

THE TOUCH THAT HEALS: UNRAVELLING THE MULTIMODAL MECHANISMS OF ABHYANGA IN MODERN PHYSIOLOGY

Kajal Adhikari¹, Manjry Anshumala Barla², Rakesh Roushan^{3*}

¹PG Scholar, Dept. of Kriya Sharir, CBPACS, New Delhi, India, <https://orcid.org/0009-0006-7038-9762>.

²CMO, NFSG, Directorate of AYUSH, Govt. of NCT OF Delhi, India, <https://orcid.org/0009-0005-3108-7473>.

^{3*}Associate Professor, Department of Kriya Sharir, CBPACS, <https://orcid.org/0000-0002-0874-0332>.

ABSTRACT

Abhyanga, the Ayurvedic practice of therapeutic oil massage, is a core Dinacharya regimen described in the Ashtang Hridaya with benefits ranging from delayed ageing and relief of fatigue to improved sleep, skin integrity, and pacification of Vata. Modern physiological explanations for these classical outcomes remain incomplete, and direct mechanistic data specific to Abhyanga are sparse. To critically examine the physiological mechanisms underlying the outcomes of Abhyanga as described in the Ashtang Hridaya, from the perspective of contemporary human physiology, integrating Ayurvedic concepts with modern physiological principles. We conducted a review integrating classical Ayurvedic primary sources with modern physiological literature, focusing on cutaneous, circulatory, lymphatic, neurological, and endocrine correlates of oil massage. The physiological effects of Abhyanga can be categorized into local cutaneous effects, hemodynamic and lymphatic alterations, neuroendocrine modulation, and systemic metabolic influences. Abhyanga likely operates through multimodal physiological pathways. Rigorous standardised protocols with objective biomarkers, pharmacokinetic sampling, and factorial designs isolating mechanical from pharmacological effects are required.

KEYWORDS: Abhyanga, Ayurveda, C-tactile afferents, Integrative physiology, Lymphatic drainage, Mechanotransduction, Neuroendocrine.

INTRODUCTION

Ayurveda, the eternal science of life, offers a comprehensive framework for understanding human physiology through its foundational theories. The primary objective of Ayurveda is to maintain and preserve the health of the healthy, and the secondary objective is to cure the disease of the unhealthy [1]. To fulfil Ayurveda's primary objective, Acharyas elaborately advised to follow Dinacharya (Diurnal regimen), Ratricharya (Nocturnal regimen), Ritucharya (seasonal regimen), Sadavritta (Ethical Conduct), and Achara Rasayana (Behavioural conduct) [2]. Following all the regimens prescribed by Acharyas maintains health. But with the hectic and fast-paced life, lifestyle alterations and disturbed daily routines, people do not follow these regimens, which leads to an increased occurrence of non-communicable diseases such as Diabetes mellitus (T2DM), Hypertension (HTN), Polyendocrine metabolic ovarian syndrome (PMOS), overweight and obesity [3]. Ayurveda explains the natural variation of doshas across day-night time, season, age and food intake [4]. Dinacharya describes a series of charyas to keep the doshas in a homeostatic condition. One such charya is Abhyanga (Therapeutic oleation). Usually, taila is used in the Abhyanga process, but with modernisation and urbanisation, people have replaced taila Abhyanga with local applications of easily available aromatic moisturisers, although acharyas recommend using taila. Therefore, the desirable effect of abhyanga is not attained and visualised. Abhyanga is the traditional Ayurvedic practice of anointing the body with warm, medicated oils, included in Dinacharya and in the therapeutic and pre- purification procedures of Panchakarma. Application of oil induces Snehana (unctuousness), Kledana (fluidity), Mriduta (softness), and Snigdhatta (moistness) in the body [5]. Abhyanga is the process of applying oil and gently massaging the body; it is part of Bahiparimarjana chikitsa (external purificatory measures) and serves as a treatment protocol for various diseases. Rubbing oil over the body generates heat through friction and stimulates blood and lymphatic circulation through sophisticated neurophysiological mechanisms [6]. Abhyanga has potential psychogenic and physiological benefits [7]. The therapeutic cascade initiated by Abhyanga involves transdermal absorption mediated by Bhrajaka Pitta, modulation of autonomic nervous system function, enhancement of circulatory and lymphatic dynamics, and neuroendocrine regulation. Contemporary research reveals that massage helps decrease heart rate and blood pressure [8]. Bipolar disorders, anxiety [9], dementia [10] and stress [11] are also relieved by Abhyanga. Despite its rich traditional roots, the mechanism of Abhyanga has not been sufficiently clarified in modern physiological terms. While classical descriptions offer clinical insights, they lack the mechanistic precision expected in contemporary biomedical discussions. This article examines potential mechanisms and offers a comprehensive analysis of how Abhyanga works by combining classical Ayurvedic principles with current physiological and pharmacological understanding.

Benefits of Abhyanga on Different Body Parts

The skin, as the largest organ of the body, serves as the primary interface between the external environment and the internal milieu. It is endowed with an intricate network of sensory receptors, immune cells, and vascular structures that collectively mediate the effects of tactile stimulation. Abhyanga, through its systematic application of oil and rhythmic manipulation, engages these cutaneous elements to initiate a cascade of physiological events that extend far beyond the local site of

application. Understanding these mechanisms requires a multidisciplinary approach that draws upon dermatology, neurophysiology, endocrinology, and lymphatic biology.

The classical Ayurvedic literature provides a detailed account of the benefits of Abhyanga, including its effects on various body parts such as the scalp, ears, and feet. Daily oil massage of the scalp (Murdhni tala) alleviates headaches, prevents premature greying and alopecia, strengthens hair roots, enhances sensory clarity, smooths facial skin, and promotes restful sleep and overall happiness. By filling the ears with oil (Karna poorana) daily, there will be no Vataja ear diseases, no stiffness of the neck or jaws, no difficulty in hearing and reduced chances of deafness. Daily application of oil on the body (Taila mardana) retards ageing, overcomes fatigue (Shrama), annihilates aggravated Vata, improves clarity of vision, renders nourishment, longevity, good sleep, good skin (tone, complexion and elasticity), a sturdy physique and is not liable to be afflicted with injury due to external trauma or strenuous physical exertion [12]. Oil-gargling (Gandusha) imparts strength to the jaws, voice and excellent plumpness/flabbiness to the face, excellent gustatory sensation and good taste for food, does not suffer from the dryness of the throat, chafing of lips, teeth do not become carious, become firmly rooted and do not ache nor are they set on edge by sour intake but become strong enough to chew even the hardest eatables [13]. Massaging the legs (Padabhyanga) alleviates roughness, stiffness, dryness, fatigue and numbness of feet, attain gentleness, strength, firmness, brightness of eyes, and pacification of Vata, prevents Gridhrasi (sciatica), fissures in the feet, contraction of the muscles, and blood vessels of legs [14]. Abhyanga is contraindicated for those suffering from vitiation of Kapha dosha, those having undergone either one of the five purificatory methods and those suffering from Ajirna (dyspepsia) [15]. These contraindications reflect the Ayurvedic understanding of the physiological state necessary for the optimal effects of Abhyanga, and modern physiology can provide insights into why these conditions might impair its beneficial effects. Abhyanga is a smooth mechanical process that stimulates mechanoreceptors, and the resulting sensory stimuli are transmitted to the brain, leading to the release of neurotransmitters such as serotonin, producing a soothing, calming, and relaxing effect. This review explains the detailed mechanism further.

Classical Outcomes: A Framework for Mechanistic Translation

Vagbhatta's verses describe outcomes that can be grouped into functional domains amenable to physiological analysis [16]:

Classical outcome (Ashtang Hridaya 2/8)	Proposed physiological domain
Jara apaha (delays ageing)	Cutaneous barrier restoration; oxidative stress modulation
Shrama hara (relieves fatigue)	Muscle spindle/Golgi tendon modulation; improved local perfusion
Vata hara (pacifies Vata)	Autonomic rebalancing; mechanoreceptor activation
Drishti prasada (clarity of vision)	Possibly trigeminal/autonomic reflexes from head/face; unresolved
Pushti (nourishment)	Enhanced cutaneous and systemic circulation
Ayu (longevity)	Multifactorial; not mechanistically specified
Swapna (good sleep)	Parasympathetic dominance; insular/limbic modulation
Su Twakatva (good skin)	Occlusion, lipid replenishment, hydration
Dardyakrit/Bala (strength or sturdy physique)	Musculoskeletal effects; possibly somatovisceral reflexes

This translation is heuristic. As the subsequent sections demonstrate, some mappings are well supported (cutaneous effects, autonomic modulation), others are plausible (Vata pacification, Drishti prasada).

Sensory pathways for transmitting Abhyanga stimulus into the Central Nervous System

Modern physiology describes the skin as an enormous sense organ with millions of nerve endings. The gentle rhythmic strokes and pressure variations during Abhyanga provide a rich spectrum of mechanical stimuli, activating a diverse array of mechanoreceptors (Meissner's corpuscles (light touch), Pacinian corpuscles (deep pressure and vibration), Merkel discs (sustained touch), and Ruffini endings (stretch) and thermoreceptors, transmitting different modalities of sensation. The sensory tactile stimuli are transduced into nerve impulses and travel via A β , A δ , and C fibres to the dorsal horn of the spinal cord. Almost all sensory information from the somatic segments of the body enters the spinal cord through the dorsal roots of the spinal nerves. However, from the entry point into the cord and then to the brain, the sensory signals are carried through one of two alternative sensory pathways: i) The dorsal column–medial lemniscal system and ii) The anterolateral system. The signals in the anterolateral system, immediately after entering the spinal cord from the dorsal spinal nerve roots, synapse in the dorsal horns of the spinal gray matter, the second-order neuron crosses to the opposite side of the cord and ascends through the anterior and lateral white columns of the cord. They terminate at all levels of the lower brain stem and in the thalamus. The anterolateral system is composed of smaller myelinated fibres that transmit signals at velocities ranging from a few meters per second up to 40 m/sec. The sensory information that does not need to be transmitted rapidly or with great spatial fidelity is transmitted mainly in the anterolateral system. The anterolateral system has the special capability to transmit a broad spectrum of sensory modalities pain, warmth, cold, and crude tactile sensations. Abhyanga involves crude touch sensation, the sensory tactile stimuli are transmitted to the somatosensory cortex via the anterolateral system, in response to which there is release of neurotransmitters like serotonin, enkephalins, and endorphins, resulting in calmness, euphoria, relaxation and analgesia.

In contrast, the dorsal column–medial lemniscal system transmits fine touch, vibration, and proprioceptive information with high spatial and temporal fidelity. This system comprises large myelinated fibres that transmit signals at velocities up to 120 m/sec. The sensory information carried by this system is used for precise localization and discrimination of tactile

stimuli. While Abhyanga involves both crude and fine touch, the emotional and affective aspects of the massage experience are primarily mediated through the anterolateral system and its projections to the limbic system. The autonomic nervous system is mainly activated by centres in the spinal cord, brainstem, and hypothalamus. Portions of the cerebral cortex, especially the limbic cortex, can also transmit signals to the lower centres and, in this way, influence autonomic control. The autonomic nervous system also often operates through visceral reflexes. That is, subconscious sensory signals from a visceral organ can enter the autonomic ganglia, the brain stem, or the hypothalamus and then return subconscious reflex responses directly back to the visceral organ to control its activities. Efferent autonomic signals are transmitted to the body's organs through two major subdivisions: the sympathetic nervous system and the parasympathetic nervous system. The hypothalamus serves as the principal integration centre for autonomic and neuroendocrine responses to Abhyanga. Sensory input from the skin, transmitted via the spinothalamic and spinoreticular pathways, reaches the hypothalamus either directly or through relays in the brainstem. The hypothalamus then coordinates the autonomic and endocrine responses that underlie the relaxation and restorative effects of Abhyanga.

Physiological Mechanisms

Inhibition of Pain Transmission by Simultaneous Tactile Sensory Signals

Classical claim: Abhyanga relieves fatigue (Shrama); Nociceptive gating and analgesia

Mechanism: Stimulation of large type A β sensory fibres from peripheral tactile receptors can inhibit the transmission of pain signals originating from the same body region. This effect results from activation of the analgesia system in the brain and spinal cord. This mechanism may explain the effectiveness of simple actions, such as rubbing the skin near painful areas, in alleviating pain. Similarly, this process may explain the analgesic effects of liniments. Furthermore, both this mechanism and concurrent psychogenic activation of the central analgesia system are considered to underlie the pain-relieving effects of acupuncture [17]. The gate control theory of pain, proposed by Melzack and Wall, provides a framework for understanding how tactile stimulation can modulate pain perception. According to this theory, the dorsal horn of the spinal cord contains a "gate" mechanism that can be opened or closed by different types of sensory input. Activation of large-diameter A β fibers by tactile stimulation inhibits the transmission of pain signals carried by smaller A δ and C fibers, effectively "closing the gate" and reducing the perception of pain. Abhyanga, through its activation of A β fibers, may thus produce analgesia through this gating mechanism. Additionally, the activation of descending inhibitory pathways from the brainstem, including the periaqueductal gray and the rostral ventromedial medulla, can further suppress pain transmission at the spinal level. The analgesic effects of Abhyanga may also involve the release of endogenous opioids such as β -endorphin and enkephalins. These endogenous opioid peptides bind to opioid receptors in the brain and spinal cord, producing analgesia and a sense of well-being. Massage has been shown to increase plasma β -endorphin levels, which may contribute to the pain-relieving effects observed in conditions such as low back pain, osteoarthritis, and fibromyalgia.

Classical claim: Abhyanga pacifies Vata, induces good sleep (Swapna), and produces calmness.

Mechanism: Skin as the body's largest sensory organ, densely innervated with mechanoreceptors; Meissner's corpuscles (light touch, 5-50 Hz), Pacinian corpuscles (deep pressure, vibration, 50-400 Hz), Merkel discs (sustained touch), and Ruffini endings (skin stretch). Abhyanga's rhythmic strokes and pressure variation activate this array. The particular relevance to the calming and sleep-promoting effects is C-tactile (CT) afferents—unmyelinated, low-threshold mechanoreceptors present in hairy skin, tuned to gentle, slow stroking at velocities of approximately 0.5-2 m/s. Neuroimaging studies demonstrate that CT stimulation activates posterior insular cortex without activating somatosensory areas 1 and 2, supporting a role in affective rather than discriminative touch [18]. Patients with reduced C-fibre density (hereditary sensory and autonomic neuropathy type V) perceive gentle stroking as less pleasant, and their insular responses to CT-optimal stimulation are blunted [19]. This suggests that the hedonic quality of slow touch depends on CT afferent integrity. The stroke velocities typical of Abhyanga are plausibly within the CT-optimal range.

HPA Axis and Cortisol: A Necessary Correction

Classical claim: Abhyanga relieves stress and promotes well-being.

Mechanism: It is often claimed that massage reduces cortisol and that this reduction mediates benefits. A comprehensive meta-analysis of massage–cortisol studies found that between-group effect sizes were almost all small ($d_s = 0.05$ – 0.30) and non-significant, with the sole exception of a multiple-dose effect in children ($d = 0.52$), based on only three studies and vulnerable to file-drawer bias [20]. The authors concluded that massage's effect on cortisol is generally very small and, in most cases, not statistically distinguishable from zero, and therefore cannot be the cause of massage's well-established effects on anxiety, depression, and pain. A separate meta-analysis of 37 studies found that single massage applications reduced state anxiety, blood pressure, and heart rate but not cortisol [21].

Cutaneous Barrier, Hydration, and Transdermal Absorption

Classical claim: Abhyanga produces “good skin” (Twak Prasadana and Su Twakatva), improved complexion, and nourishment.

Mechanism: The stratum corneum is the rate-limiting barrier to percutaneous absorption [22], composed of corneocytes embedded in a lipid matrix. Skin acts as a dual barrier: preventing water loss and impeding entry of external substances. Application of oil creates an occlusive layer that reduces trans epidermal water loss (TEWL), while fatty acids (oleic, linoleic, palmitic) integrate into the intercellular lipid matrix, restoring barrier function [23]. Warm oil increases cutaneous blood flow and fluidises stratum corneum lipids, increasing diffusion coefficients for lipophilic penetrants. The Ayurvedic concept of Bhrajaka Pitta, the “digestive” function of the skin, bears a functional parallel to cutaneous xenobiotic

metabolism. The skin possesses cytochrome P450 enzymes and esterases capable of biotransforming topically applied compounds [24]. Bhrajaka Pitta is a theoretical construct, and no study has correlated its function with enzymatic activity. The parallel is offered as a conceptual bridge, not a demonstrated identity.

Essential oils and their volatile constituents (terpenes, phenylpropanoids) can enhance penetration of co-administered compounds by disrupting intercellular lipid organisation. In a comparative study, enhancement ratios for several oils exceeded the synthetic enhancer azone (turpentine 2.23, Angelica 1.83, chuanxiong 2.60, Cyperus 2.49, cinnamon 2.63, clove 1.97), with ATR-FTIR indicating enhancement occurs through lipid disturbance rather than extraction [25]. These findings provide a plausible basis for medicated oil formulations.

Autonomic Rebalancing: Explaining Calmness and Cardiovascular Effects

Classical claim: Abhyanga produces calmness, improves sleep, and supports daily health maintenance.

Mechanism: The autonomic nervous system, comprises sympathetic and parasympathetic branches regulated by hypothalamic and brainstem centres. Heart rate variability (HRV) analysis provides a window into autonomic balance. Moderate-pressure massage comparable to Abhyanga has been associated with increased high-frequency HRV components, indicating enhanced parasympathetic (vagal) tone. However, the evidence is not uniform. A systematic review of manual therapies concluded that while they may affect both sympathetic and parasympathetic systems, findings are inconsistent because of methodological heterogeneity, and the magnitude of any specific autonomic effect and its clinical relevance remain uncertain [26]. A meta-analysis of thoracic mobilisation/manipulation found no statistically significant effect on autonomic markers, including the low-frequency-to-high-frequency ratio [27]. These null findings underscore the need for caution: not all manual therapies produce reliable autonomic effects, and the specific parameters of Abhyanga that might do so remain unidentified.

Musculoskeletal Effects: Explaining Bala and Shrama Hara

Classical claim: Abhyanga imparts strength (Bala) and relieves fatigue (Shrama).

Mechanism: The muscle spindle and Golgi tendon organ are key proprioceptive sensors regulating muscle tone. Massage reduces muscle tone through inhibition of gamma motor neurons; Golgi tendon organ activation by stretch stimulates A β afferents that inhibit alpha motor neurons [28]. Cutaneous mechanoreceptor activation contributes to muscle tone inhibition through segmental reflex pathways. Improved local blood flow delivers oxygen and nutrients while removing metabolic waste, potentially relieving fatigue. These mechanisms are well established in exercise physiology.

Lymphatic Mobilisation: Explaining Srotas Shodhana (Channel Purification)

Classical claim: Abhyanga opens channels (Srotas) and removes metabolic waste (Mala).

Mechanism: The lymphatic system lacks a central pump and relies on external forces including muscle contraction, respiration, and manual pressure. Abhyanga strokes, typically directed toward the heart, may promote lymph flow by creating variations in interstitial pressure. Computational modelling suggests that irregularly shaped initial lymphatics increase luminal volume more than round lymphatics when tissue is stretched, and that lymph formation rate relates to massage frequency through tissue viscoelastic properties [29]. The lymphatic mechanism is physiologically plausible and aligns with the Ayurvedic concept of Srotas purification.

CONCLUSION

The Ashtang Hridaya describes Abhyanga as producing a coherent set of outcomes: delayed ageing, relief of fatigue, pacification of Vata, good sleep, healthy skin, and strength. Modern physiology can plausibly explain several of these through mechanisms such as cutaneous barrier restoration, CT afferent activation, gate-control analgesia, autonomic rebalancing, and musculoskeletal modulation. However, this appraisal shows the evidence base relies heavily on extrapolation from generic massage, that cortisol reduction is not well supported, and that key claims—systemic oil absorption, CT afferent activation during Abhyanga, and cumulative effects of long-term practice—remain untested. Abhyanga is a multimodal intervention with plausible, partially evidenced mechanisms. Its distinctive features—warm medicated taila applied in a structured daily regimen—have not been isolated experimentally. Future research should prioritise standardised protocols, factorial designs, pharmacokinetic sampling, and objective biomarkers, while correcting the unsupported cortisol claim that persists in integrative medicine literature. Such work would allow Ayurvedic practice and modern physiology to inform each other on empirical rather than rhetorical grounds.

REFERENCES

1. Acharya Agnivesha, Charaka Samhita, Sutra Sthana, Chapter 30, Verse 26, edited by Pandey K, Chaturvedi G, Chaukamba Bharti Academy, Varanasi 2018; 587
2. Adhikari K, Barla M, Roushan R. A review on non-pharmacological intervention of Ayurveda in management of mental wellbeing. international journal of research in ayurveda and pharmacy. 2024;15(6):66-71.
3. Roushanam P. Evaluation of cardiovascular autonomic function tests in obese and non-obese healthy indians. Journal of Advanced Scientific Research. 2023 Mar 31;14(03):57-64.
4. Maharana S, Adhikari K, Chaple J, Bharti, Rawekar A, Roushan R, et al. Critical Review on Dietary Consideration of Ayurveda. 2025;11:2025. doi:10.64252/5eevkg12.
5. Acharya Agnivesha, Charaka Samhita, Sutra Sthana, Chapter 22, Verse 10, edited by Pandey K, Chaturvedi G, Chaukamba Bharti Academy, Varanasi 2018; 424
6. Madhukar LS, Nivrutti BA, Bhatnagar V, Bhatnagar S. Physio-anatomical explanation of abhyanga: An ayurvedic massage technique for healthy life. Journal of Traditional Medicine & Clinical Naturopathy. 2018;7(1):252.

7. Pp, Sabna & Sivaram, Anjali & Panthappulan, Hakkeem. (2021). Review on physiological evaluation of abhyanga. *International Ayurvedic Medical Journal*. 9. 3074-3080. 10.46607/iamj2409122021.
8. Ferrel-Torrey AT, Glick OJ. The use of therapeutic massage as a nursing intervention to modify anxiety and the perception of cancer pain. *Cancer Nurs*. 1993; 16:93–101.
9. Field T. Massage therapy. *Med Clin North Am*. 2002; 86:163–71.
10. Chieh-Yu Fu, Wendy Moyle, Marie Cooke. A randomized controlled trial of the use of aromatherapy and hand massage to reduce disruptive behavior in people with dementia. *BMC Complementary and Alternative Medicine*, 2013;13:165
11. Bost N, Wallis M. The effectiveness of a 15-minute weekly massage in reducing physical and psychological stress in nurses. *Australian Journal of Advanced Nursing*, 2006; 23 (4): 28-33.
12. Acharya Agnivesha, Charaka Samhita, Sutra Sthana, Chapter 5, Verse 81-89, edited by Pandey K, Chaturvedi G, Chaukamba Bharti Academy, Varanasi 2018; 127-129
13. Acharya Agnivesha, Charaka Samhita, Sutra Sthana, Chapter 5, Verse 81-89, edited by Pandey K, Chaturvedi G, Chaukamba Bharti Academy, Varanasi 2018; 127-129
14. Acharya Agnivesha, Charaka Samhita, Sutra Sthana, Chapter 5, Verse 90-92, edited by Pandey K, Chaturvedi G, Chaukamba Bharti Academy, Varanasi 2018; 129
15. Sreekumar T, editor. Ashtanga Hridaya of Vagbhata. Sutra Sthana, Chapter 2, Dinacarya Adhyayam, Sloka 9-10. 6th ed. Vol. 1. Thrissur: Harisree Hospital; 2016. p. 69.
16. Sreekumar T, editor. Ashtanga Hridaya of Vagbhata. Sutra Sthana, Chapter 2, Dinacarya Adhyayam, Sloka 8. 6th ed. Vol. 1. Thrissur: Harisree Hospital; 2016. p. 69.
17. Vaz M, Kurpad A, Raj T. Guyton & Hall Textbook of Medical Physiology_3rd SAE-E-book. Elsevier Health Sciences; 2020.page 763
18. Morrison I, Björnsdotter M, Olausson H. Vicarious responses to social touch in posterior insular cortex are tuned to pleasant caressing speeds. *The Journal of Neuroscience*. 2011 Jun 29;31(26):9554-62.
19. Case LK, Madian N, McCall MV, Bradson ML, Liljencrantz J, Goldstein B, Alasha VJ, Zimmerman MS. Aβ-CT affective touch: Touch pleasantness ratings for gentle stroking and deep pressure exhibit dependence on A-fibers. *Eneuro*. 2023;10(5):ENEURO-0504.
20. Moyer PD, Seefeldt BL, Mann BE, Jackley LM. Does massage therapy reduce cortisol? A comprehensive quantitative review. *Journal of bodywork and movement therapies*. 2011 Jan 1;15(1):3-14.
21. Moyer CA, Rounds J, Hannum JW. A meta-analysis of massage therapy research. *Psychological bulletin*. 2004 Jan;130(1):3.
22. Schafer N, Balwierz R, Biernat P, Ochędzan-Siodłak W, Lipok J. Natural ingredients of transdermal drug delivery systems as permeation enhancers of active substances through the stratum corneum. *Molecular Pharmaceutics*. 2023 Jun 6;20(7):3278-97.
23. Lin TK, Zhong L, Santiago JL. Anti-inflammatory and skin barrier repair effects of topical application of some plant oils. *International journal of molecular sciences*. 2017 Dec 27;19(1):70.
24. Chen Q, Wang T, Wu X, Yuan H, Wei Y, Xiao Y. The role of the cytochrome P450 superfamily in the skin. *Expert Rev Mol Med*. 2024 Apr 15;26:e15. doi: 10.1017/erm.2024.5. PMID: 38621674; PMCID: PMC11140544.
25. Jiang Q, Wu Y, Zhang H, Liu P, Yao J, Yao P, Chen J, Duan J. Development of essential oils as skin permeation enhancers: Penetration enhancement effect and mechanism of action. *Pharmaceutical biology*. 2017 Jan 1;55(1):1592-600.
26. Roura S, Alvarez G, Sola I, Cerritelli F. Do manual therapies have a specific autonomic effect? An overview of systematic reviews. *PLoS One*. 2021 Dec 2;16(12):e0260642.
27. Hansen L, Goebel H, Pagels L, Luedtke K. Effects of mobilization or manipulation of the thoracic spine on autonomic nervous system markers in symptomatic and asymptomatic participants—a systematic review and meta- analysis. *Journal of Manual & Manipulative Therapy*. 2025 Nov 2;33(6):466-89.
28. Zampieri N, de Nooij JC. Regulating muscle spindle and Golgi tendon organ proprioceptor phenotypes. *Current opinion in physiology*. 2021 Feb 1;19:204-10.
29. Jayathungage Don TD, Safaei S, Maso Talou GD, Russell PS, Phillips AR, Reynolds HM. Computational fluid dynamic modeling of the lymphatic system: a review of existing models and future directions. *Biomechanics and Modeling in Mechanobiology*. 2024 Feb;23(1):3-22.