase in plasma adrenaline concentration compared to the resting state ($p=0.06$), while inhalation of rose oil fragrance caused a decrease in 30% in adrenaline concentration ($p<0.01$). Therefore, inhalation of EOs fragrances can modulate sympathetic activity in normal adults **[5]**.

In addition, a study analyzed the essential oil of flowers of *Rhaponticum acaule* (L) which was characterized by gas chromatography and mass spectrometry. The antioxidant activities of R. *acaule* essential oil (RaEO) were also determined using 2,2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid, reducing power, phosphomolybdenum and DNA cutting assays. The inhibitory power of RaEO against α-glucosidase, xanthine oxidase and pancreatic lipase was evaluated. Enzyme kinetic studies using Michaelis-Menten and Lineweaver-Burk (LB) derived graphs were performed to understand the possible mechanism of inhibition exerted by the components of this essential oil. The result revealed the presence of 26 compounds (97.4%). Major constituents include germacrene D (49.2%), methyl eugenol (8.3%), (E)-β-ionone (6.2%), β-caryophyllene (5.7%), (E,E)-α-farnesene (4.2%), bicyclogermacrene (4.1%) and (Z)-α-bisabolene (3.7%). The study showed that the essential oil demonstrated a strong inhibitor of αglucosidase. The oil also showed an important inhibitory effect on xanthine oxidase, behaving as a non-competitive inhibitor. Furthermore, the essential oil inhibited pancreatic lipase, with a maximum inhibition of 80% achieved at 2 mg/mL. Furthermore, the inhibition of pancreatic lipase was irreversible. Therefore, the results revealed that RaEO is a new source of antioxidant compounds, with important practical results for human health **[18]**.

Also, the chemical composition of peppermint essential oil (Mentha x *Piperita l.*) was also analyzed by gas chromatography and mass spectrometry. The main constituents were menthol (40.7%) and menthone (23.4%). Other components were menthyl acetate, 1,8-cineole, limonene, beta-pinene and beta-caryophyllene. Peppermint oil has antiradical activity against DPPH (diphenyl picryl hydrazyl) and hydroxyl (OH*) radicals, exerting a greater antioxidant impact on the OH* radical. The concentrations required for 50% inhibition of the respective radical were 860 μg/mL for DPPH and 0.26 μg/mL for OH*. Peppermint essential oil demonstrated antioxidant activity in a linoleic acid emulsion system, as it inhibited the formation of conjugated dienes by 52.4% and the generation of secondary oxidized products of linoleic acid by 76.9% (in concentration of 0.1%) **[19]**.

Besides, one study examined the effects of aromatherapy with red rose essential oil on athletes' sleep quality before competition. The statistical population consists of 20 male futsal players. Participants were randomly divided into control and experimental groups. The instrument includes the Pittsburgh Sleep Quality Index (PSQI) and demographic questionnaire. Aromatherapy with rose oil was performed for 4 nights in the experimental group. Three drops of Rose essential oil were dropped on the participants' pillow every night. They inhaled for 8 hours. The control group did not inhale aromas. Participants completed the PSQI in the morning pretest on Day 5 (the morning of the competition). The results showed that the intervention of 4 nights of aromatherapy with rose essential oil had a slight effect on the athletes' sleep quality before competition. Therefore, it is necessary to increase the number of participants, as well as the amount and time of aromatherapy with rose oil **[20]**.

Another EO of medicinal importance is *Litsea cubeba* which consists of more than 400 species and is predominant in tropical and subtropical regions of India, Southeast Asia, southern China, Taiwan and Japan **[21]**. *Litsea cubeba* is a pioneer herb traditionally used in medicine. *Litsea cubeba* encompasses a variety of biologically active and structurally diverse compounds. Major groups of compounds include alkaloids, monoterpenes, sesquiterpenes, diterpenes, flavonoids, amides, lignans, steroids and fatty acids. These compounds have anti-cancer, anti-inflammatory, antimicrobial, antioxidant, anti-diabetic and anti-HIV properties and therefore have immense potential for the treatment of various diseases. The compound extracted from species of *Litsea cubeba* proved to be effective against gastroenterology, edema and rheumatic arthritis. The inflammatory mediators, nitric oxide (NO) and PGE2, are produced by the enzymes nitric oxide synthase (iNOS) and cyclooxygenase (COX)-2, respectively. It has been shown that iNOS and COX-2 induce the expression of other pro-inflammatory mediators such as IL-6, COX-2 and iNOS for inflammatory response. Therefore, restricting prostaglandin biosynthesis and NO production could potentially treat cancer. The antioxidant activity of three *Litsea cubeba* flavonoids represented by Kaempferol, quercetin-3-O-β-D-glucopyranoside and kaempferol-3-O-β-D-lucopyranoside revealed that Kaempferol had the highest activity while kaempferol-3-O-β -D-glucopyranoside showed the least effect. In addition, MeOH extracts from the root and stem of L. elliptica and L. resinosa represented increased antioxidant activity for DPPH (2,2-diphenyl-1- picrylhydrazyl) radicals **[21]**.

Also of paramount importance to athletes, peppermint oil (menthapiperita), a herbal remedy commonly used for gastrointestinal distress due to its smooth muscle tonicity-reducing effect, has been shown to improve lung function test results, possibly due to bronchodilator mechanisms. Given the potential benefits of peppermint on lung function, a pilot study investigated the acute effects of peppermint oil intake on exercise performance, in particular on the ventilatory threshold. Characterized as the tipping point at which lung ventilation increases disproportionately to the metabolic rate, the ventilatory threshold is positively associated with endurance performance. We hypothesized that a single ingestion of 1.0 mL of peppermint oil diluted in 250.0 mL of water would increase the ventilatory threshold as a percentage of maximal oxygen consumption (VO2max) during a graded cycling exercise test 10 minutes after ingestion. Thus, six healthy male participants performed two graded maximal exercise tests on a cycle ergometer under single-blind, randomized trials of peppermint oil and placebo. For each exercise test, the agreement between three analytical methods was used to validate the inflection point at which the ventilatory threshold occurred. Ingestion of peppermint oil was found to result in the ventilatory threshold occurring at a significantly higher percentage of VO2max compared to placebo (70.2±2.2% VO2max vs 66.2±2.0% of VO2max, $p<0.05$). Therefore, the ingestion of peppermint oil can have a positive and acute impact on the ventilatory threshold, increasing the percentage of VO2max at which the ventilatory threshold occurs **[22]**.

Furthermore, one study investigated the effects of inhaling rosemary oil on test participants' feelings, as well as its effects on various physiological parameters of the nervous system. Twenty healthy volunteers participated in the experiment. All participants underwent autonomic nervous system (ANS) recording, with measurements of skin temperature, heart rate, respiratory rate, blood pressure, assessments of the subjects' mood states, and electroencephalography (EEG) recordings in the pre-inhalation periods. , during treatment and post-inhalation compared to control conditions. The results showed significant increases in blood pressure, heart rate and respiratory rate after inhaling rosemary oil. After inhalation treatments, subjects were more active and said they felt "more refreshed". EEG analysis showed a reduction in the power of alpha1 (8–10.99 Hz) and alpha2 (11–12.99 Hz) waves. In addition, an increase in beta wave power (13-30 Hz) was observed in the anterior region of the brain. These results confirm the stimulant effects of rosemary oil and provide evidence that brain wave activity,

autonomic nervous system activity, as well as mood states are all influenced by inhaling rosemary oil **[23]**.

One study evaluated the effects of EOs inhalation from *Citrus sinensis* flowers and *Mentha spicata* leaves in two different groups of male athletes on physical performance and lung function. Participants were randomly divided into two groups *Mentha spicata* and *Citrus sinensis* (ten participants each). One group was nebulized by *Citrus sinensis* flower oil and the other by *Mentha spicata* leaf oil at a concentration of (0.02 mL/kg body weight) which was mixed with 2 mL of normal saline solution for 5 min before a test run of 1500 m. Pulmonary function tests were measured with a spirometer for each student before and after nebulization, giving the same running distance before and after inhaling oils. Pulmonary function tests showed an improvement in the students' lung status after inhaling the oils. Interestingly, there was a significant increase in forced expiratory volume and forced vital capacity after inhalation for both oils. In addition, significant reductions in average running time were observed between these two groups. Normal spirometric results were 50%, while after inhalation with *M. spicata* oil the proportion was 60%. Therefore, the results support the efficacy of *Mentha spicata* and Citrus sinensis EO on exercise performance and respiratory function parameters. **[24]**.

Studies have shown that inhalations of various peppermint species were effective in reducing muscle soreness and fatigue, as well as having a muscle-relaxing effect **[25-27]**. Another investigation was conducted by McKenzie and Hedge, 2005 **[28]** on the effects of inhaling peppermint oil on running performance under different conditions. Eighteen young women run 3.25 miles and were divided into groups; tired of a peppermint perfume mask group and unscented mask group. The results showed that peppermint inhalation was significantly lower heart rate during the running task.

Yet, a study by Dedeçay, 1995 **[29]** showed that the aqueous solution containing rosemary and peppermint that was given to French cyclists for muscle relaxation and decreased muscle fatigue. In addition, studies on Peppermint inhalation found that this plant essential oil reduced perceived exertion, temporal workload, physical workload, and frustration **[30-32]**.

A study by Asghar S., 2011 looked at the effects of peppermint inhalation on VO2max and reaction time, in 20 male athletes voluntarily participated in the study and the results showed that there is a significant relationship between peppermint inhalation -pepper with aerobic performance and reaction time **[33]**. These results were confirmed with the findings of Meamarbashi and Rajabi, 2013 and Raudenbush et al., 2001, who analyzed the effects of peppermint administration on the performance of athletes during exercise **[30, 34]**.

In this sense, inhalation of EOs fragrances is widely used in aromatherapy and is known to affect blood pressure (BP) and heart rate (HR) through autonomic control of circulation. Thus, one study examined whether changes in hemodynamics with fragrance inhalation were observed along with changes in muscle sympathetic nerve activity (MSNA). In study 1, thirteen healthy men were exposed to orange EO fragrance stimulation for 10 min, and BP, HR and SLA were measured continuously. In study 2, nine other healthy men were exposed to the same fragrance stimulation, BP and HR responses were measured continuously, and plasma concentrations of noradrenaline and cortisol were determined. Diastolic BP was found to increase significantly during fragrance inhalation, while the other variables remained unchanged in both studies. A significant linear correlation was found between changes in diastolic BP in the last 5 minutes of fragrance inhalation and changes in SLA burst frequency. Furthermore, the plasma cortisol concentration decreased significantly within 10 minutes of fragrance inhalation, although the noradrenaline concentration remained unchanged. These results suggested that changes in BP with inhalation of EOs fragrances are associated with changes in SNA, even with decreased stress hormone **[35]**.

Also, baths with emulsified turpentine (*Pistacia terebinthus*) are widely used in balneotherapy. They produce beneficial prophylactic effects especially pronounced in patients with microthrombosis and microvascular stasis. In addition, these baths can be prescribed to improve microcirculation, increase the functional reserves and physical capacity of athletes. Thus, a study involving 10 subjects evaluated the effectiveness of modified emulsified turpentine baths as a method to restore and increase the physical capacity of professional cross-country skiers. The athletes' physical capacity was evaluated from the results of the exercise test on a stationary bicycle with the use of the "Oxycon Pro" system. The data obtained suggest that a course of emulsified turpentine baths increases the activity of the cardiorespiratory system, improves physical capacity and increases the body's functional reserves in the anaerobic zone **[36]**.

One study examined the effects of EO inhalation of sweet marjoram (*Origanum majorana* oil - Mont Saint Michel Aroma Laboratory, Osaka, Japan) through two protocols on blood pressure, heart rate and respiratory responses under resting condition, each subject was

tested by inhaling air containing sweet marjoram essential oil (scented inhalation condition) and by inhaling air that does not contain essential oil (control condition). All subjects had no known cardiovascular or pulmonary disorders, had no history of traumatic brain injury, and were not taking any prescribed medications known to influence systemic or cerebrovascular function. Subjects were asked to abstain from drinks containing caffeine for 12 hours, and from strenuous physical activity and alcohol for at least 24 hours prior to the day of the experiment. The experiments were carried out in a temperature-controlled laboratory (24 ± 1 °C). Protocol 1, after resting for 2 minutes in a sitting position breathing room air, the subject inhaled air without essential oil (control condition) or air containing sweet marjoram essential oil (fragrance inhalation condition) from the bag for 6 minutes. For the experimental trials, heart rate (HR) and blood pressure (BP), as well as breath-to-breath respiratory variables, were continuously recorded. The order of tests (control condition and fragrance inhalation condition) was randomized in each subject, with an interposition interval of at least 20 min. Protocol 2, after resting for 5 min in the supine position breathing room air, the subject inhaled air containing marjoram EO from the bag for 10 min, and then recovered for 10 min breathing room air. Noticeable changes in BP and HR during inhalation of marjoram EO were observed, but no change in these parameters was observed under control conditions. During fragrance inhalation for 6 min, the subject's minute ventilation was 8.4±2.5 L/min. Fragrance inhalation significantly decreased BP=5.769, p=0.043) and HR=8.623, p=0.019 compared to the control condition in the last 2 min. No significant differences were detected in respiratory variables between fragrance inhalation and control conditions **[37]**.

Other authors have investigated the dynamics of the functional state of the cardiovascular system after the exercise load of the bicycle, followed by the cold inhalation of lavender oil (*Lavandula angustifolia*). The exams were performed in the first half of the day at the same time, three times, 10) before the exercise load (state of physiological norm), 20) immediately after the 15-minute load on the bicycle training device "Proteus Pec 3320" in the third position, followed by aromatherapy and 30) at 15 minutes of the post-exercise load recovery period. In the absence of correction factors (control group), bicycle ergometer work was established to be accompanied by significant deviations in all investigated heart rate parameters, most of which persisted also at 15 minutes of the post-exercise loading period. Inhalation with the EO of lavender under bicycle load has a sedative effect on the activity of cardiac rhythm regulatory mechanisms, increasing the sympathetic influence on heart rate, initiated by physical activity, and facilitating the rapid recovery of the functional state of the body in the period post-exercise load, with increased tolerance to the effects of stress factors **[38]**.

One study investigated the effects of static rest, massage, aromatherapy (Rosemary essential oil) and acupuncture on the levels of fatigue substances and stress hormones produced after a boxing session. The study was conducted on teenage female boxers (n = 12) who underwent four recovery methods with a 7-day rest period between each session. Before each method, participants performed five rounds of 4-minute boxing matches, and maximum intensity was defined as 70%-80% of maximum heart rate. Static rest, massage, aromatherapy (20 minutes of inhalation) and acupuncture points significantly decreased lactic acid levels. Creatine phosphokinase levels decreased in the aromatherapy and acupuncture groups, while lactate dehydrogenase levels decreased significantly in the massage, aromatherapy and acupuncture groups. A significant decrease in cortisol level was observed in the aromatherapy group and an upward trend was observed in cortisol level in the static rest group. The level of adrenocorticotropic hormone significantly decreased in the aromatherapy group and showed a tendency to decrease after participants received massage or acupuncture. High-intensity exercise results not only in physical but also psychological fatigue. Massage and aromatherapy can improve the physical and psychological stability and performance of athletes **[39]**.

Still on the beneficial effects of EOs for athletes, one study determined whether inhaling peppermint odor has effects on running time, maximum heart rate (MHR), maximum oxygen consumption (VO2max), oxygen consumption (VO2), minute ventilation (MV) and respiratory exchange rate (RER) during acute or non-acute intensive exercise. A total of 36 soccer players were selected to participate in this research. They were randomly divided into 3 groups (control, peppermint inhalation, peppermint and ethanol mixture inhalation). In order to have knowledge of the similarity of the groups, the BMI of the subjects was determined and the ANOVA did not show significant differences ($p<0.05$). Subjects in three groups ran on a treadmill according to the Bruce test. Heart rate, running time, VO2max, VO2, MV and RER were measured by the Gas Analyzer. After data collection, the results showed that EO inhalation had no significant effect on running time, MHR, VO2max, VO2, MV and RER, due to the intensity

and duration of training [40].

In this sense, another study investigated the effects of peppermint ingestion on physiological parameters and exercise performance after 5 min and 1 h. Thirty healthy male participants were randomly divided into experimental (n=15) and control (n=15) groups. Maximum isometric grip strength, vertical and long jumps, spirometric parameters, visual and audio reaction times, blood pressure, heart rate and respiratory rate were recorded three times before, five minutes and one hour after oral administration of a single dose of peppermint essential oil (50 μL). Results revealed significant improvement in all variables after oral administration of peppermint EO. The experimental group compared to the control group showed an incremental and significant increase in grip strength (36.1%), standing vertical jump (7.0%) and standing long jump (6.4%). Data obtained from the experimental group after five minutes exhibited a significant increase in forced vital capacity in the first second (35.1%), peak inspiratory flow rate (66.4%) and peak expiratory flow rate (65.1%), while after one hour, only peak inspiratory flow showed a significant increase compared to baseline and control. At both times, visual and audio reaction times significantly decreased. Physiological parameters also improved significantly after five minutes. A considerable increase in grip strength, spirometry and other parameters were the important findings of this study. Therefore, the improvement in spirometric measurements may be due to the effects of peppermint on bronchial smooth muscle tone with or without affecting pulmonary surfactant. However, there is still no scientific evidence on isometric forces [41].

Also, the same author of the study in the previous paragraph studied twelve healthy male students who consumed a 500 mL bottle of mineral water daily, containing 0.05 mL of peppermint essential oil, for ten days. Blood pressure, heart rate and spirometry parameters, including forced vital capacity (FVC), peak expiratory flow (PEF) and peak inspiratory flow (PIF) were determined one day before and after the supplementation period. Participants with measurement of a treadmill exercise with metabolic gas analysis. The FVC, PEF and PIF changed significantly after ten days of supplementation. Exercise performance assessed by time to exhaustion (664.5 ± 114.2 vs. 830.2 ± 129.8 s), work (78.34 ± 32.84 vs. 118.7 ± 47.38 kJ) and power (114.3 ± 24.24 vs. 139.4 ± 27.80 kW) increased ($p<0.001$). In addition, the results of respiratory gas analysis showed significant differences in VO2 (2.74 ± 0.40 vs. 3.03 ± 0.351 L/min; $p<0.001$) and VCO2 (3.08 ± 0.47 vs. 3.73 ± 0.518 L/min; $p<0.001$). Therefore, the results of the experiment support the effectiveness of peppermint essential oil on exercise performance, gas analysis, spirometry parameters, blood pressure and respiratory rate in young male students. Relaxation of bronchial smooth muscle, increased ventilation and oxygen concentration in the brain, and decreased blood lactate level are the most plausible explanations [42].

Finally, a study by Xuan et al, 2022 proposed a treatment for knee synovitis, which is a common sports injury. The use of UTVOR, which is a combination of the use of volatile frankincense oil (VOO) and volatile oil of Chuanxiong Rhizoma (VOCR) and conventional ultrasound therapy (US) has been proposed. Participants were randomly assigned to a control group (conventional US therapy group) and a test group (UTVOR group). The control group received conventional US therapy with a coupling agent as a medium. The test group received a revised US therapy with VOO and VOCR as media. Both groups were treated once a day for three consecutive days. Visual Analog Scale (VAS) pain score, Lysholm knee score, degree of knee swelling, circumference and range of motion of the knee joint were assessed before the first treatment and 24 h after the third treatment. A total of 116 participants were included in the analysis (test group: n=64; control group: n=52). The evaluation results showed that the VAS pain scores of male and female participants in both groups decreased after treatment ($p<0.001$), but only the difference between the male subgroup had a significant difference between the groups ($p<0.001$). After treatment, Lysholm scores in both groups increased significantly (all $p<0.001$), range of motion and circumference of the injured knee decreased significantly ($p<0.001$). No side effects or complications were reported during treatment [43].

Conclusion

Essential oils have been used in medicine for decades and have been proven to eliminate toxins from the body. They are also shown to improve the body's ability to absorb essential vitamins and nutrients. In this sense, the application of these oils not only helps to prevent and heal sports injuries, but also to stimulate and relax the mind and body, leading to higher levels of fitness. Because of these inherent properties of essential oils, there is growing interest in using them to tone the body and mind in a variety of ways, such as musculoskeletal preparation, injury prevention, and improving mood and performance to achieve a higher success rate in sports and fitness, as well as post-exertion recovery. They can be used as an aid to make recovery faster, reducing the effect of fatigue and raising the energy level of the mind and body.

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Data sharing statement
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Conflict of interest
The authors declare no conflict of interest.

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References
1. WHO. World Health Organization Traditional Medicines Strategy 2014–2023. Geneva: WHO Press; 2013. Acessado em 02 de outubro de 2022.
2. Nan Lv X, Jun Liu Z, Jing Zhang H, Tzeng CM. Aromatherapy and the central nerve system (CNS): therapeutic mechanism and its associated genes. Curr Drug Targets. 2013;14(8):872–9.
3. Huntley A. Aromatherapy Science: A Guide for Healthcare Professionals. United States: Pharmaceutical Press; 2006.
4. Sharma P, Meena TR Aromatherapy for sports and fitness. British Journal of Sports Medicine 2010;44:i4.
5. Haze S, Sakai K, Gozu Y. Effects of fragrance inhalation on sympathetic activity in normal adults. Jpn J Pharmacol. 2002;90(3):247-253. doi:10.1254/jjp.90.247.
6. Stewart D. The Chemistry of Essential Oils Made Simple: God's Love Manifest in Molecules. UK: Care Publications; 2005.
7. Yan L, Wang J, Kim H, Meng Q, Ao X, Hong S, et al. Influence of essential oil supplementation and diets with different nutrient densities on growth performance, nutrient digestibility, blood characteristics, meat quality and fecal noxious gas content in grower–finisher pigs. Livest Sci. 2010;128(1):115–22.
8. Schulz V, Hänsel R, Tyler VE. Rational Phytotherapy: A physician's Guide to Herbal Medicine. UK: Psychology Press; 2001.
9. Khan IA, Abourashed EA. Leung's Encyclopedia of Common Natural Ingredients: Used in Food, Drugs and Cosmetics. United States: Wiley; 2011.
10. Dorman H, Deans S. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J Appl Microbiol. 2000; 88(2):308–16.
11. Raut JS, Karuppayil SM. A status review on the medicinal properties of essential oils. Ind Crop Prod. 2014;62:250–64.
12. Freiesleben SH, Soelberg J, Jäger AK. Medicinal plants used as excipients in the history in Ghanaian herbal medicine. J Ethnopharmacol. 2015;174:561-8.
13. Knasko SC. Ambient odor's effect on creativity, mood, and perceived health. Chem Senses. 1992;17(1):27–35.
14. Chebat J-C, Michon R. Impact of ambient odors on mall shoppers' emotions, cognition, and spending: a test of competitive causal theories. J Bus Res. 2003;56(7):529–39.
15. Ceccarelli I, Lariviere WR, Fiorenzani P, Sacerdote P, Aloisi AM. Effects of long-term exposure of lemon essential oil odor on behavioral, hormonal and neuronal parameters in male and female rats. Brain Res. 2004;1001(1):78–86.
16. Sellaro R, Hommel B, Paccani CR, Colzato LS. With peppermints you're not my prince: aroma modulates self-other integration. Atten Percept Psychophys. 2015;77(8):2817–25.
17. Aydin E, Hritcu L, Dogan G, Hayta S, Bagci E. The effects of inhaled Pimpinella peregrina essential Oil on scopolamine-induced memory impairment, anxiety, and depression in laboratory rats. Mol Neurobiol. 2016;1-11.
18. Mosbah H, Chahdoura H, Kammoun J, et al. Rhaponticum acaule (L) DC essential oil: chemical composition, in vitro antioxidant and enzyme inhibition properties. BMC Complement Altern Med. 2018;18(1):79. Published 2018 Mar 5. doi:10.1186/s12906-018-2145-5.
19. Schmidt E, Bail S, Buchbauer G, et al. Chemical composition, olfactory evaluation and

antioxidant effects of essential oil from Mentha x piperita. Nat Prod Commun. 2009;4(8):1107-1112.

20. Atashi N, Bahari SM, Sanatkaran A. The effects of red rose essential oil aromatherapy on athletes' sleep quality before the competition. J Novel Appl Sci. 2015; 4(7): 814-819.
21. Kamle M, Mahato DK, Lee KE, et al. Ethnopharmacological Properties and Medicinal Uses of Litsea cubeba. Plants (Basel). 2019;8(6):150. Published 2019 Jun 1. doi:10.3390/plants8060150.
22. David F S, Chi-An W E. The Effects of Peppermint Oil Ingestion on the Ventilatory Threshold: A Pilot Study. Res Inves Sports Med 3(3). RISM.000565.2018. DOI: 10.31031/RISM.2018.03.000565.
23. Sayorwan W, Ruangrungsi N, Piriyapunyporn T, Hongratanaworakit T, Kotchabhakdi N, Siripornpanich V. Effects of inhaled rosemary oil on subjective feelings and activities of the nervous system. Sci Pharm. 2013 Apr-Jun;81(2):531-42. doi: 10.3797/scipharm.1209-05.
24. Jaradat NA, Al Zabadi H, Rahhal B, et al. The effect of inhalation of Citrus sinensis flowers and Mentha spicata leave essential oils on lung function and exercise performance: a quasi-experimental uncontrolled before-and-after study. J Int Soc Sports Nutr. 2016;13:36. Published 2016 Sep 22. doi:10.1186/s12970-016-0146-7.
25. Mimica-Dukic N, Jakovljevic V, Sabo A, Popovic M, Lukic V, Gasic O, et al. Evaluation of some pharmacodynamic effects of Mentha longifolia extracts. Planta Med. 1993;59:691–9.
26. Forster H, Niklas H, Lutz S. Antispasmodic effects of some medicinal plants. Planta Med. 1980;40:309–419.
27. Bremness L. The Complete Book of Herbs. London: Ward Lock Limited; 1988.
28. MacKenzie CM, Hedge A. Is peppermint an ergogenic Aid to athletic performance? Rev Hum Factors Ergon. 2005;49:1229–33.
29. Dedecay S. The odor and therapeutic effects of the plants found in Cyprus. J Nicosia Private Turkish Univ. 1995;1:137–44.
30. Raudenbush B, Corley N, Eppich W. Enhancing athletic performance through the administration of peppermint odor. J Sport Exercise Psychol. 2001;23(2):156–60.
31. Raudenbush B, Meyer B, Eppich B. The effects of odors on objective and subjective measures of athletic performance. Int Sports J. 2002;6(1):14–27.
32. Spotten L, Corish C, Lorton C, Dhuibhir PU, O'Donoghue N, O'Connor B, et al. Subjective taste and smell changes in treatment-naive people with solid tumours. Support Care Cancer. 2016;1–8.
33. Asghar S. Effects of Mentha piperita inhalation on VO2 max and reaction time, on man elite karate-do. Ann Biol Res. 2011;2:84–7.
34. Meamarbashi A, Rajabi A. The effects of peppermint on exercise performance. J Int Soc Sports Nut. 2013;10:15–20.
35. Kawai E, Takeda R, Ota A, et al. Increase in diastolic blood pressure induced by fragrance inhalation of grapefruit essential oil is positively correlated with muscle sympathetic nerve activity. J Physiol Sci. 2020;70(1):2. Published 2020 Jan 30. doi:10.1186/s12576-020-00733-6.
36. Garnov IO, Kuchin AV, Loginova TP, Varlamova NG, Boiko ER. Vopr Kurortol Fizioter Lech Fiz Kult. 2016;93(2):26-31. doi:10.17116/kurort2016226-31.
37. Kawai E, Nakahara H, Ueda SY, Manabe K, Miyamoto T. A novel approach for evaluating the effects of odor stimulation on dynamic cardiorespiratory functions. PLoS One. 2017;12(3):e0172841. Published 2017 Mar 3. doi:10.1371/journal.pone.0172841.
38. Gevorkyan ES, Minasyan SM, Adamyan TI, Ksadzhikyan NN. Gig Sanit. 2016;95(7):665-669.
39. Tianlong D, Sim YJ. Effects of different recovery methods on postboxing sparring fatigue substances and stress hormones. J Exerc Rehabil. 2019;15(2):258-263. Published 2019 Apr 26. doi:10.12965/jer.1938050.025.
40. Pournemati P, Azarbayjani MA, Rezaee MB, Ziaee V, Pournemati P. The effect of inhaling peppermint odor and ethanol in women athletes. Bratisl Lek Listy. 2009;110(12):782-787.
41. Meamarbashi A. Instant effects of peppermint essential oil on the physiological parameters and exercise performance. Avicenna J Phytomed. 2014;4(1):72-78.
42. Meamarbashi A, Rajabi A. The effects of peppermint on exercise performance. J Int Soc Sports Nutr. 2013;10(1):15. Published 2013 Mar 21. doi:10.1186/1550- 2783-10-15.
43. Xuan Q, Ruan Y, Cao C, Yin Z, Du J, Lv C, Fang F, Gu W. Effect of Ultrasonic Penetration with

Volatile Oil of Olibanum and Chuanxiong Rhizoma on Acute Knee Synovitis Induced by Sports Training: An Open-Label Randomized Controlled Study. Pain Res Manag. 2022 Feb 28;2022:6806565. doi: 10.1155/2022/6806565.