

Predicting Stress Response to Gelam Oil Therapy Using Electroencephalography and Heart Rate Variability

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ABSTRACT : Every year, more than one million people worldwide die from suicide, which is attributed to depression in 6.7% of cases. These incidents often stem from life-related stresses that can progress into more severe mental health challenges, potentially leading to mental disorders. High levels of depression, anxiety, and stress are prevalent mental health issues that quietly infiltrate various aspects of people's lives, eroding their well-being. Early recognition and detection are essential for gaining a better understanding and implementing timely interventions to prevent further deterioration into mental disorders and associated complications. However, early recognition and detection alone are insufficient to prevent mental disorders. Effective therapeutic sessions are necessary to address and manage these conditions. Nonetheless, evaluating a patient's progress in therapy can be a challenging and somewhat ambiguous task, influenced by the biases and theoretical training of the clinicians involved, often yielding uncertain or unmeasured results. Therefore, this research aims to investigate how patients respond to therapy using data from electroencephalography (EEG) and heart rate variability (HRV) signals. This study introduces a therapeutic approach using sensational oil derived from the Gelam tree. Therapy sessions and consultations will be conducted for workers in the Kuala Terengganu region. During these sessions, EEG and HRV signals will help detect the levels of alpha and beta waves, enabling the recognition of physical signs and symptoms of stress and anxiety by interpreting visual and auditory cues using a mind-body technique. The findings from questionnaires, EEG, and HRV data will be combined and analysed using statistical methods. This combination of quantitative, qualitative, experimental, and statistical methods is expected to yield the following results: 1) predicting responses to therapy, 2) determining the timing and extent of response to therapy, and 3) assessing the suitability of the therapy approach. Overall, aroma therapy has been found to demonstrate great efficacy in inducing deep relaxation. Ultimately,

this research aims to tailor therapy to each patient's specific needs, contributing to the promotion of mental health within the community and fostering a healthier, mentally resilient generation.

Keywords : *Mental Health, Therapeutic Sessions, Aroma Therapy, EEG, HRV*

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1.0 INTRODUCTION

Currently, one of the major concerns affecting society revolves around issues related to mental health. Mental health encompasses a spectrum of challenges associated with how individuals react, think, behave, interact, and experience emotions relative to others. Conversely, it may manifest as a reduced sense of enjoyment, happiness, and interest, accompanied by a low mood intertwined with behavioural, cognitive, and emotional symptoms, as outlined by the Mental Health Foundation in 2016. Furthermore, mental illnesses can be classified as brain disorders influenced by both genetic and environmental factors, as posited by The National Institute for Mental Health (NIMH) according to the World Health Organization (WHO) in 2013. Vos et al. (2016) reported that mental health problems pose a considerable global burden. The repercussions of mental issues extend beyond the affected individuals, as they also have an influence on the lives of their families and friends. Approximately 25% of Europeans have experienced mental health issues at least once in their lives. Furthermore, research suggests that Australian individuals are contending with mental health challenges, as reported in the National Preventive Health Strategy of 2021, indicating that approximately one in five Australians aged 16–85 years will experience a mental disorder at some stage in their lives.

Malaysia, similar to numerous other nations, faces mental health challenges, particularly within its workforce. According to the Malaysian Ministry of Health, one in three Malaysians aged ≥ 16 years grapples with mental health issues, and this figure continues to escalate annually. For instance, a study performed by Mohamed et al. (2022) focused on the mental well-being of Malaysian police officers, revealing alarming statistics. Among police officers, 41.1% reported moderate depression, 45% moderate anxiety, and 31.8% moderate stress. They concluded that a considerable majority of police officers experience moderate to severe levels of depression, anxiety, and stress. In a separate endeavour, Azmi et al. (2021) scrutinised Malaysia's existing laws and policies concerning mental health in the workplace, drawing comparisons with those in developed Commonwealth countries, such as the UK. Their study emphasised the need for a comprehensive legal framework and effective policies in Malaysia to support mental health and well-being at work. A comparison with the UK revealed that Malaysia could gain valuable insights from the UK's experiences in addressing mental health issues, indicating a gap in Malaysia's current approach. Abdullah et al. (2020) examined psychosocial factors, including decision latitude, social support, and working conditions, contributing to mental illness among employees of private development companies in Malaysia. Their findings suggested that providing employees with ample decision latitude (freedom to make decisions) can prevent mental illness, ultimately leading to increased overall productivity.

Early recognition and detection play a crucial role in gaining a better understanding of individuals' mental status and implementing prompt interventions to prevent the progression of mental disorders and associated complications. However, relying solely on early recognition and detection is insufficient for preventing mental disorders. Effective therapeutic interventions are indispensable for managing these conditions. Nonetheless, assessing a patient's progress in therapy poses challenges, often resulting in uncertain or unquantifiable outcomes, influenced by the biases and theoretical orientations of the clinicians involved. In light of these challenges, this study aims to explore how patients respond to therapy by leveraging data obtained through electroencephalography (EEG) and heart rate variability (HRV) monitoring. Furthermore, this study aims to introduce a therapeutic approach that incorporates the use of sensational oil derived from the Gelam tree. Therapy sessions and consultations will be administered to workers in the Kuala Terengganu region. Throughout these sessions, EEG and HRV signals will be utilised to detect alpha and beta wave levels, facilitating the identification of physical signs and symptoms of stress and anxiety. This will be achieved through the interpretation of visual and auditory cues using a mind-body technique. The findings obtained from the questionnaires, as well as the EEG and HRV data, will be amalgamated and subjected to statistical analysis.

2.0 LITERATURE REVIEW

Numerous studies have investigated mental health challenges among service workers, shedding light on the prevalence of conditions, such as anxiety, depression, and stress. For example, in Malaysia, a recent study revealed that 28.6% of medical officers experience anxiety, 10.7% report depression, and 7.9% face stress. These figures align with the psychological distress rates observed in Western nations, which range from 7 to 29% (Sen et al., 2010). Nordin et al. (2022) found that individuals working in hospitals face a significantly higher risk of depression and anxiety than those working in peripheral healthcare services, with factors, such as extended working hours and 24-h on-call duties, contributing to this disparity. Additionally, a local examination of burnout among Malaysian junior doctors revealed a prevalence of 26.5%, while the prevalence of burnout among academics at a public university stood at 10.7% (Zuraida and Zainal, 2015; Henny et al., 2014). Banfield et al. (2022) investigated the awareness and perceived helpfulness of mental health peer workers in Australia and revealed limited awareness across the general community and positive perceptions of peer workers. Mohamed et al. (2022) explored the mental health of Malaysian police officers and reported that large proportions of officers experienced moderate depression (41.1%), anxiety (45%), and stress (31.8%). Their findings underscored the prevalence of moderate-to-severe mental health challenges among police officers, and identified stressors that could inform best practices. Shkemi et al. (2023) scrutinised the association between effort, reward, overcommitment, and poorer mental health among waste workers in the US, emphasising the importance of assessing workers' perceptions of overcommitment for targeted improvements. An analysis by Feldman et al. (2023) suggested that pregnant essential workers face a heightened risk of worsened mental health. However, the efficacy of mindfulness techniques in addressing the mental health conditions of workers remains unclear. Durand-Moreau et al. (2023) conducted a systematic review and found no conclusive evidence supporting durable and substantial improvement in mental health outcomes through mindfulness-based practices. Miranti and Li (2020) explored the link between mismatches in working hours, job strain, and mental health in Australia, emphasising significant associations and recommending flexible working environments to improve the mental health of mature workers. In Japan, Kitano et al. (2020) investigated the relationship between 24-h movement behaviours and mental health among workers, advocating proper time management focused on encouraging sleep in order to minimise psychological distress and optimise work engagement. Considering the prevalence of mental health problems among workers, it is imperative to extend these studies to service workers.

3.0 METHOD

To meet the set objectives, the therapy will be implemented in four steps involving a combination of quantitative and qualitative approaches.

Survey Methodology

Step 1: Identification of the target group of respondents and distribution of questionnaires using the e-MAST web-based platform

Experimental Methodology

Step 2: Selection of respondents with the highest e-MAST results

Step 3: Therapy sessions with the HSNZ team for the selected respondents

Statistical Analysis

Step 4: Analysis of the EEG and HRV data

Step 1: Identification of the target group of respondents

Each respondent will receive a set of questionnaires and will be required to answer based on their mental health status using the e-MAST software. The questionnaire consists of two parts: Part A focuses on the demographics of the respondents, and Part B is a test related to mental health screening using Depression Anxiety and Stress Scale (DASS) 21. We have distributed letters requesting 152 companies around Kuala Terengganu to participate in a mental health project. This project will include staff from service sectors in Kuala Terengganu and Kuala Nerus. Once a respondent clicks the submit button, the e-MAST will automatically compute the results. The scores, along with a detailed analysis of mental health status and personalised

recommendations, will be presented on the subsequent page. All result details will be recorded, allowing respondents to track both their current and past records. Individuals with high scores in e-MAST may be directed to receive therapy sessions.

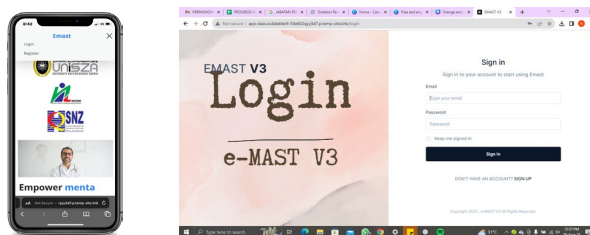


Figure 1: e-MAST

Step 2 : Selection of respondents with the highest e-MAST results

When a respondent clicks the submit button, e-MAST will automatically generate results. The scores, along with a thorough analysis of mental health status and personalised recommendations for each respondent, will be presented on the following page. All aspects of the results will be documented, enabling respondents to monitor both their present and historical records.

Potential respondents who obtain high scores in e-MAST will proceed to receive therapy sessions. When a respondent attends the therapy session, the therapist will explain the therapy process and procedure, provide the 'Research Information Sheet & Consent Form,' and inquire whether the individual has diabetes or epilepsy.

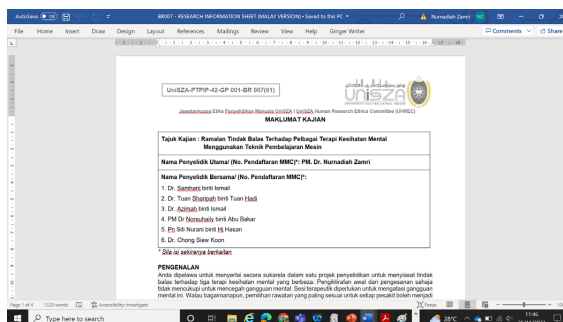


Figure 2: Consent Form

Step 3 : Therapy sessions with the HSNZ team for the selected respondents

Therapy Step 1: All participating respondents will be instructed to diligently and comprehensively fill out both the Beck Anxiety Inventory (BAI) and Beck Depression Inventory (BDI) as integral components of the assessment process. This will offer valuable insights into their levels of anxiety and depression, contributing to a thorough evaluation of their mental well-being.

The BDI serves as a widely employed tool for depression screening, evaluating the behavioural expressions and intensity of depressive symptoms. This tool comprises 21 self-reported items, and responses are provided using a multiple-choice format.

The BAI comprises 12 self-reported items, evaluated on a four-point scale, and it is employed to gauge the severity of physical and cognitive anxiety symptoms experienced within the preceding week.

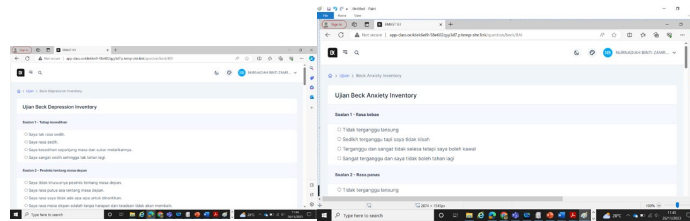


Figure 3: Beck Anxiety Inventory and Beck Depression Inventory

Therapy Step 2: The EEG and HRV monitoring equipment will be attached securely to the participating respondents, ensuring precise and stable placement to enable accurate and comprehensive data acquisition throughout the duration of the monitoring session.



Figure 4: Electroencephalography and heart rate variability monitoring

Subsequently, EEG and HRV monitoring will be incorporated into the therapy sessions. EEG offers insights into brain activity, enabling the detection of emotional states in each respondent. Frontal EEG activity patterns, particularly asymmetric patterns, differentiate between positive and negative valences, and overall frontal EEG activity distinguishes between high and low arousal levels. Determining arousal levels using EEG signals involves calculating the ratio of beta (12-28 Hz) to alpha (8-12 Hz) brainwaves in the prefrontal cortex. Valence values can be established by comparing the alpha power activation levels in the left and right cortical hemispheres (Ramirez et al., 2018). The primary objective of each therapy session will be to observe the emotional impact over time.

HRV refers to the physiological variation in heartbeats. Cardiac autonomic activity can be assessed using spectral analysis of HRV as a non-invasive and easily implementable tool. Two pivotal frequency domain parameters extracted from spectral analysis are commonly applied: low-frequency (LF) power (0.04-0.15 Hz), reflecting both sympathetic and vagal influences, and high-frequency (HF) power (0.15-0.40 Hz), indicating vagal tone modulation. Additionally, the LF/HF ratio offers insights into the balance between the sympathetic and vagal tones (Li et al., 2019). Our aim is to characterise the respondents' autonomic dysfunction, monitor the natural fluctuations in autonomic function, evaluate autonomic changes post-therapy, and predict prognosis after therapy sessions.

Therapy Step 3: The recording process for EEG and HRV will be initiated, the equipment will be set up meticulously to capture physiological data, and subsequently clear instructions will be provided to the respondent, directing them to rest for a period of 5 min to facilitate optimal data collection and analysis.

Therapy Step 4: Therapy sessions, each lasting 15 min, will be conducted. In the aromatherapy group, tailored interventions and methodologies will be applied to address the specific therapeutic objectives and modalities associated with each group's respective treatment approach.

Aromatherapy is a holistic healing practice that harnesses the aromatic essence of plant extracts, referred to as essential oils, to enhance physical, mental, and emotional well-being. It is a versatile and readily accessible wellness practice that individuals frequently integrate into their daily routines for relaxation, mood improvement, and comprehensive health benefits. In this therapeutic approach, Gelam oil extracted from the leaves of the Melaleuca cajuputi tree by steam distillation, will be introduced as a key element. This incorporation will capitalise on its distinctive fresh and medicinal aroma coupled with its potential antibacterial, antifungal, and decongestant properties to amplify the overall therapeutic experience and to target specific wellness concerns.

Gelam oil is often associated with the essential oil extracted from the Melaleuca cajuputi tree, commonly known as the "Cajuput" tree or "Gelam" tree. This tree is native to Southeast Asia, and its essential oil has traditionally been used in aromatherapy and traditional medicine. Aromatherapy with Gelam oil is an example of how essential oils derived from plants can be integrated into holistic wellness practices. It is essential to approach aromatherapy with an understanding of individual preferences and potential sensitivities, and, if necessary, consultation with healthcare professionals. Essential oils should always be used with care, and attention should be paid to safety guidelines.

Therapy Step 5: Following the completion of the designated activity or assessment, the respondent will be requested to take rest for a period of 5 min, allowing for a brief recovery and relaxation period, after which the EEG and HRV will be recorded to ensure a comprehensive and accurate representation of physiological data during the specified rest interval.

Therapy Step 6: All participating respondents will be kindly and explicitly requested to diligently and comprehensively revisit and complete the BAI and BDI once more as part of the assessment protocol to provide additional or updated insights into their anxiety and depression levels, thereby contributing to a more thorough and nuanced understanding of their mental health status.

Step 4: Analysis of the EEG and HRV data

The analysis of the EEG and HRV data will involve a comprehensive examination of the recorded information to derive meaningful insights into the brain's electrical activity and variability in the time intervals between consecutive heartbeats. In this study, we will extract key features from the EEG and HRV signals, such as frequency bands in EEG and time- and frequency-domain features in HRV. Subsequently, metrics that quantify the variability in both the EEG and HRV data will be calculated. In addition, EEG rhythms including alpha, beta, theta, and delta waves will be used to understand different states of consciousness. We will also explore patterns in HRV data to assess autonomic nervous system activity and stress levels and will examine correlations between EEG features and HRV metrics to identify potential relationships. Finally, we will relate the findings to the goals of the study or clinical context, considering the impact on mental state, cognitive processes, and overall well-being.

4.0 RESULTS

We distributed information regarding this project to 157 organisations around Kuala Terengganu and Kuala Nerus. Consequently, 30 organisations agreed to participate in the program. Across the 30 participating organisations, approximately 294 respondents completed the DASS questionnaire on the e-MAST website. The results for all the respondents are available to be retrieved from the E-MAST website.

NO	NAMA	SKOR KEMURUNGAN	SKOR TEKANAN	SKOR KEBIMBANGAN	TARIKH DIAMBIL	TINDAKAN
1		Sederhana	Teruk	Sangat Teruk	2023-07-10 06:13:34	⋮
2		Sederhana	Ringan	Sangat Teruk	2023-07-10 06:30:22	⋮
3		Teruk	Sederhana	Sangat Teruk	2023-07-12 03:01:24	⋮
4		Teruk	Sederhana	Sangat Teruk	2023-07-12 03:01:25	⋮

Figure 5: Depression Anxiety and Stress Scale Results

Some of the DASS results are listed in Table 1.

Table 1 Depression Anxiety and Stress Scale Results

Respondent	Depression	Stress	Depression
1	Mild	Normal	Moderate
2	Mild	Normal	Moderate
3	Severe	Moderate	Moderate
4	Moderate	Moderate	Severe
5	Severe	Moderate	Very Severe
6	Moderate	Low	Normal
7	Very Severe	Low	Low
8	Very Severe	Severe	Severe
9	Low	Normal	Moderate

Around 72 respondents have been identified as having either moderate or higher levels of depression, anxiety, or stress. All these 72 respondents have been invited to join the therapy sessions.

Once the respondents agree to participate in the therapy, we will explain all the details of the therapy process and procedure. We will provide them with the 'Research Information Sheet & Consent Form' retrieved from UniSZA's Ethics Committee, which outlines all the pros and cons that could arise before, during, and after the therapy sessions. Respondents with diabetes, epilepsy, or those currently on medication will be excluded.

Prior to commencing therapy sessions, all participants will be required to fill out the BDI. It is important to note that the BDI is already integrated into the E-MAST software.

NO	NAME	SKOR	TAHAP	TARIKH DIAMBIL
1	[REDACTED]	0	Normal	2023-09-23 23:15:30
2	[REDACTED]	0	Normal	2023-09-23 23:15:33
3	[REDACTED]	32	Teruk	2023-09-24 11:09:13
4	[REDACTED]	63	Sangat Teruk	2023-09-24 11:09:55
5	[REDACTED]	63	Sangat Teruk	2023-09-24 11:10:05

Figure 6: Beck Depression Inventory Results

Apart from the BDI, participants must also fulfil the requirement of completing the BAI.

NO	NAME	SKOR	TAHAP	TARIKH DIAMBIL
1	[REDACTED]	63	Sangat Teruk	2023-09-27 09:58:29
2	[REDACTED]	7	Normal	2023-10-03 10:23:43
3	[REDACTED]	4	Normal	2023-10-03 11:41:09
4	[REDACTED]	40	Teruk	2023-10-03 15:08:52

Figure 7: Beck Anxiety Inventory Results

Seventy-one respondents attended the therapy. These respondents were randomly assigned using the Randomiser software (<https://www.sealedenvelope.com/simple-randomiser/v1/lists>). Based on the randomisation of this software, 17 respondents attended the aroma therapy session.

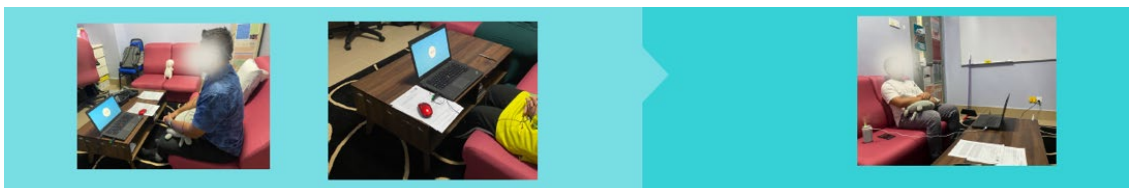


Figure 8: Aroma Therapy Sessions

5.0 DISCUSSION

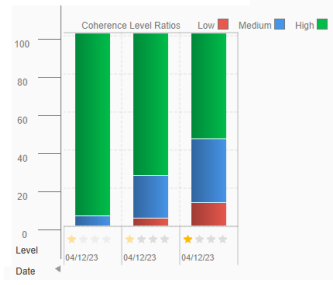
To understand the multifaceted effects of therapeutic interventions on psychological well-being, the comprehensive analysis presented in Table 2 comprises a vast array of data, delineating the outcomes derived from the assessments of DASS, BDI, BAI, and HRV results. This extensive summation provides nuanced insights into the effectiveness of applied therapies in addressing and mitigating psychological distress among participants. Through an extensive examination of the collected data, this study seeks to unravel the intricate tapestry of therapeutic influence on mental health, paving the way for a deeper comprehension of the interconnected dynamics between emotional well-being and therapeutic interventions.

Table 2 Summarisation of DASS, BDI, BAI and HRV Results

Respondent	DASS	BDI	HRV	BAI
1	Depression-Very Severe Stress-Severe Anxiety-Severe	Before-Moderate After-Normal		Before- Mild After-Normal
2	Depression-Severe Stress-Mild Anxiety-Mild	Before-Normal After-Normal		Before-Normal After-Normal
3	Depression-Moderate Stress-Moderate Anxiety - Mild	Before-Normal After-Normal		Before-Normal After-Normal
4	Depression-Severe	Before-Normal After-Normal		Before-Normal After-Normal

Stress-
Moderate

Anxiety
Moderate



5

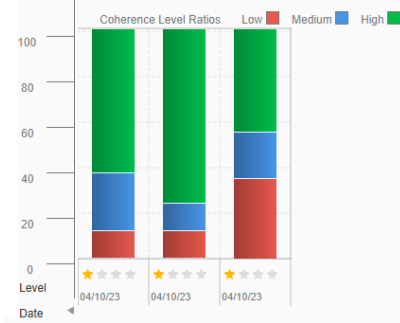
Depression-
Mild

Before- Mild

After-Normal

Stress-
Normal

Anxiety-
Moderate



Before-Mild

After-Normal

The outcomes summarised in Table 2 underscore the effectiveness of the therapies in ameliorating psychological distress in the participants. Exemplified by the case of Respondent 1, who initially presented with very severe depression, severe stress levels, and severe anxiety, the therapeutic interventions resulted in a notable positive impact. Prior to therapy, the BDI and BAI results indicated moderate and mild states, respectively. After the therapy, a significant improvement was observed, with the BDI and BAI results shifting to normal. In conjunction with psychological assessments, HRV analysis provided additional insights into the respondents' well-being. Pre-therapy HRV assessment indicated a 70% green graph, symbolising a certain level of equilibrium. As the therapy progressed, there was a discernible positive trend, with the green graph increasing to 80% at the end of the post-therapy period. These results collectively suggest that the implemented therapies not only contributed to the alleviation of depressive symptoms, but also positively influenced the autonomic nervous system, as reflected in the improved HRV metrics.

To explore the effects of aroma therapy, Figs. 9 and 10 present insights into the outcomes related to the frequency band powers. These figures provide a simple yet comprehensive view of how aromatic interventions influence specific frequency bands, thereby shedding light on the therapeutic effects of aromatherapy. Through this study, we aim to understand the straightforward yet impactful connections between aromatics and neural responses, contributing to a broader understanding of the therapeutic benefits of aromatic practices.

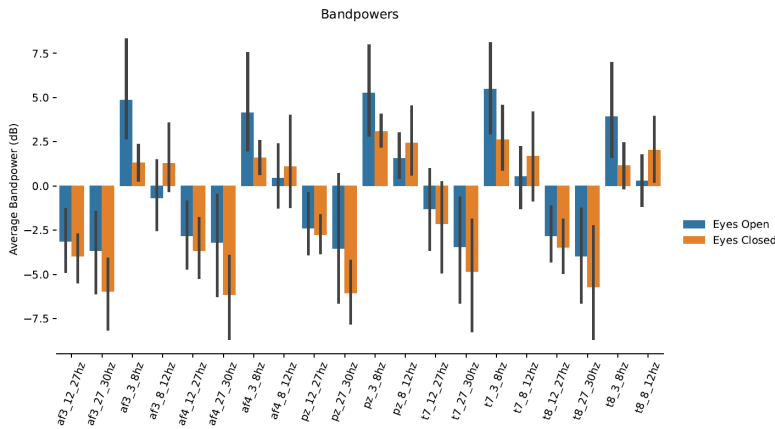


Figure 9: Pre-Aroma Therapy Results

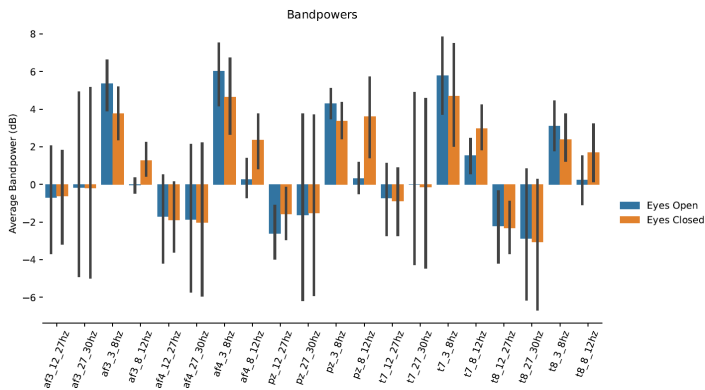


Figure 10: Aroma Therapy Results

The results show that aroma therapy based on Gelam oil exerts a potential influence on brainwave patterns, manifesting in an increase in high theta waves (3-8 Hz) and high alpha waves (8-12 Hz) during EEG recordings; this indicates a synergistic effect on inducing a deeply relaxed and meditative mental state, which may contribute to stress reduction, heightened relaxation, and an overall enhancement of mindfulness and tranquillity, thereby suggesting that aromatherapy could play a valuable role in modulating brainwave activity for therapeutic purposes and in promoting a holistic sense of well-being. The modulation and interaction of theta and alpha waves in the brain, representing distinct but interconnected neural oscillatory patterns, play a pivotal role in shaping cognitive processes, including attention, memory consolidation, and overall mental states. Variations in the amplitude, frequency, and synchronisation of these waves potentially serve as crucial indicators of neural network functioning and offer valuable insights into the intricate dynamics of brain activity during diverse cognitive tasks and states of consciousness.

6.0 CONCLUSION

This study aims to address the current mental health challenge by exploring how patients respond to therapy through a comprehensive analysis of EEG and HRV signals. This study will introduce a therapeutic approach utilising sensational oil derived from the Gelam tree by conducting therapy sessions and consultations tailored to workers in the Kuala Terengganu region. The integration of EEG and HRV signals facilitates the detection of alpha and beta waves, offering a nuanced understanding of physical signs and symptoms related to stress and anxiety. This mind-body technique interprets visual and auditory cues and provides a holistic approach to therapy. The analysis of the questionnaire responses and EEG and HRV data using statistical methods aims to achieve three primary objectives. The study seeks to predict responses to therapy, offering insights into the efficacy of the therapeutic approach. Based on the results, it aims to show that aroma therapy based on Gelam oil exerts a potential influence on brainwave patterns, manifesting in an increase in high theta waves (3-8 Hz) and high alpha waves (8-12 Hz) during EEG recordings, indicating a synergistic effect on inducing a deeply relaxed and meditative mental state, which may contribute to stress reduction, heightened relaxation, and an overall enhancement of mindfulness and tranquillity; this suggests that aromatherapy could play a valuable role in modulating brainwave activity for therapeutic purposes and in promoting a holistic sense of well-being. In essence, this research aspires to make significant strides in the field of mental health not only by improving early detection and intervention but also by advancing the precision and effectiveness of therapeutic sessions. Ultimately, the overarching goal is to contribute to the promotion of mental health within the community by cultivating a generation that is not only physically healthy but also mentally resilient.

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