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# A Review on Seven Selected Essential Oils used as Aromatherapy to Maintain Sports Performance

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## ABSTRACT

**Sivaphongthongchai A, Nakkliang K, Thetsana P, Seepika N, Thammarakkit T, Nopthaisong T, Phuneerub P.** A Review on Seven Selected Essential Oils used as Aromatherapy to Maintain Sports Performance. **JEPonline** 2023;26(5):40-54. Aromatherapy is the science of holistic medicine for taking care of the human body and mind using pleasant smells of essential oils. Sports performance refers to carrying out physical routines or procedures by those who are trained or skilled in physical activity to achieve goals by meeting or surpassing specific standards. Essential oils widely used as aromatherapy in sports performance belong to three families. In Lamiaceae family, *Lavendula angustifolia* Mill (**lavender**) helps athletes recover from their training, and it is used as a massage oil in athletes. *Rosmarinus officinalis* (**rosemary**) helps improve fatigue, reduce the stress hormone levels and cure muscle spasm. *Salvia officinalis* L. (**sage**) improves mood, fatigue, memory performance and boosts cognitive function. *Mentha x piperita* (**peppermint**) helps stimulate, strengthen, and improve concentration, lung function, and physical performance. In Rutaceae family, *Citrus sinensis* (**sweet orange**) lowers physical and cognitive anxiety while improves lung function and exercise performance. *Citrus limon* (L.) Burm. f. (**lemon**) promotes repeated high-intensity exercise performance. In Poaceae family,

*Cymbopogon citratus* (**lemongrass**) promotes athletic performance, lung function, cognitive function, and alters mood. Aromatherapy is an alternative for athletes to maintain their sports performance.

**Key Words:** Aromatherapy, Athletes, Essential Oils, Sports Performance

## INTRODUCTION

Aromatherapy is the science of holistic medicine for taking care of the human body and mind using pleasant smells of essential oils. In aromatherapy, essential oils used as the main therapeutic agents are highly concentrated elements separated from stalks, fruits, flowers, leaves, roots or extracted from resins (15). For centuries, the inhalation of volatile herbal materials has been used in complementary and alternative therapies for mental and physical balance in humans. Essential oil or volatile oil refers to a concentrated hydrophobic liquid consisting of volatile compounds, which can be extracted from plants. In Figure 1, essential oils are applied in 3 pathways: by inhaling through the olfactory system, and the skin, as the chemical compounds will reach the skin, by topically applying essential oil on the skin as a major route and by consumption, including drinking and consuming through the digestive system as a major route (34). In general, essential oils contain major chemical compounds that may cause stimulating or sedative effects depending on their chemical compounds functioning together as a whole. Chemical compounds in essential oils can be categorized into various types such as monoterpenes, sesquiterpenes, ethers, alcohols, ketones phenols, acids, esters, and aldehydes (67).

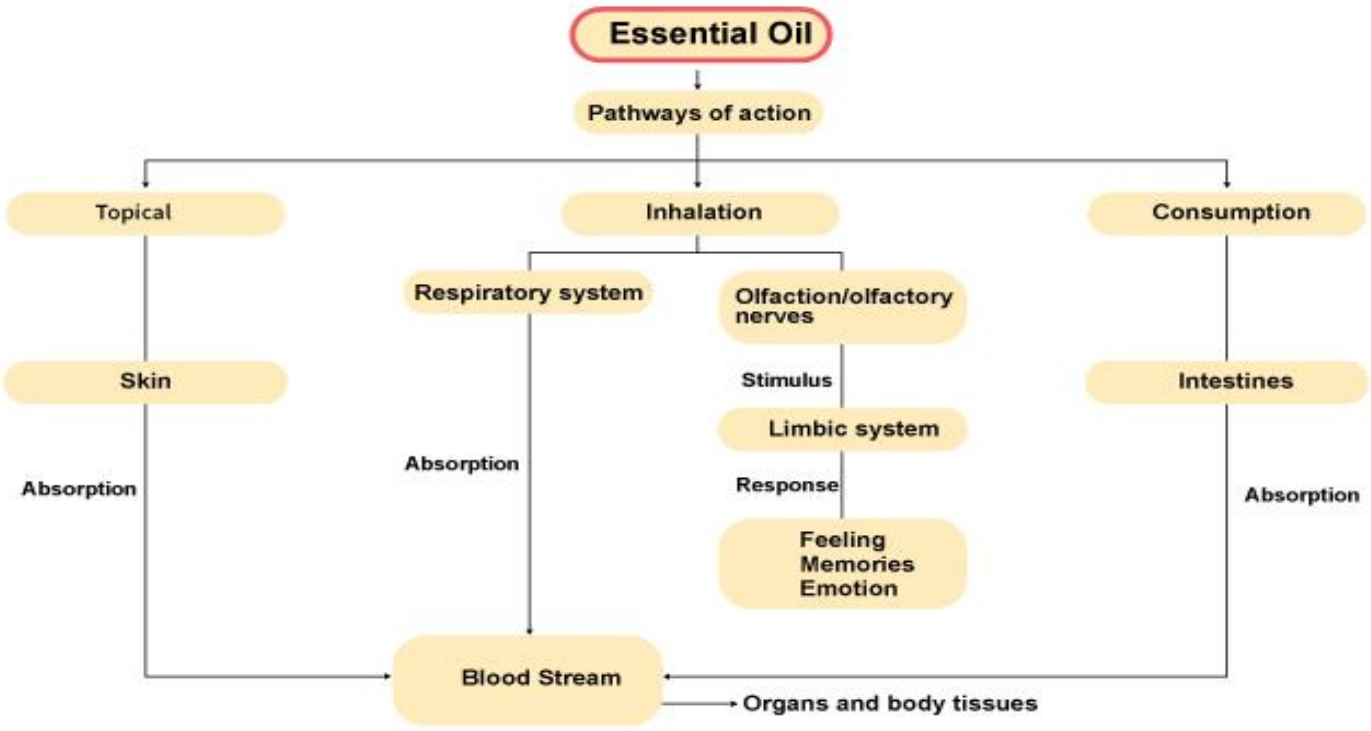


Figure 1. Pathways of Essential Oils Divided into Three Routes Adapted from a Previous Study (20).

The major advantage of essential oils including good penetrants because of their ability to promote the disruption of lipid bilayers in cells, enhancing their bioavailability and that of co-administered

drugs has qualified essential oils as viable synergists. Bioavailability refers to the fraction of an administered dose of unchanged drug that reaches the systemic circulation, and this fraction can be stored or used for a certain purpose (14). On the other hand, the main drawbacks of essential oils including easy degradation, less stability in fluctuating environmental conditions should be considered (2). Most essential oils are quickly absorbed through topical application, inhalation, and consumption routes. They can bypass the blood-brain barrier (BBB), affecting receptors in the central nervous system while enhancing biological functions (14). The BBB is a physical and metabolic barricade that blocks the infiltration of molecules (51) since its function is to prevent toxins and variations from entering the central nervous system and to maintain the consistency of the brain environment (1). To preserve their properties and bioavailability, essential oils are formulated into four forms: liquid, semi-solid, solid, and aerosol form (40).

The active compounds in essential oils determine the effects of essential oils that can engage in various neurotransmitter pathways, including noradrenergic, 5-HTergic, γ-aminobutyric acid (GABA)-ergic, and DAergic systems (37). These compounds induce different beneficial effects. Regarding a pathway through skin absorption, current literature has verified the active compounds in essential oils as safe and suitable skin penetration enhancers for both hydrophilic and hydrophobic drugs while the mechanism of their effects through skin absorption still requires further investigation. Once essential oils are applied through topical absorption, they are dissolved in water such as baths or in a fatty carrier such as massage (44). Essential oils can be absorbed through skin in three possible ways: the intercellular way between skin cells, the transcellular way through cells, and going through hair follicles bypassing the stratum corneum, the outermost layer of the epidermis (25).

The inhalation pathway comprises olfactory and respiratory systems. The olfactory system encompasses the olfactory bulb regulating odorant signal transmission located in the nasal cavity. The olfactory system is related to various brain areas such as the hypothalamus and the hippocampus. Chemical molecules go through olfactory mucosa and are transmitted to the central nervous system to trigger emotional reactions. In contrast, the respiratory system deals with gaseous exchange. Vapor molecules can go through various parts of the respiratory system via diffusion (18). Through oral consumption pathway, essential oils and their metabolites are absorbed and transported throughout the body via bloodstream. When essential oil molecules remain in the body, they exert their effects through three varying action modes including biochemical (pharmacological), physiological, and psychological (14).

Sports performance refers to carrying out physical routines or procedures by those who are trained or skilled in physical activity to achieve goals by meeting or surpassing specific standards. Both physiological and psychological attributes are interrelated factors. Aromatherapy is the science of holistic medicine for taking care of the human body and mind using pleasant smells of essential oils. Sports performance refers to carrying out physical routines or procedures by those who are trained or skilled in physical activity to achieve goals by meeting or surpassing specific standards. Essential oils widely used as aromatherapy in sports performance belong to three families. In Lamiaceae family, *Lavendula angustifolia* Mill (**lavender**) helps athletes recover from their training, and it is used as a massage oil in athletes. *Rosmarinus officinalis* (**rosemary**) helps improve fatigue, reduce the stress hormone levels and cure muscle spasm. *Salvia officinalis* (**sage**) improves mood, fatigue, memory performance and boosts cognitive function. *Mentha x piperita* (**peppermint**) helps stimulate, strengthen, and improve concentration, lung function, and physical performance. In Rutaceae family, *Citrus sinensis* (**sweet orange**) lowers physical and cognitive anxiety while improves lung function and exercise performance. *Citrus limon* (L.) Burm. f. (**lemon**)

promotes repeated high-intensity exercise performance. In Poaceae family, *Cymbopogon citratus* (**lemongrass**) promotes athletic performance, lung function, cognitive function and alters mood. Aromatherapy is an alternative for athletes to maintain their sports performance.

Athletes depend on skills, abilities, and sports performance to achieve their goals by consistently delivering such skills and abilities in sports competitions (55). Therefore, sports performance can be influenced by physiological factors, including strength, speed, endurance, flexibility (23), and psychological factors, including motivation, concentration, and decision (8). A 2020 study discovered three types of commitment profiles based on the Sport Commitment Model: (a) enthusiastic athletes who considered sport as a positive experience; (b) obligatory athletes who were obliged to exercise; and (c) noncommitted athletes who were unmotivated. Enthusiastic athletes valued well-being, future goals, and intrinsic ambitions while obligatory athletes regarded extrinsic ambitions and health-related viewpoints (9). Coaches and athletes work together to improve athletic performance. Accordingly, athletes must optimize their sports performance to stay on top of the competition.

Sports performance involves four major dimensions: (a) skill; (b) strength; (c) endurance; and (d) recovery shown in Figure 2. High sports performance requires a characteristic blend of these dimensions (24). Muscle strength and endurance mean the ability of muscle groups to exert or maintain maximum and repetitive contractions that last long enough to induce muscle fatigue (60). The strength of muscle endurance can be promoted and maintained by weight training (47). A recent study in 2022 determined the effects of weight training on strength and endurance in archery athletes. The results indicated that weight training with the compound set method had a significant effect on promoting endurance in these athletes (48). During competition, athletes must cope with physical factors, including fatigue and psychological factors, including negative emotions and mental pressure (4). Athletes' coping skills that require training and improvement determine their performance since the skills influence their personal and professional lives (13). Recovery is a stage of restoring athletes' physical condition to its normal state before competition (53). To help the athletes gain recovery, sport massage can be applied as a treatment on specific body parts by using hands or special tools to improve blood circulation or reduce fatigue (49). Efficient brain function such as attention, spatial/working memory, executive function, alertness, concentration can contribute to peak sports performance. Essential oils can help improve sports performance by modulating psychological states, better alertness, and lower mental fatigue (29). Athletes can use these oils to help them prevent and cure themselves. Essential oils play a major role in preparing body and mind for optimum sports performance and post-exertion recovery. The objectives of this review are to search, to investigate, and to report the findings of related research that has used essential oils as interventions to improve sports performance.


Figure 2. Four Major Dimensions of Sports Performance.

## METHODS

Regarding the methodology of this review, the researchers have collaborated to find and assimilate related research appropriate for the objectives so that this review can be a useful guideline for essential oils used as an alternative for athletes to improve sports performance. This review has found that seven essential oils from three families are widely used and chosen as interventions in experiments related to sports performance.

## RESULTS

Seven essential oils were selected as aromatherapy in sports performance. These essential oils belong to three families: (a) Lamiaceae; (b) Rutaceae; and (c) Poaceae.

**Lamiaceae family includes:**

1. lavender essential oil
2. rosemary essential oil
3. sage essential oil
4. peppermint essential oil

**Rutaceae family includes:**

5. sweet orange essential oil
6. lemon essential oil

**Poaceae family includes:**

7. lemongrass essential oil

The botanical illustration on all seven plants distilled for essential oils is displayed in Figure 3. The effects of all the essential oils in these families have been validated by sports science and related research studies.

### 1. Lavender Essential Oil

Lavender is an aromatic, bushy, flowering, and perennial plant native to the Mediterranean. Since its scientific name is *Lavandula angustifolia* Mill, lavender belongs to the Lamiaceae family. *L. angustifolia* commonly gives five integrated petals with square stems and its leaves are opposite each other (11). The major compounds in lavender essential oil include linalool and linalyl acetate (54).

The lavender essential oil retains therapeutic properties, including sedatives, antidepressants, antifungal, carminative (smooth muscle relaxant), and wound healing activities (12). The oil can help athletes recover from their training. Recovery in athletes consists of two related components: rest and repair. Rest is essential for athletes so that their bodies can recover properly. Masago et al. (42) reported that lavender essential oil caused an increase in alpha activity that is highly correlated with a comfortable state in humans after the lavender oil inhalation. Also, lavender essential oil is effective in improving sleep quality, and it may help promote sleep quality after the

oil inhalation. Therefore, athletes can inhale lavender essential oil before going to bed to improve their sleep quality.

Moreover, lavender essential oil is used as a massage oil in athletes. Bayer and Eken (7) conducted a clinical study that evaluated the effects of aromatherapy massage on repeated sprint performance in young male futsal players. The findings revealed that aromatherapy massage (ATM) had a positive effect on the Repetitive Sprint Test (RST) performance compared to the non-massage protocol (NM) and the Swedish massage (SM) protocols. The ATM protocol applied in the evening was more effective than the ATM protocol applied in the morning and afternoon. Aeini (3) investigated the effect of massage on fatigue and mood in female rowers. The findings showed that the lemon and the lavender essential oils massage deceased perceived intensity and fatigue significantly while also lowering anger, confusion, depression, mood fatigue, and stress significantly compared to the control group. The researchers concluded that massage therapy can be used as a complementary intervention to decrease fatigue and improve mood in healthy athletes. Consequently, the lavender essential oil helps athletes recover from their training, and it is used as a massage oil in athletes.

### 2. Rosemary Essential Oil

Rosemary is an aromatic herb with its scientific name as *Rosmarinus officinalis* L., which belongs to the Lamiaceae family. *R. officinalis* L. is a perennial, aromatic shrub that has fragrant, needle-like leaves, and clusters of blue to white flowers (33). Rosemary has various pharmacological properties to treat diseases, including treatments for Alzheimer's disease (22) and its hepatoprotective abilities (56). Rosemary essential oils can be extracted through steam distillations of twigs and fresh leaves. A previous study by Sienkiewicz et al. (62) revealed that the major compounds in rosemary essential oil include 1,8-cineole (46.4%), camphor (11.4%), and α-pinene (11.0%).

Tianlong and Sim (65) studied the effects of four different recovery methods namely static rest, massage, aromatherapy, and acupoint acupressure on post-boxing sparring fatigue substances and stress hormones in young, healthy, female boxers. The results showed that aromatherapy using essential oils was the most effective method in improving fatigue and reducing stress hormone levels. The researchers concluded that aromatherapy helped stabilize the autonomic nervous system's balance.

Therefore, aromatherapy is known to alleviate symptoms related to imbalance in the autonomic nervous system. A 2019 study conducted by Kishen, Gayatri Devi, and Jyothipriya determined the effects of rosemary essential oil on muscle spasm in adult participants. Rosemary essential oil was more effective in curing muscle spasm in a shorter timeframe of 15 minutes compared to peppermint essential oil with a longer timeframe of 30 minutes (31). As a result, rosemary essential oil helps to improve fatigue, reduce stress hormone levels, and cure muscle spasm.

### 3. Sage Essential Oil

Sage with its scientific name *Salvia officinalis* L. is a versatile culinary plant which belongs to Lamiaceae family. It is a perennial, aromatic sub-shrub locally found in the northern Mediterranean region. Sage is also called common sage, culinary sage and garden sage (61). Common sage or Salvia officinalis is one of the Salvia species. The Salvia species are widely used as herbal medicine and flavoring spices (5). A 2017 study reported that the major compounds in Salvia

officinalis essential oil included camphor (25.14 %), α-thujone (18.83 %), 1,8-cineole (14.14 %) and viridiflorol (7.98 %) (30). The pharmacological properties of sage essential oil are antioxidant, antimicrobial, anticancer and sage essential oil also serve as scavenging agents (17).

Moreover, sage essential oil seems to improve emotions and cognitive functions in humans. Moss et al. (46) assessed the cognitive and mood effects of sage oil inhalation in healthy young adults. The results revealed that sage essential oil improved mood and memory performance after sage essential oil inhalation compared to the control group without essential oil (46). Gaballah, Elnawasry, Santos, and Bressel (19) measured the effect of sage herbal consumption on respiratory functions in soccer players. The researchers suggested sage consumption may improve long aerobic activities while lowering pulmonary inflammation after high intensity training (19). A recent study in 2021 was conducted to investigate the acute effects of Salvia supplements (a combination between *Salvia officinalis* and *Salvia lavandulaefolia*) on cognitive function in athletes during a fatiguing cycling exercise. Sage supplements were reported to be effective in stimulating cognitive function during endurance cycling exercise (6). Apparently, sage essential oil improves mood, fatigue, memory performance and boosts the cognitive function.

## 4. Peppermint Essential Oil

The peppermint plant, which is a hybrid between water mint and spearmint yields peppermint essential oil. The essential oil can be extracted through steam distillation of underground parts of *Mentha x piperita* L., which belongs to Lamiaceae family. *M. x piperita* L. is an aromatic and perennial plant which possesses broad stems overground and underground. The color profile of its leaves is extensive from blue, dark green to purple while its flowers are white or purple (35). M. piperita is a medicinal herb used as a flavoring agent such as chewing gum and an ingredient in cosmetics and pharmaceutical products. Peppermint oil from *M. x piperita* L. comprises menthol, a major chemical compound (57). Peppermint essential oil is colorless, pale yellow to greenish-yellow liquid. The major compounds include menthol (30–55%) and menthone (14–32%) (58). Peppermint essential oil is widely used as flavoring, fragrance, and home treatment to cure different symptoms namely indigestion, nausea, and headaches (32).

Sayowan, Saetan, Otbamrung, and Phungphol (59) determined the effects of peppermint essential oil inhalation on autonomic nervous system in healthy volunteers. Peppermint essential oil with refreshing scent is known to stimulate, strengthen and improve concentration. The results showed that in peppermint essential oil group, the peppermint essential oil increased blood pressure, respiratory rate and spatial abilities significantly compared to the control group. Lin et al., (36) measured the effects of *M. x piperita* L. essential oil on stimulation in different visual environments through Electroencephalography (EEG) in healthy participants. Peppermint essential oil could offer physical relaxation effects and facilitate learning simultaneously.

Meamarbashi (43) measured the effects of peppermint essential oil on physiological parameters and exercise performance in healthy participants. Peppermint essential oil could improve lung function and physical performance (grip force, standing vertical and long jump) compared to the control group. So, peppermint essential oil helps to stimulate, strengthen, and improve concentration, lung function, and physical performance. A 2021 study determined the effects of *M. x piperita* L. (MP) essential oil for 10 days on heart rate variability (HRV) and cardiopulmonary regulation during exercise. The findings indicated that 10-day intake of MP essential oil boosted sympathetic activity at rest and might help respiratory regulation during high-intensity exercise (39).

## 5. Sweet Orange Essential Oil

Sweet orange is the fruit from a plant with its scientific name known as *Citrus sinensis* (L.), which belongs to Rutaceae family. Sweet orange essential oil can be extracted from orange skins with its major compounds, including linalool, aldehyde, flavonoid. Moreover, sweet orange possesses various pharmacological properties such as improving digestion, stimulating the central nervous system (50), and exerting anti-microbial and anti-fungal effects (63). Sweet orange essential oil also displays an acute anxiolytic effect on healthy participants after the essential oil inhalation by making them feel more energetic (21). A 2014 study investigated the effects of orange oil inhalation on left and right prefrontal cortex activity and subjective feelings in healthy participants. The findings showed that orange oil decreased the oxyhemoglobin concentration in the right prefrontal cortex significantly while the participants felt more comfortable, relaxed, and natural. Orange oil seemed to induce psychophysiological relaxation (26).

Sweet orange essential oil is applied through inhalation in the sports industry. For example, Ebrahimi, Agdasi, and Mokaberian (2021) investigated the effectiveness of inhaling sweet orange essential oil on self-confidence and anxiety compared with relaxation method in female futsal players. The results showed that sweet orange essential oil inhalation could help lower both physical and cognitive anxiety significantly while increasing the confidence factor significantly compared to the control group (16). Jaradat et al. (2016) investigated the effect of inhalation of *C. sinensis* (L.) (orange) flowers and Mentha spicata leave essential oils on lung function and exercise performance in healthy participants. Both essential oils caused a significant increase in Forced Expiratory Volume and Forced Vital Capacity after the inhalation of both essential oils. Both essential oils also reduced the running time in both groups (27). In essence, sweet orange essential oil lowers physical and cognitive anxiety while improving lung function and exercise performance.

## 6. Lemon Essential Oil

Lemon or *Citrus limon* (L.) Burm. f. as its scientific name, which is a small evergreen tree yielding yellow edible fruits, belongs to Rutaceae family. Lemon fruits are full of juicy pulp separated into segments like oranges (38). Lemon essential oil can be obtained by cold pressing the outer layers of lemon peel. Lemon essential oil which is yellow or colorless offers a unique but strong lemon scent (41). A recent study in 2020 found that monoterpenoids seemed to be the main components, including limonene (55.40%), neral (10.39%), trans-verbenol (6.43%), and decanal (3.25%). Limonene, which is a cyclic monoterpene delivering a lemon-like scent, is one of the major compounds in many essential oils belonging to citrus species (52).

A 2022 study examined the effects of inhaling lemon, sandalwood, and kusunoki essential oils on human brain activity and memory function through EEG recordings in healthy participants. Lemon essential oil inhalation improved task performance significantly by activating delta and theta in prefrontal cortex, the anterior cingulate gyrus and so on. Therefore, lemon essential oil inhalation contributed to memory encoding and retrieval leading to better task performance after the inhalation. Essential oils, including lemon could help healthy individuals who wish to maintain and promote memory and emotional functions (68). A previous study was conducted to determine the effects of lemon aroma on power output on exercise performance with high intensity in healthy male participants. Lemon aroma seemed to promote repeated high-intensity exercise performance in short duration and to remove blood lactate in healthy participants (45). Thus, lemon essential oil promotes repeated high-intensity exercise performance.

## 7. Lemongrass Essential Oil

Lemongrass, also known as *Cymbopogon citratus* in its scientific name is a perennial tropical herb with long striped leaves that belongs to Poaceae family. Its fragrance is soft, sweet, and smoky. It is an aromatic herb used in Thailand for cooking and medicinal purposes as insect repellents and carminative or expelling gas from the stomach (64,69). People have used its leaves in alternative medicine for its sedative, anti-inflammatory, anti-microbial effects (10). Lemongrass essential oil can be extracted from the dried or fresh leaves of lemongrass through steam distillation. The major compounds in lemongrass essential oil consist of citral monoterpenes that are isomeric mixture between geranial (42.2%) and neral (31.5%) (69). Lemongrass essential oil has pharmacological properties that include anti-inflammatory and antifungal effects (10).

Lemongrass essential oil has demonstrated positive effects in vivo research. For instance, Zabadi et al. (70) studied the inhalation effects of *Clinopodium serpyllifolium* (white leafed savory) essential oil and *Cymbopogon citratus* (lemongrass) essential oil on exercise performance and lung function in healthy participants. The researchers suggested that both essential oils were effective in improving exercise performance and respiratory functions. Another previous study by Sriraksa et al. (64) in 2018 reported that the lemongrass essential oil could increase cognitive performance in the domains of attention and the quality of memory significantly.

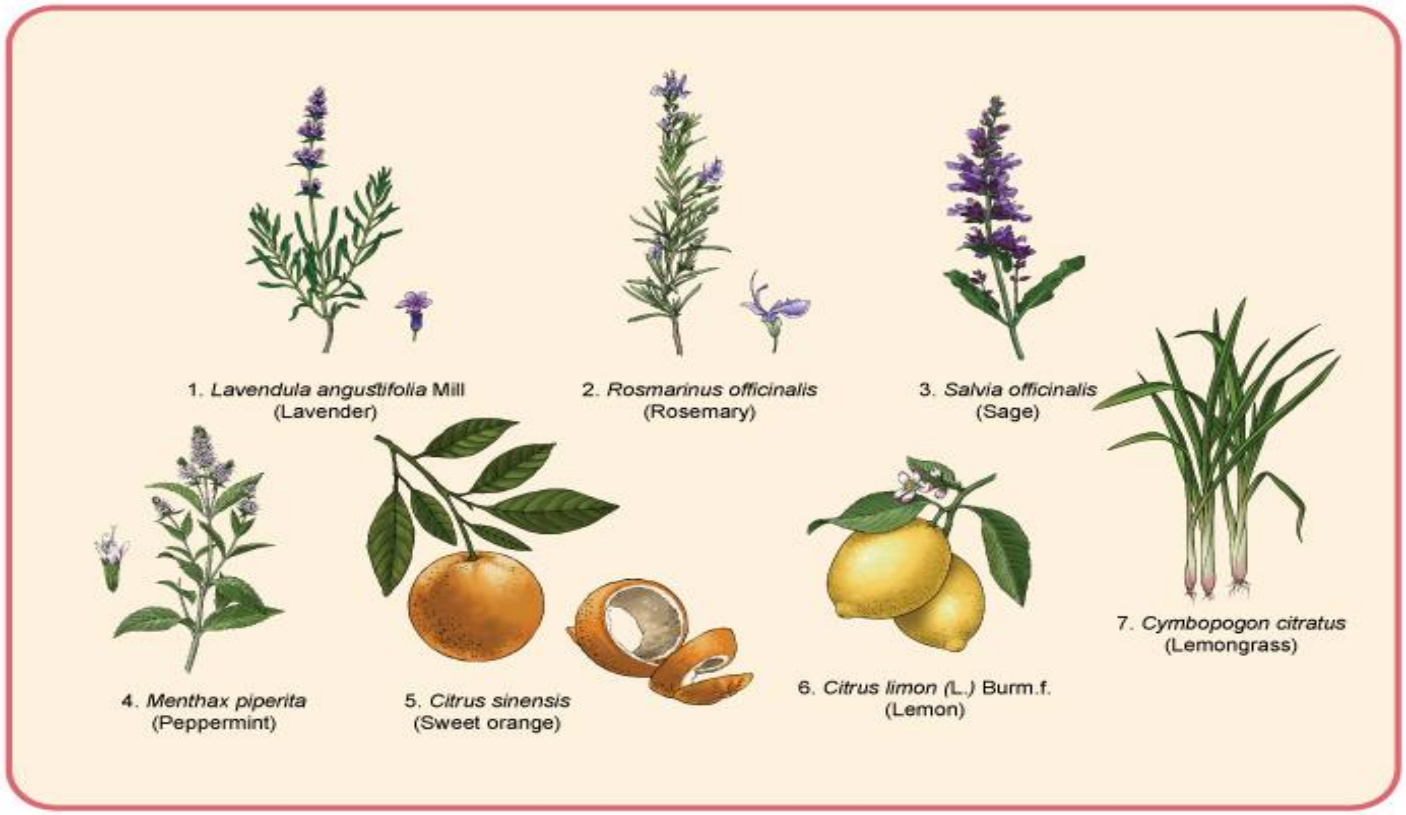


**Figure 3.** Botanical illustration of all seven plants distilled for essential oils: *Lavandula augustifolia* Mill (Lavender), *Rosmarinus officinalis* L. (Rosemary), *Salvia officinalis* L. (Sage), *Mentha* x *piperita* L. (Peppermint), *Citrus sinensis* L. (Sweet orange), *Citrus limon* (L.) Burm. f. (Lemon) and *Cymbopogon citratus* (Lemongrass).

Therefore, the lemongrass essential oil helps to promote cognitive function and alter mood in healthy participants without affecting physiological status (64). A previous study in 2015 was

conducted to determine the physiological effects of lemongrass massage oil on human vital signs, including blood pressure and pulse rate in healthy participants. The results showed that the aroma massage with lemongrass essential oil could lower diastolic blood pressure (DBP) significantly compared to the control group. Moreover, the participants were completely satisfied with aromatherapy massage, including the properties of essential oil (28). A 2019 study suggested that lemongrass could be used to relieve the pain and discomfort triggered by headaches and migraines as well as spasms, backaches, sprains, and muscle cramps. It is effective in treating sports wounds, such as bruises, internal injuries, and dislocations. Lemongrass tea is also consumed to help calm muscles and nerves to promote better sleep (66). In short, lemongrass essential oil promotes athletic performance, lung function, cognitive function and alters mood.

## CONCLUSIONS

Aromatherapy which uses essential oils as the main therapeutic agents is safe and readily available at a reasonable price. It is an alternative to maintain all the four dimensions of sport performance. Athletes can reap the benefits of essential oils, including healthy respiratory function, clear breathing, better sleep quality, more energy, sharp focus, and better emotional states. Essential oils are very effective in reducing mental and physical fatigue, promoting athletic performance and accelerating recovery in athletes. *Lavendula augustifolia* Mill (lavender), *Rosmarinus officinalis* L. (rosemary) and *Salvia officinalis* L. (sage) promote sports recovery and relieve fatigue while *Mentha x piperita* L. (peppermint) improves physical performance and concentration. *Citrus sinensis* L. (sweet orange) and *Citrus limon* (L.) Burm. F. (lemon) boost exercise performance while *Cymbopogon citratus* (lemongrass) promotes sports performance and physical functions. Therefore, athletes can apply essential oils to help them maintain and improve their overall sports performance. There are still other essential oils that may not have been applied in sports performance yet. Future research should be conducted to apply their benefits to sports performance.

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## REFERENCES

1. Abbott NJ, Friedman, A. Overview and introduction: The blood–brain barrier in health and disease. ***Epilepsia*.** 2012;(53*)*:1-6.

2. Adorjan B, Buchbauer G. Biological properties of essential oils: An updated review. ***Flavour Fragr J.*** 2010;*25*(6):407-426.

3. Aeini M. Effect of massage on fatigue and mood in female rowers. ***J HASES*****.** 2022;2(2): 248-258.

4. Argiris ET, Mavvidis A, Tsigilis N. Dealing with stress during tennis competition. The association of approach-and avoidance-coping with metacognition and achievement goal theory perspectives. ***J Phys Educ Sport.*** 2018;18(4):2454-2465.

5. Ayat ES, Shojaei A, Kobarfard F, et al. Two flavones from salvia leriaefolia. Iran J Pharm Res**.** 2009;8(3):179-184.

6. Babault N, Noureddine A, Amiez N, Guillemet D, Cometti C. Acute effects of salvia supplementation on cognitive function in athletes during a fatiguing cycling exercise: A randomized cross-over, placebo-controlled, and double-blind study. ***Front Nutr*****.** 2021;949.

7. Bayer R, Eken Ö. Effects of time-of-day on repeated sprint performance of aromatherapy massage applied young futsal players. ***Pak J Med Health Sci.*** 2022;16(2):384-384.

8. Beckmann J, Elbe AM. ***Sport Psychological Interventions in Competitive Sports*****.** Cambridge Scholars Publishing, 2015.

9. Berki T, Pikó B, Page RM. Sport commitment profiles of adolescent athletes: Relation between health and psychological behaviour. ***J Phys Educ Sport.*** 2020;20(3):1393-1401.

10. Boukhatem MN, Ferhat MA, Kameli A, Saidi F, Kebir HT. Lemon grass (cymbopogon citratus) essential oil as a potent anti-inflammatory and antifungal drugs. ***Libyan J Med.*** 2014;9(1).

11. Buckle J. Basic plant taxonomy, basic essential oil chemistry, extraction, biosynthesis, and analysis. ***Clinical Aromatherapy*****.** 2015;37-72.

12. Cavanagh HM, Wilkinson JM. Lavender essential oil: A review. ***Australian Infection Control*****.** 2005;10(1):35-37.

13. Cosma G, Chiracu A, Stepan R, Cosma A, Nanu C, Păunescu C. Impact of coping strategies on sport performance. ***J Phys Educ Sport.*** 2020;20(3):1380-1385.

14. Djilani A, Dicko A. The therapeutic benefits of essential oils. ***Nutrition, Well-Being and Health*****.** 2012;(*7)*:155-179.

15. Dunning T. Aromatherapy: Overview, safety, and quality issues. ***OA Alternative Medicine*****.** 2013;1(1):6.

16. Ebrahimi S, Agdasi MT, Mokaberian M. Analysis of the effect of inhaling orange essential oil on self-confidence and competitive anxiety of female athletics comparing with relaxation. ***Int J Health Sci.*** 2021;8(3):24-29.

17. El Hadri A, del Rio MG, Sanz J, et al. Cytotoxic activity of α-humulene and transcaryophyllene from salvia officinalis in animal and human tumor cells. ***An R Acad Nac Farm*****.** 2010;*76*(3):343-356.

18. Fung TK, Lau BW, Ngai SP, Tsang HW. Therapeutic effect and mechanisms of essential oils in mood disorders: Interaction between the nervous and respiratory systems. ***Int J Mol Sci.*** 2021;22(9):4844.

19. Gaballah A, Elnawasry H, Santos JA, Bressel E. The effect of pilates exercise with sage herbal consumption on respiratory functions for soccer players. ***Am J Sports Sci Med.*** 2016;4(4):103-108.

20. Gnatta JR, Kurebayashi LFS, Turrini, RNT, Silva, MJPD. Aromatherapy and nursing: Historical and theoretical conception. ***Revista da Escola de Enfermagem da USP*.** 2016; 50:127-133.

21. Goes TC, Antunes FD, Alves PB, Teixeira-Silva F. Effect of sweet orange aroma on experimental anxiety in humans. ***J Altern Complement Med.*** 2012;18(8):798-804.

22. Habtemariam S. The therapeutic potential of rosemary (rosmarinus officinalis) diterpenes for Alzheimer's disease. ***Evid Based Complement Altern Med.*** 2016;2680409.

23. Halson SL. Monitoring training load to understand fatigue in athletes. ***Sports Med.*** 2014;44 (2):139-147.

24. Handelsman DJ. Performance enhancing hormone doping in sport. ***Endotext*** [Internet]**.** https://www.ncbi.nlm.nih.gov/books/NBK305894/, 2020.

25. Herman A, Herman AP. Essential oils and their constituents as skin penetration enhancer for transdermal drug delivery: A review. ***J Pharm Pharmacol.*** 2015;67(4):473-485.

26. Igarashi M, Ikei H, Song C, Miyazaki Y. Effects of olfactory stimulation with rose and orange oil on prefrontal cortex activity. ***Complement Ther Med.*** 2014;22(6):1027-1031.

27. 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(1), 36.

28. Kamkaen N, Ruangrungsi N, Patalung NN, Watthanachaiyingcharoen R. Physiological and psychological effects of lemongrass and sweet almond massage oil. ***J Health Res.*** 2015; 29(2):85-91.

29. Kennedy DO. Phytochemicals for improving aspects of cognitive function and psychological state potentially relevant to sports performance. ***Sports Med.*** 2019;49(1):39-58.

30. Khedher MRB., Khedher SB, Chaieb I, Tounsi S, Hammami M. Chemical composition and biological activities of salvia officinalis essential oil from Tunisia. ***EXCLI J.*** 2017;(16):160.

31. Kishen A, Gayatri Devi R, Jyothipriya A. Comparative effect of rosemary and peppermint oil on muscle spasm. ***Drug Invent Today*.** 2019;11(5).

32. Kligler B, Chaudary S. Peppermint oil. ***Am Fam Physician*.** 2007;75(7):1027-1030.

33. Kompelly A, Kompelly S, Vasudha B, Narender B. Rosmarinus officinalis L: An update review of its phytochemistry and biological activity. ***J Drug Deliv Ther.*** 2019;9(1):323-330.

34. Koyama S, Heinbockel T. The effects of essential oils and terpenes in relation to their routes of intake and application. ***Int J Mol Sci.*** 2020;21(5):1558.

35. Lawrence BM. ***Mint: The Genus Mentha*****.** Chapter 1, Mentha: An Overview of Its Classification and Relationships. CRC Press: pp. 3-5, 2006.

36. Lin S, Wang Y, Wu K, et al. Study on the effect of mentha× piperita L. essential oil on electroencephalography upon stimulation with different visual effects. ***Molecules*****.** 2022;27 (13):4059.

37. Lizarraga-Valderrama LR. Effects of essential oils on central nervous system: Focus on mental health. ***Phytotherapy Research***. 2021;35(2):657-679.

38. Mabberley DJ. Citrus (Rutaceae): A review of recent advances in etymology, systematics, and medical applications. ***Blumea-Biodiversity, Evolution and Biogeography of Plants*****.** 2004;49(2-3):481-498.

39. Mao TY, Huang CF, Liu DY, Chen CT, Yang CC. Effects of mentha piperita essential oil uptake or inhalation on heart rate variability and cardiopulmonary regulation during Exercise. ***Montenegrin J Sports Sci Med.*** 2021;10(2):65-72.

40. Martín Á, Varona S, Navarrete A, Cocero MJ. Encapsulation and co-precipitation processes with supercritical fluids: Applications with essential oils. ***Open Chem Eng J.*** 2010;4(1).

41. Millet F. Huiles essentielles et essence de citronnier (citrus limon L.) Burm. f.). ***Phytotherapie*****.** 2014;12(2):89-97.

42. Masago R, Matsuda T, Kikuchi Y, et al. Effects of inhalation of essential oils on EEG activity and sensory evaluation. ***J Physiol Anthropol Appl Human Sci.*** 2000;19(1):35-42.

43. Meamarbashi A. Instant effects of peppermint essential oil on the physiological parameters and exercise performance. ***Avicenna J Phytomedicine.*** 2014;4(1):72.

44. Michalak M. Aromatherapy and methods of applying essential oils. ***Arch Physiother Glob Res.*** 2018;22(2):25-31.

45. Miyahara Y, Nishijima K. Effects of lemon aroma on power output during repeated high intensity exercise. ***J Phys Fit Sports Med.*** 2020;9(6):306-308.

46. Moss L, Rouse M, Wesnes KA, Moss M. Differential effects of the aromas of salvia species on memory and mood. ***Hum Psychopharm Clin*****.** 2010;*25*(5):388-396.

47. Nasrulloh A, Prasetyo Y, Nugroho S, et al. Tricet method to increase the hypertrophy muscle. ***J Phys Conf Ser.*** (Vol. 1529, No. 3, p. 032006). IOP Publishing, 2020.

48. Nasrulloh A, Prasetyo Y, Nugroho S, Yuniana R, Pratama KW. The effect of weight training with compound set method on strength and endurance among archery athletes. ***J Phys Educ Sport.*** 2022;22(6):1457-1463.

49. Ningsih YF, Kurniasih F, Puspitaningrum DA, Mahmudi K, Wardoyo AA. The effect of sport massage and Thai massage to lactic acid and pulse decreased. ***Int J Adv Eng Res Sci.*** 2017;4(12):237335.

50. Ozgoli G, Shahveh M, Esmaielli S, Nassiri N. Essential oil of citrus sinensis for the treatment of premenstrual syndrome: A randomized double-blind placebo-controlled trial. ***J Reprod Infertil.*** 2011;12(2).

51. Pardridge WM. The blood-brain barrier: Bottleneck in brain drug development. ***NeuroRx*****.** 2005;(*2):*3-14.

52. Paw M, Begum T, Gogoi R, Pandey SK, Lal M. Chemical composition of citrus limon L. burmf peel essential oil from north east India. ***J Essent Oil-Bear Plants.*** 2020; 23(2), 337-344.

53. Peiffer JJ, Abbiss CR, Watson G, Nosaka K, Laursen PB. Effect of cold-water immersion duration on body temperature and muscle function. ***J Sports Sci.*** 2009;27(10):987-993.

54. Pokajewicz K, Białoń M, Svydenko L, Fedin R, Hudz N. Chemical composition of the essential oil of the new cultivars of lavandula angustifolia mill. bred in Ukraine. ***Molecules*****.** 2021;26(18):5681.

55. Portenga ST, Aoyagi MW, Cohen AB. Helping to build a profession: A working definition of sport and performance psychology. ***J Sport Psychol Action.*** 2017;8(1):47-59.

56. Raškovic A, Milanovic I, Pavlovic N, Cebovic T, Vukmirovic S, Mikov M. Antioxidant activity of rosemary (*rosmarinus officinalis L*.) essential oil and its hepatoprotective potential. ***BMC Complement Altern Med*****.** 2014;(14):225.

57. Rita P, Animesh DK. An updated overview on peppermint (**m**entha piperita L.). ***Int Res J Pharm.*** 2011;2(8):1-10.

58. Sachan AK, Das DR, Shuaib MD, Gangwar SS, Sharma R. An overview on menthae piperitae (peppermint oil). ***Int J Pharmaceut Chem Biol Sci*****.** 2013;(3):834-838.

59. Sayowan S, Otbamrung, P. The effects of peppermint oil inhalation on autonomic nervous system and spatial abilities. ***J Prapokklao Hosp Clin Med Educat Center.*** 2018;35(1):8-17.

60. Schoenfeld BJ, Grgic J, Van Every DW, et al. Loading recommendations for muscle strength, hypertrophy, and local endurance: A re-examination of the repetition continuum. ***Sports*****.** 2021;9(2):32.

61. Sharma Y, Fagan J, Schaefer J. Ethnobotany, phytochemistry, cultivation, and medicinal properties of garden sage (salvia officinalis L). ***J Pharmacogn Phytochem.*** 2019;8(3): 3139-3148.

62. Sienkiewicz M, Lysakowska M, Pastuszka M, Bienias W, Kowalczyk E. The potential of use basil and rosemary essential oils as effective antibacterial agents. ***Molecules.*** 2013;18: 9334–9351.

63. Singh V, Katiyar D, Katiyar D, Ali M. Comparative study of volatile constituents and antimicrobial activities of leaves and fruit peels of citrus sinensis linn. ***J Phytopharm*****.** 2015;4(2):102-105.

64. Sriraksa N, Kaewwongse M, Phachonpai W, Hawiset T. Effects of lemongrass (cymbopogon citratus) essential oil inhalation on cognitive performance and mood in healthy women. ***Thai Pharmaceut Health Sci J.*** 2018;13 (2):80-88.

65. Tianlong D, Sim YJ. Effects of different recovery methods on post-boxing sparring fatigue substances and stress hormones. ***J Exerc Rehabil.*** 2019;15(2):258.

66. Toungos MD. Lemongrass (Cymbopogon, L. Spreng) valuable grass but underutilized in Northern Nigeria. ***Int J Innov Food Nutr Sustain Agric.*** 2019;7(2):6-14.

67. Wen W, Xu P, Xiang H, et al. Comprehensive two-dimensional countercurrent chromatography× gas chromatography characterization of artemisia argyi essential oil. ***Analytica Chimica Acta*****.** 2023;(1237):340614.

68. Ueda K, Horita T, Suzuki T. Effects of inhaling essential oils of citrus limonum l., santalum album, and cinnamomum camphora on human brain activity. ***Brain Behav.*** 2023;e2889.

69. Wifek M, Saeed A, Rehman R, Nisar S. Lemongrass: A review on its botany, properties, applications, and active components. ***Int J Chem Biochem Sci.*** 2016;*9*(January):79-84.

70. Zabadi HA, Hussein A, Shaker J, et al. Lung function and exercise performance assessment after inhalation of naturally essential oils: A descriptive observational study. ***Chula Med J.*** 2019;63(4):271-279.