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# Assessment of EEG changes after the intervention of selected forms of massage – a systematic review of the literature

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**ABSTRACT**

**Introduction**: Massage therapy reduces pain, alleviates muscle tension, and enhances psychological well-being. In addition to subjective methods for assessing changes in well-being due to massage, researchers are increasingly seeking effective objective methods. One such method is electroencephalogram (EEG) analysis. This study aimed to conduct a systematic review to evaluate the effects of different forms of massage on EEG recordings in healthy adult subjects.

**Materials and methods**: To conduct the review, the databases PubMed, Medline, ScienceDirect, and Google Scholar were searched for publications from 2012 to 2023. The keywords used were: massage therapy, EEG, and electroencephalography. The available publications were screened against the established inclusion and exclusion criteria, resulting in 7 papers being included in the final analysis.

**Results**: In the papers included in the analysis, the intervention included aromatherapy massage, mechanical massage, Swedish massage, and foot reflexology. Most of the papers found changes in brainwave amplitude under the influence of massage; however, the directions of change (decrease/increase in amplitude) varied within the range of individual waves.

**Conclusions**: Based on the literature review, it can be concluded that massage affects EEG recordings in healthy adults. However, this effect appears to depend on the type of massage applied. The significant discrepancies in the interventions used indicate a need for further research and analysis involving standardized massage protocols.

**Keywords**: massage; electroencephalography; systematic review; brain waves; relaxation.

## INTRODUCTION

Stress is defined as a disturbance of the body's homeostasis caused by negative psychological or physical experiences [1, 2]. Chronic exposure to stressors can lead to pathological consequences, including: increased blood pressure, cardiovascular diseases, psychiatric disorders, and reduced immunity [3]. The musculo-fascial system is particularly sensitive to stress, and its prolonged presence can cause habitual muscle tension and musculo-fascial imbalance, contributing to pain syndromes [4]. Calming methods such as Jacobson's relaxation technique, visualization techniques, breathing exercises, and manual techniques can reduce stress. Even gentle touch can stimulate the parasympathetic nervous system, inducing changes in the neuroendocrine system, such as a decrease in cortisol levels and an increase in serotonin secretion [5].

Massage therapy involves the systematic manipulation of soft tissues using rhythmic pressure and stroking [6]. There are over 150 different massage techniques, selected according to specific conditions [7]. Massage therapy stimulates the central nervous system, leading to a reduction in heart rate and respiration, resulting in a feeling of calm [8]. Some reports indicate that massage alters the pressure gradient between tissues and vessels, facilitating fluid flow between them and regulating blood pressure [9]. The effects of manual intervention in soft tissues include increased lymph flow, accelerated clearance of excess lactate, and a positive impact on the immune system. Local biomechanical changes from therapy contribute to increased neural activity at the level of the medulla and subcortical nuclei, improving mood and pain control [10]. Psychologically, massage promotes mental relaxation and reduces depression and negative emotions such as anger, fear, and anxiety [11].

Assessing psychological stress is challenging because everyone experiences it differently. The reliability of the assessment depends on the method and analysis. Traditionally, stress has been assessed using subjective methods, including self-report questionnaires [12]. Studies confirm that questionnaires and interviews are the most common ways to assess patients' mental states, but factors such as self-monitoring can lead to inaccurate measurements. These methods are subjective and not actual measurements, carrying a high risk of error. A more accurate method involves analyzing cortisol or alpha-amylase levels [13]. Other measurements can include heart rate, blood pressure, and skin conductance [14]. Therefore, electroencephalogram (EEG) signals are increasingly used in engineering studies and clinical diagnoses [15]. The most commonly used EEG frequency features are obtained from clinical brain wave bands: delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (14–30 Hz), and gamma (30–50 Hz). These brain rhythms contain important information related to mental stress and other mental disorders.

In newborns and children up to 18 months old, slow delta waves, typical of the deep sleep state, predominate. As they age, faster theta waves, typical of the state between waking and sleeping, begin to dominate. The faster alpha wave is the axis of bioelectrical brain activity, predominant in adults with eyes closed, and in children aged 6–10 years, it is the dominant activity in the alert state. The sensorimotor rhythm (SMR) wave is responsible for storing and recalling information and has a positive effect on maintaining the balance of the central nervous system. Beta 1 is a faster wave than SMR and is responsible for activity, dependent on the person's will, and dominates during intellectual problem solving [16]. Beta 2 is a very fast wave, and its excessive presence in brain activity indicates a state of over-excitation of the neural structures. The gamma wave is the fastest brain wave and is associated with simultaneous processing of information from different brain areas, noted in states of feeling love and altruism [17].

The aim of this study was to analyze research results on changes in EEG recordings after massage treatments to explore the potential of using EEG as an objective method for assessing the impact of massage on the psychophysical condition of healthy adults.

## MATERIALS AND METHODS

The study design has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the identifier CRD42023442839. To identify a suitable pool of studies, a broad search strategy was employed, including clinical trials and randomized and non-randomized studies where the intervention involved different forms of massage. The databases PubMed, Medline, Science Direct, and Google Scholar were searched by 3 independent researchers to identify relevant studies. These searches covered the entire databases from their inception until July 2023.

The following combinations of Medical Subject Headings (MeSH) and keyword terms were used as search terms. For MeSH, the terms 'massage' and 'EEG' were selected. For keywords, the terms 'massage therapy', 'EEG', 'electroencephalogram', and 'electroencephalography' were used (Tab. 1).

Studies were excluded if they involved subjects under 18 or over 65 years of age or if the subjects had comorbidities. Additionally, studies using manual techniques other than massage and physical therapy treatments were excluded. Papers without full-text availability, as well as review articles and meta-analyses, were not considered. To facilitate collaboration among all study team members, only studies published in English were included in the search (Tab. 2).

**TABLE 1. Stages of a literature search**

| Search stages | Search phases |
|---|---|
| 1. | keywords: massage therapy, EEG, electroencephalogram, electroencephalography<br>MESH: massage, EEG |
| 2. | publications in English |
| 3. | publications issued between 2012–2023 |
| 4. | full versions of publications available |

**TABLE 2. Inclusion and exclusion criteria**

| Inclusion criteria |
|---|
| The survey covers adults of working age (18–64 years) |
| Clinical trials and randomized and non-randomized studies in which the intervention is the application of different forms of massage |
| The effectiveness of the massage intervention was assessed by changes in eeg recordings |
| The study group consists of healthy subjects with no comorbidities |
| **Exclusion criteria** |
| Review articles and meta-analyses |
| The survey covers persons under 18 and over 65 years of age |
| Intervention consists in the use of manual techniques other than massage/physical therapy treatments |
| The study group consists of people with comorbidities |

The researchers worked independently and recorded the results of their review in an MS Excel spreadsheet. After completing their work, any papers included by more than 1 researcher were verified and duplicates were rejected. Any doubts about whether a selected paper should be included in the review were resolved through discussion among the researchers.

A keyword search extracted 1,748 scientific publications. After rejecting 1,266 duplicate items, 482 scientific articles remained for further analysis. In the next step, 406 publications that did not meet the search conditions were rejected. Following a title analysis, 49 items were rejected, and an additional 13 items were rejected after an abstract analysis. Fourteen full-text publications were analyzed, and 7 more items were rejected based on this analysis. Ultimately, 7 articles meeting all search conditions were obtained. The article review process is presented in the PRISMA 2020 flow diagram in Figure 1.

The included papers were then screened to assess their quality using the Cochrane Risk of Bias (ROB) 2.0 Tool. All selected papers met the quality criteria and were included in the final analysis.

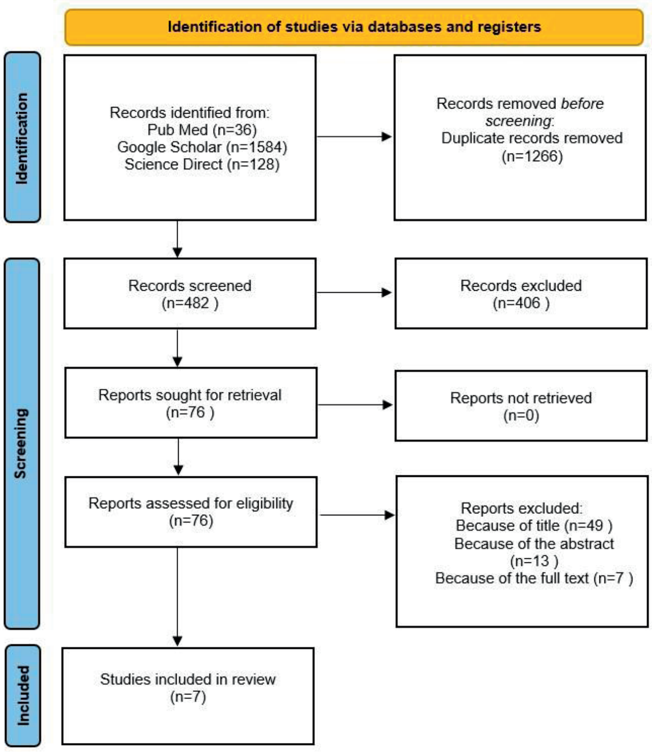


**FIGURE 1.** PRISMA 2020 data – flow diagram

## RESULTS

To characterize the papers included in the analysis, the following evaluation aspects were distinguished: description of the study group, description of the intervention used (including the type of massage, duration of a single session, frequency of massage, and duration of the entire intervention), the most important outcome expressed by the change in amplitude of individual brain waves, and the most important conclusion. The characteristics of the papers included in the analysis are shown in Table 3.

In total, the evaluated studies included 170 participants. Of the 7 eligible articles, 3 focused on aromatherapy massage.

The second study involved an aromatherapy massage intervention lasting 40 min, performed twice a week for 4 weeks. Twenty-five participants aged 34–48 were randomly allocated to the aromatherapy massage group (n = 13) and the control group (n = 12). The study found a decrease in delta wave amplitude and an increase in the amplitudes of alpha, beta 1, beta 2, gamma 1, gamma 2, and theta waves. The authors concluded that aromatherapy massage significantly affects many neurobiological indicators, such as the EEG power spectrum, and also influences quantitative psychological assessments [19].

In another study, the group consisted of 16 healthy subjects (10 men and 6 women) aged 30–60 years. The intervention was a single 45-minute massage session. An increase in alpha wave amplitude was observed in all subjects, while an increase in theta wave amplitude was observed in 1 person. A decrease in beta 1 and beta 2 wave amplitudes was also observed in 1 person. Gamma 1, gamma 2, and delta waves were not included in this study. The authors emphasized that the changes in the EEG recordings confirmed the subjective relaxation and stress-relieving effects assessed by the visual analogue scale (VAS) [21].

In a study by Jeong et al., 15 women received a 50-minute aromatherapy massage once a week for 2 weeks. A decrease in alpha wave amplitude was observed in both brain hemispheres. The authors concluded that aromatherapy massage has a positive effect on psychological relaxation [23].

Another article examined the effect of mechanical massage on EEG recordings. Chang et al. studied 24 subjects aged 18–24 years, who received a 12-minute mechanical massage in 3 sessions. The intervention resulted in decreased amplitudes of alpha, beta 1, and beta 2 waves, and an increased delta wave amplitude. Gamma 1, gamma 2, and theta wave amplitudes remained unchanged [20].

Kerautret et al. conducted a study using a manual massage intervention with 20 subjects (10 women and 10 men) aged 20–32 years. After a single 16-minute massage session, an increase in the amplitudes of alpha, beta 1, and beta 2 waves was observed. Due to the consistent direction of changes in alpha, beta 1, and beta 2 wave amplitudes, the authors concluded that manual massage intervention has relaxation properties [24].

In a study by Kaewcun and Siripornpanich, the intervention was based on Swedish massage. The study involved 18 healthy adults (5 men and 13 women) aged 22–36 years. A single Swedish massage session, divided into two 25-minute parts, resulted in an increase in alpha wave amplitude and a decrease in beta 1, beta 2, and delta wave amplitudes. Gamma 1 and gamma 2 waves were not mentioned. The authors concluded that a single session of Swedish massage has an inhibitory effect, particularly on the right somatosensory cortex [22].

The final eligible article investigated the effect of foot reflexology on EEG recordings. Seven men aged 17–30 years participated in this study. The foot reflexology intervention was performed for 5 min once a day over 1 week. A decrease in alpha and delta wave amplitudes was observed, while an increase in beta 1, beta 2, gamma 1, gamma 2, and theta wave amplitudes was noted. The authors concluded that beta and gamma waves have potential as measures of functional brain activation associated with foot reflexology [18].

## DISCUSSION

The studies included in this literature review examined the association between various massage protocols – aromatherapy massage, manual massage, mechanical massage, Swedish massage, and foot reflexotherapy – and changes in brain bioelectrical activity. Qualified studies using EEG to assess the effects of therapy focused on analyzing the amplitudes of delta (0–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), and beta (13–30 Hz) rhythms [25].

Findings on the physiological effects of massage therapy via electroencephalography suggest that for the intervention

**TABLE 3. Description of the work included in the analysis**

| No. | Authors | Study group | Intervention: 1. type of massage, 2. duration of a single session, 3. frequency, 4. duration of the entire session | Main results – observed changes in amplitude of brain wave activity | | | | | | | Main conclusions |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | alfa | beta 1 | beta 2 | gamma 1 | gamma 2 | delta | theta | |
| **1.** | Unal et al., 2018 [18] | 7 presumably healthy male participants aged 17–30 years took part in the study; all participants were right-handed, by self-declaration and confirmed with a Edinburgh Handedness Inventory | 1. reflexotherapy,<br>2. 5 min per foot,<br>3. once a day, week 4 | drop | growth | growth | growth | growth | drop | growth | cortical beta and gamma EEG waves can be used as measures of functional brain activation associated with foot reflex therapy |
| **2.** | Wu et al., 2014 [19] | 25 participants aged 34–48 years were enrolled in the study; they were randomly allocated to either the aromatherapy massage group (n = 13) or the control group (n = 12) | 1. aromatherapy massage,<br>2. 40 min,<br>3. twice a week,<br>4. 4 weeks growth | drop | growth | growth | growth | growth | drop | growth | the results suggest that aromatherapy massage can exert a significant impact on many neurobiological indicators, such as EEG power spectrum, salivary cortisol and plasma BDNF, as well as quantitative psychological assessments |
| **3.** | Chang et al., 2012 [20] | 24 volunteers, mainly university students, took part in the study: 13 men and 11 women, aged between 18–24 | 1. manual and mechanical massage,<br>2. 12 min,<br>3. no data available,<br>4. 3 sessions drop | drop | drop | drop | no change | no change | growth | no change | power and EEG coherence are the 2 main tools for studying brain activity; manual massage is less intense than mechanical massage |
| **4.** | Dhuri et al., 2013 [21] | the study group consisted of 16 volunteers (10 men and 6 women); the study subjects were healthy people 30–60 years old, weighing 45–90 kg, with normal blood pressure and no disease in the past 3 months | 1. aromatherapy massage,<br>2. 45 min,<br>3. single intervention,<br>4 single intervention growth | growth | decrease (only in 2 persons) | decrease (only in 2 persons) | no data available | no data available | no data available | growth (only in 1 person) | changes in the EEG recordings confirmed the subjective relaxation effect assessed by VAS as relieving stress |

**TABLE 3. Description of the work included in the analysis**

| No. | Authors | Study group | Intervention: 1. type of massage, 2. duration of a single session, 3. frequency, 4. duration of the entire session | Main results – observed changes in amplitude of brain wave activity | | | | | | | Main conclusions |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | alfa | beta 1 | beta 2 | gamma 1 | gamma 2 | delta | theta | |
| **5.** | Kaewcum and Siripornpanich, 2018 [22] | the subjects were 18 healthy adult participants (5 men, 13 women) ranging in age 22–36 years | 1. Swedish massage,<br>2. twice 25 min each,<br>3. single intervention,<br>4. single intervention growth | growth | drop | drop | no data available | no data available | drop | drop | the inhibitory effect of Swedish massage on the right somatosensory cortex has been demonstrated to receive sensory stimulation through massage on the left side of the body |
| **6.** | Jeong et al., 2021 [23] | the study group consists of 15 healthy women, aged between 40–60 years, with no history of regular menstruation in the 3 months prior to the study | 1. aromatherapy massage,<br>2. 50 min,<br>3. once a week,<br>4. 2 weeks drop | drop | no data available | no data available | no data available | no data available | no data available | no data available | the study found that aromatherapy head massage therapy is closely linked to relieving physical stress and providing mental stability for middle-aged women |
| **7.** | Kerautret et al., 2021 [24] | 65 healthy adults were enrolled in the study; the group, where manual massage was the intervention, consisted of 20 subjects (10 women and 10 men) aged between 20–32 years | 1. manual massage,<br>2. 16 min,<br>3. single intervention,<br>4. 6 months growth | growth | growth | growth | no data available | no data available | no data available | no data available | the manual massage intervention promoted a cerebral state of relaxation, characterised by the synchronisation of alpha and beta waves in the frontal and parietal regions, respectively |

EEG – electroencephalogram; BDNF – brain-derived neurotrophic factor; VAS – visual analogue scale to be relaxing and anxiety-reducing, EEG results should show an increase in delta wave amplitude and a decrease in alpha and beta amplitudes [26]. Jones and Field also found that massage therapy shifts the frontal alpha wave asymmetry index from right brain hemisphere dominance to left brain hemisphere dominance [27]. Furthermore, these findings were corroborated by Diego et al., who observed an increase in frontal delta wave activity along with a decrease in frontal alpha and beta wave activities after massage, accompanied by a subjective sensation of relaxation and sedation in participants [28].

However, the results of the analyzed articles varied widely. In the reviewed papers, only the study by Chang et al. reported a decrease in alpha and beta wave amplitudes [20]. Alpha wave amplitude also decreased in the study by Jeong et al. [23] following aromatherapy massage, which led to stress relief in participants. Nonetheless, most data obtained were highly variable. Kaewcum and Siripornpanich observed an increase in alpha wave amplitude alongside a decrease in beta 1 and beta 2 wave amplitudes [22].

Despite discrepancies in the EEG recordings, most authors simultaneously indicated the relaxing nature of the massage interventions described. A relaxing effect was noted even in the study by Kerautret et al., which showed an increase in alpha, beta 1, and beta 2 wave amplitudes [24]. Similar findings were reported by Rattanawan et al. and Nakano et al. In a study by Japanese authors, a hand and foot massage intervention in a group of 69 people aged 65 years and older resulted in an increased amplitude of alpha waves in the insula structures and the posterior part of the cingulate cortex on both sides of the brain. Participants also reported feeling highly relaxed after the interventions [29, 30].

Despite the popularity and variety of massage therapy, there are limited scientific reports on its effects on EEG changes, especially studies with high reliability (systematic literature reviews or meta-analyses) focusing solely on healthy adults. Additionally, most studies addressing this issue have limitations. Many do not specify whether the intervention was delivered by a single massage therapist throughout the study period. Thus, it is unclear whether only the type of intervention or the individual characteristics of the massage therapist, including subtle differences in pace, pressure, or atmosphere during the massage, influenced the EEG recordings. Secondly, several studies involved small sample sizes, which may affect the reliability of the results.

## CONCLUSIONS

Based on the literature review, it can be concluded that there is an association between massage-based interventions and changes in EEG recordings in healthy adults. However, the impact depends on the type of massage used and the study protocol adopted. The variability and inconsistency of the results may be attributed to the variety of massage techniques, their duration, the treatment area, and even the skill level of the person performing the intervention. These large discrepancies suggest the need for further research and analysis involving standardized massage protocols.

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