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ALPHA BRAINWAVE ENTRAINMENT AS A NON-PHARMACOLOGICAL APPROACH TO REDUCE ANXIETY AND ENHANCE SLEEP IN AGING POPULATIONS: AN EXPERIMENTAL CONTROLLED TRIAL

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ABSTRACT

The relationship between anxiety and sleep quality has long been recognised as an important factor in mental health, particularly in the elderly population. This study aims to evaluate the effectiveness of alpha wave activation intervention in reducing anxiety symptoms and improving sleep quality in older adults. A total of 30 participants were divided into two groups: control (n=15) and treatment (n=15). Anxiety levels were measured using the Hamilton Anxiety Rating Scale (HARS), while sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) before and after the intervention. The treatment group received alpha wave activation neurofeedback training for 4 weeks, while the control group did not receive any specific intervention. Results showed that the treatment group experienced a significant decrease in average HARS scores by 6.6 points ($p < 0.001$) and a decrease in PSQI scores by 10.9 points ($p < 0.001$). In contrast, the control group did not show significant changes in either variable. These findings suggest that alpha wave activation may serve as an effective non-pharmacological strategy for managing anxiety and sleep disorders in the elderly population. This intervention warrants further development as an alternative or adjunct to conventional psychological therapies such as Cognitive Behavioral Therapy (CBT).

Keywords: alpha waves, anxiety, sleep quality

Background

The relationship between sleep quality and anxiety has been the focus of increasingly intensive research in the last decade. Numerous studies have shown that these two conditions mutually influence each other, creating a difficult-to-break cycle where sleep disturbances can trigger or exacerbate anxiety symptoms, and conversely, anxiety also disrupts sleep patterns (Kravitz et al., 2024; Zhong et al., 2025; Mitsalina et al., 2023). This pattern of interaction is often described as a 'vicious cycle' that contributes to increased risk of mental disorders and overall reduced quality of life (He et al., 2025). This association has been demonstrated through various statistical analyses showing a significant relationship between sleep quality and anxiety levels.

From a global perspective, the prevalence of sleep and anxiety issues continues to rise, particularly following the COVID-19 pandemic, which exacerbated psychological stress among the population. Cross-national studies such as those conducted by Shen et al. (2020) and Chen et al. (2024) indicate

that individuals with poor sleep quality have a significantly higher risk of experiencing anxiety symptoms compared to those with good sleep quality. In Indonesia, the situation is no less concerning, with mental health surveys indicating an increase in anxiety cases among adolescents and working adults, alongside rising academic, social, and work-related pressures that also impact sleep quality.

Recent research indicates that the relationship between sleep quality and anxiety is consistent across various population groups, including students (Du et al., 2020; Kumar et al., 2022), adolescents (Kim et al., 2022; Bendall et al., 2024), and healthcare workers (Shepherd et al., 2024). Factors such as sleep duration, sleep latency, and subjective perceptions of sleep quality all have a significant impact on anxiety levels. In fact, some studies indicate that insufficient sleep (<7 hours/day) is associated with a sevenfold increase in anxiety risk compared to normal sleep duration (Chen et al., 2024).

Recent research findings suggest that the relationship between sleep quality and anxiety may be mediated by other factors such as smartphone addiction, academic stress, and emotional regulation strategies (Qin et al., 2025; Chen et al., 2025; Bendall et al., 2024). These findings open up opportunities for holistic interventions that focus not only on symptomatic treatment but also on improving sleep quality as a strategy for anxiety prevention and management. Therefore, non-pharmacological approaches such as alpha wave activation could be an innovative alternative in breaking the vicious cycle between anxiety and sleep disorders, especially in the elderly population who are vulnerable to both conditions.

Methods

This study used a quasi-experimental design with a pretest-posttest control group approach to evaluate the effect of intervention on anxiety levels and sleep quality in elderly respondents. Participants were divided into two groups: a control group and a treatment group, each consisting of 15 participants. Data collection was conducted using purposive sampling based on inclusion criteria, including age over 25 years, moderate baseline anxiety levels, and the absence of severe neurological or psychiatric disorders.

Measurements of the primary variables were conducted before (pretest) and after (posttest) the intervention. To measure anxiety levels, the Hamilton Anxiety Rating Scale (HARS) was used, which has been validated in various clinical populations. Meanwhile, sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), an instrument that includes seven subjective and objective components of sleep quality over the past month.

The intervention was administered to the treatment group through the administration of pure crystal wave sounds. The control group did not receive a specific intervention but

continued their daily routines without any special modifications. The pretest and posttest data were then analysed using a paired sample t-test to examine changes within one group and an independent t-test to compare effects between groups. The significance level was set at $p < 0.05$.

Result

Table 1. Characteristics Respondent

Group	Man	Woman	Total
Control	7	8	15
Interventio n	7	8	15
Total	14	16	30

Table 1 shows the characteristics of the respondents in this study, which consisted of two groups: control and treatment. Each group consisted of 15 respondents, with a relatively balanced distribution of gender between man and woman . In the control group, there were 7 males and 8 females, while in the treatment group, the numbers were the same, namely 7 males and 8 females.

Table 2. Analisis Pair T test

Group	Variabel	Mean Pre	Mean Post	Difference	t-value	*p*-value	Conclusion
Control	HARS	20.6	20.5	+0.1	0.13	> 0.05	Not significant
	PSQI	14.3	14.3	0.0	0.00	> 0.05	Not significant
Intervention	HARS	20.7	14.1	-6.6	-9.24	< 0.001	Significant (reduction in anxiety)
	PSQI	17.2	6.2	-11.0	-11.43	< 0.001	Significant (improvement in sleep)

The results of statistical analysis using a paired sample t-test, as shown in Table 2, indicate that the alpha wave activation intervention had a significant impact on the treatment group. In the control group, no significant changes were found in either HARS or PSQI scores ($p > 0.05$), indicating that without active intervention, anxiety levels and sleep quality remained stable. Conversely, the treatment group experienced a significant decrease in anxiety levels (HARS) of 6.6 points ($p < 0.001$) and an improvement in sleep quality (PSQI) of 11.0 points ($p < 0.001$). These findings support the effectiveness of the alpha wave activation intervention in reducing anxiety symptoms and improving sleep quality among participants.

Discussion

The results of this study indicate that the treatment group experienced a significant decrease in HARS and PSQI scores, while the control group did not show any significant changes. The intervention appears to have successfully modulated alpha wave activity, which contributed to a decrease in anxiety levels and an improvement in sleep quality. These findings align with Zhang et al. (2022), who reported that alpha-wave-based neurofeedback is effective in reducing anxiety symptoms through neurophysiological relaxation mechanisms. Additionally, Wang et al. (2023) stated that alpha-wave activation enhances prefrontal cortex function, which is involved in emotion regulation and stress responses.

The strong correlation between reduced anxiety and improved sleep quality supports the hypothesis that the two conditions mutually influence each other (He et al., 2024). Anxiety can cause hyperactivation of the sympathetic nervous system, which disrupts sleep onset and maintenance, while sleep disturbances exacerbate emotional sensitivity and negative memories, thereby worsening anxiety symptoms (Du et al., 2023). Therefore, interventions that can influence neurobiological factors such as brain waves have great potential to break this cycle.

In terms of demographics, the average age of respondents was above 60 years, making them vulnerable to anxiety disorders and insomnia due to physiological changes associated with ageing (Kim & Lee, 2022). Although advanced age is often associated with changes in sleep architecture, the results of this study indicate that the treatment group still experienced significant improvements in sleep quality and reductions in anxiety. This suggests that alpha wave activation intervention could be a viable non-pharmacological strategy for the elderly population.

These findings also support a holistic approach to mental health management, where modulation of neurophysiological functions is used as a preventive and therapeutic strategy (Liu et al., 2021). A study by Chen et al. (2023) found that combining biofeedback techniques and mindfulness meditation increases alpha wave production and reduces cortisol levels, the primary stress hormone. These results provide additional empirical support that modifying brain activity can serve as an alternative or complement to conventional psychological therapies such as CBT.

Limitation

This study has several limitations that should be noted. First, the relatively small sample size (n=30) may limit the generalisation of the results to a wider population. Second, the quasi-experimental design without full randomisation may introduce selection bias. Third, the absence of long-term follow-up reduces understanding of the sustainability of intervention effects. Fourth, the use of subjective screening instruments such as HARS and PSQI, although valid, does not replace objective evaluation using clinical diagnostic tools such as PSG or fMRI. Finally, although alpha wave activation was observed as the primary mechanism, a comprehensive quantitative EEG analysis was not conducted to verify specific changes in brain wave frequencies. Further research with larger sample sizes, randomised designs, and the use of objective methods is urgently needed to validate these findings.

Conclusion

Based on the results of data analysis from 30 respondents divided into control and treatment groups, alpha wave activation intervention showed a significant effect in reducing anxiety levels and improving sleep quality. The

average HARS score in the treatment group decreased by 6.6 points (from 20.7 to 14.1), while the PSQI score also decreased significantly by 10.9 points (from 17.1 to 6.2), with a p-value < 0.001 for both variables. In contrast, the control group did not show any significant changes between pre- and post-intervention measurements. These findings support the hypothesis that alpha wave activity modulation can be an effective non-pharmacological strategy for managing anxiety and sleep disorders, especially in the elderly population.

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