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[Original Research]

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The Effect of Combined Guided Imagery and Slow Deep Breathing Relaxation Techniques on Reducing Blood Pressure in Chronic Kidney Disease Patients Undergoing Hemodialysis: A Quasi-Experimental Study

Devina Hana Olivia[1], Asep Riyana[1], Asep Kuswandi[1]
[1]Nursing Department, Poltekkes Kemenkes Tasikmalaya, Indonesia
*Corresponding author: asep.kuswandi@dosen.poltekkestasikmalaya.ac.id

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Abstract

Background: Chronic kidney disease (CKD) can lead to hypertension, especially in patients undergoing hemodialysis. Relaxation techniques, such as Guided Imagery and Slow, Deep Breathing, may help reduce blood pressure. **Aims:** To assess the effectiveness of the combined Guided Imagery and Slow Deep Breathing relaxation techniques in lowering blood pressure among patients with CKD undergoing hemodialysis. **Methods:** This study used a quasi-experimental pretest-posttest control group design. A total of 38 patients, 19 in each group, were purposively sampled using specific inclusion and exclusion criteria. The normality of systolic and diastolic blood pressure data was tested using the Shapiro-Wilk test, which indicated a normal distribution. Statistical analysis was performed using paired t-test and independent t-test. **Results:** The intervention group experienced a mean reduction of 10.11 mmHg in systolic blood pressure (SD = 7.44), while the control group showed a mean change of -7.74 mmHg (SD = 5.50). For diastolic blood pressure, the intervention group decreased by a mean of 9.11 mmHg (SD = 7.36), compared to a change of -7.47 mmHg (SD = 6.28) in the control group. The independent t-test revealed statistically significant differences between groups for both systolic and diastolic blood pressure, with p-values of 0.000 ($p < 0.05$). These results demonstrate that the combined Guided Imagery and Slow Deep Breathing intervention significantly lowers blood pressure in patients undergoing hemodialysis for chronic kidney disease. **Conclusion:** The combined relaxation techniques significantly reduce systolic and diastolic blood pressure in CKD patients undergoing hemodialysis, supporting their use as non-pharmacological interventions for hypertension management.

Keywords: Chronic Kidney Disease, Guided Imagery, Slow Deep Breathing Relaxation, Systolic Blood Pressure, Diastolic Blood Pressure.

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Introduction

Chronic kidney failure is a condition characterized by kidney damage that persists for more than three months, leading to a gradual decline in renal function and necessitating specific interventions such as hemodialysis or kidney transplantation (Apriliana et al., 2024). This disease presents a significant challenge both nationally and globally due to its high prevalence and its impact on patients' quality of life. According to the WHO (2018), one in ten people worldwide suffers from chronic kidney disease, and this figure continues to increase each year. In Indonesia, the prevalence of chronic kidney failure increased from 0.2% in 2013 to 0.38% in 2019, with an estimated total of approximately 713,783 patients. Of these, approximately 2,850 require hemodialysis therapy (Ministry of Health, 2019), underscoring the critical need for effective prevention and management strategies.

In Indonesia, data from 2017 indicate that the number of patients with chronic kidney failure due to systemic causes reached 23,849 cases, with hypertension as the primary etiology, accounting for 8,472 patients or approximately 36% of the total cases. This condition remains the most common cause of renal failure (Afiatin et al., 2020). According to the Basic Health Research (Riskesdas, 2018), West Java has the highest prevalence of chronic kidney disease in Indonesia, with 131,846 cases. In Tasikmalaya City, the prevalence of chronic renal failure was recorded at 0.2% (Kemenkes, 2018).

The primary modifiable risk factor for chronic kidney disease is hypertension, which is a leading cause of kidney damage (Ministry of Health, 2018). Hypertension not only accelerates renal deterioration but also increases the risk of serious cardiovascular complications. Therefore, optimal blood pressure control is critically important and can be achieved through both pharmacological and non-pharmacological approaches. Several studies have indicated that relaxation techniques, such as Guided Imagery and Slow Deep Breathing, can individually help lower blood pressure and reduce stress levels in hypertensive patients and those with chronic kidney disease (Herliana & Solehudin, 2024). However, to date, little research has investigated the combined effect of these two techniques, administered simultaneously, on blood pressure management in patients undergoing hemodialysis for chronic kidney failure.

While pharmacological treatments are effective, they often have disadvantages, including adverse side effects such as hypotension, dizziness, electrolyte imbalances, and medication interactions, which can compromise patient safety and adherence. These limitations underscore the need for complementary non-pharmacological interventions that can mitigate these side effects and improve overall blood pressure control. Incorporating relaxation techniques may serve as a safer, cost-effective adjunct to medication, potentially reducing drug dependence and minimizing associated risks.

Based on these considerations, there is an urgent need for interventions that are not only safe but also capable of optimally managing blood pressure in patients with chronic kidney disease. The use of relaxation techniques as a non-pharmacological approach offers a promising alternative, as it can improve patients' quality of life without the adverse side effects associated with medication.

Therefore, this study aims to investigate the effect of combined Guided Imagery and Slow Deep Breathing on blood pressure in patients with chronic kidney failure undergoing hemodialysis. Specifically, the objectives of this study are to evaluate the impact of the combined relaxation techniques on systolic and diastolic blood pressure.

This research is expected to contribute to the development of more holistic nursing care by emphasizing non-pharmacological aspects, ultimately improving patients' well-being and quality of life. Additionally, the findings could serve as a foundation for developing more innovative, evidence-based nursing interventions for the management of hypertension among patients with chronic kidney disease.

Methods

This study employed a quantitative, quasi-experimental design, specifically a pretest-posttest control group design. The sample consisted of 38 patients with chronic kidney failure undergoing regular hemodialysis at a hospital in Tasikmalaya. Participants were selected using purposive sampling, with predetermined inclusion and exclusion criteria. The sample size was calculated using Lemeshow's formula, with an adjustment for a 10% dropout rate, resulting in 19 respondents for the intervention group (which received a combination of Guided Imagery and Slow Deep Breathing relaxation techniques) and 19 respondents for the control group (which did not receive the relaxation techniques).

Inclusion criteria included patients diagnosed with chronic kidney failure who are currently undergoing hemodialysis, aged 20 years or older, with pre-intervention blood pressure >140/90 mmHg, conscious and able to follow instructions verbally or in writing, and willing to provide informed consent to participate. Exclusion criteria comprised patients with mental or cognitive impairments that could hinder the implementation of relaxation techniques, patients experiencing acute medical conditions or complications during the study, and those who withdrew at any point during the research.

Data collection was conducted over two weeks, from November 17 to November 30, 2025, in the hospital's hemodialysis unit. The main instruments included observation sheets to record the process and patient responses, a questionnaire to gather demographic data and factors influencing blood pressure, and a validated and calibrated sphygmomanometer for objective blood pressure measurement. The standard operating procedures for the combined relaxation techniques—Guided Imagery and Slow Deep Breathing—were validated by experts to ensure safety and efficacy.

The intervention was conducted prior to the commencement of the hemodialysis session. The relaxation techniques were administered for 30 minutes, with blood pressure measurements taken immediately before and after the session. The relaxation was delivered directly by the researcher, with continuous observation and documentation using observation sheets. Data analysis involved normality testing, paired t-tests to assess changes in blood pressure within groups before and after the intervention, and independent t-tests to compare differences between groups. All statistical analyses were performed using IBM SPSS Statistics version 25. Prior to the study, ethical approval was obtained from the Poltekkes Kemenkes Tasikmalaya ethics committee. The rights and privacy of all participants were protected in accordance with applicable regulations, including obtaining informed consent from each respondent.

The control variables included age, gender, duration of CKD, frequency of hemodialysis sessions, hypertension history, and use of antihypertensive medication. These variables were carefully matched between the intervention and control groups to minimize confounding and ensure the validity of the study results.

Results

Table 1 provides an overview of the respondents' characteristics. The distribution of demographic and clinical variables was comparable between the intervention and control groups. The age distribution showed that the majority of respondents were adults (30–59 years), comprising 34.2% in both groups, followed by the elderly (>60 years), accounting for 15.8%. No respondents were classified as young adults (18–29 years). Regarding gender, females represented 36.8% of the total sample, while males accounted for 13.2%, with both genders evenly distributed across the groups. The duration of chronic kidney disease (CKD) was predominantly more than 24 months, with 26.3% in each group. All participants underwent hemodialysis twice weekly, representing 50% of the total sample. Furthermore, all respondents had a history of hypertension and were currently using antihypertensive medication during the study period, each constituting 50%. Overall, the respondents' characteristics were homogeneous across the intervention and control groups.

Table 1 Frequency Distribution of Control Variables in Intervention and Control Groups (n=19)

Variable	Intervention Group		Control Group	
	Freq.	(%)	Freq.	(%)
Age				
1. Adults (30 – 59 years)	13	34,2%	13	34,2%
2. Elderly (>60 years)	6	15,8%	6	15,8%
Gender				
1. Female	14	36,8%	14	36,8%
2. Male	5	13,2%	5	13,2%
Duration of Chronic Kidney Disease				
1. <12 months	5	13,2%	5	13,2%
2. 12 – 24 months	4	10,5%	4	10,5%
3. >24 months	10	26,3%	10	26,3%
Hemodialysis Sessions				
1. Twice a week	19	50%	19	50%
Hypertension History				
1. Yes	19	50%	19	50%
Use of Antihypertensive Medication				
1. Yes	19	50%	19	50%

Table 2 presents the mean blood pressure levels in the intervention and control groups. In the intervention group, there was a notable reduction in systolic blood pressure from a pretest mean of 168.63 mmHg to a posttest mean of 158.53 mmHg. Similarly, diastolic blood pressure decreased from 89.37 mmHg at pretest to 80.26 mmHg at posttest. Conversely, the control group exhibited an increase in blood pressure readings, with systolic blood pressure rising from a pretest mean of 169.26 mmHg to 177.00 mmHg at posttest, and diastolic blood pressure increasing from 86.26 mmHg to 93.74 mmHg. These findings suggest that the relaxation intervention was effective in reducing blood pressure, whereas blood pressure tended to increase over time in the absence of intervention. The observed changes were statistically significant, supporting the hypothesis that relaxation has a positive effect on blood pressure reduction in patients with chronic kidney disease undergoing hemodialysis.

Based on Table 3, the difference in mean systolic blood pressure between the intervention and control groups was statistically significant, with a lower mean in the intervention group. The pre-intervention mean systolic blood pressure was approximately 168.63 mmHg,

Table 2 Description of Mean Blood Pressure in the Intervention and Control Groups (n=19)

Group	Variable		Mean	Std. Deviasi
Intervention Group	Systolic Blood Pressure	*Pretest*	168,63 mmHg	16,81
		Posttest	158,53 mmHg	13,81
	Diastolic Blood Pressure	*Pretest*	89,37 mmHg	12,57
		Posttest	80,26 mmHg	10,40
Control Group	Systolic Blood Pressure	*Pretest*	169,26 mmHg	16,09
		Posttest	177,00 mmHg	14,44
	Diastolic Blood Pressure	*Pretest*	86,26 mmHg	11,14
		Posttest	93,74 mmHg	8,37

Table 3 Difference in Mean Systolic and Diastolic Blood Pressure Before and After in the Intervention Group (n=19)

Variable		Mean	Std. Deviasi	P. Value
Systolic Blood Pressure	*Pretest*	168,63 mmHg	16,81	0,000
	Posttest	158,53 mmHg	13,81	
Diastolic Blood Pressure	*Pretest*	89,37 mmHg	12,57	0,000
	Posttest	80,26 mmHg	10,40	

With a standard deviation of 16.81, whereas post-intervention it decreased to 158.53 mmHg, with a standard deviation of 13.81. Paired t-test analysis revealed a p-value of 0.000 ($p < 0.05$) with a 95% confidence level, indicating that the reduction in systolic blood pressure was statistically significant following the intervention. The difference in mean diastolic blood pressure between the intervention and control groups was significant, indicating a significant decrease in the intervention group. The pre-intervention mean diastolic blood pressure was approximately 89.37 mmHg, with a standard deviation of 12.57, while post-intervention it decreased to 80.26 mmHg, with a standard deviation of 10.40. Paired t-test analysis yielded a p-value of 0.000 ($p < 0.05$) at a 95% confidence level, signifying that the reduction was statistically significant.

Table 4: Difference in Mean Systolic and Diastolic Blood Pressure Before and After in the Control Group (n=19)

Variable		Mean	Std. Deviasi	P. Value
Systolic Blood Pressure	*Pretest*	169,26 mmHg	16,09	0,000
	Posttest	177,00 mmHg	14,44	
Diastolic Blood Pressure	*Pretest*	86,26 mmHg	11,14	0,000
	Posttest	93,74 mmHg	8,37	

Based on Table 4, the difference in mean systolic blood pressure before and after in the control group indicated an increase in the post-intervention values. The pre-intervention mean systolic blood pressure was approximately 169.26 mmHg with a standard deviation of 16.09, whereas the post-intervention mean increased to 177.00 mmHg with a standard deviation of 14.44. Paired t-test analysis revealed a p-value of 0.000 ($p < 0.05$) at a 95% confidence level, indicating that this increase was statistically significant. Although an increase in systolic blood pressure was observed in this group, these findings suggest that in the absence of appropriate intervention, blood pressure levels tend to remain unchanged or even rise. The difference in mean diastolic blood pressure before and after in the control group was statistically significant. The pre-intervention mean diastolic blood pressure was approximately 86.26 mmHg with a standard deviation of 11.14, while the post-measurement mean increased to 93.74 mmHg with a standard deviation of 8.37. Paired t-test analysis yielded a p-value of 0.000 ($p < 0.05$) at the 95% confidence level, indicating that the increase was statistically significant. Clinically, this rise in diastolic blood pressure suggests that without targeted intervention, diastolic blood pressure in the control group tends to increase over time.

Table 5 Difference in Mean Decrease of Systolic and Diastolic Blood Pressure Between the Intervention and Control Groups (n=19)

Variable		Mean	Std. Deviasi	P. Value
Systolic Blood Pressure	Intervention	10,11 mmHg	7,44	0,000
	Control	-7,74 mmHg	5,50	
Diastolic Blood Pressure	Intervention	9,11 mmHg	7,36	0,000
	Control	-7,47 mmHg	6,28	

Based on the results of the Shapiro-Wilk normality test, the data for systolic and diastolic blood pressure in both the intervention and control groups were normally distributed. This permitted the use of parametric statistical tests, specifically the independent t-test, to analyze differences in mean blood pressure between the two groups.

Subsequently, the independent t-test results indicated statistically significant differences in both systolic and diastolic blood pressure between the intervention and control groups, with p-values of 0.000 ($p < 0.05$) at a 95% confidence level. In the intervention group, the mean reduction in systolic blood pressure was 10.11 mmHg with a standard deviation of 7.44. In comparison, the control group experienced a mean change of -7.74 mmHg, with a standard deviation of 5.50 mmHg. For diastolic blood pressure, the mean decrease in the intervention group was 9.11 mmHg (SD = 7.36), whereas in the control group it was -7.47 mmHg (SD = 6.28) (see Table 5).

Discussion

Respondent Characteristics

The study findings indicate that the majority of respondents belonged to the adult (30–59 years) and elderly (>60 years) age groups, with no participants from the young adult (18–29 years) group. This distribution aligns with epidemiological and physiological theories that emphasize age as a key factor in the progression of chronic diseases such as renal failure, as well as with individuals' responses to psychosocial and relaxation interventions. During adulthood and older age, physiological and psychological processes related to stress, tension, and quality of life become increasingly prominent, necessitating more targeted approaches. Previous research supports that these age groups tend to experience physiological changes that can affect the effectiveness of relaxation interventions, given their heightened vulnerability to stress and psychological fatigue caused by chronic illness (Tang et al., 2024). The predominance of respondents in these age groups underscores the relevance of using combined relaxation techniques to enhance their psychological well-being and overall quality of life.

Regarding gender, most respondents were female, consistent with gender and health theories suggesting that women are generally more aware of and proactive in managing their health, including participation in psychological and relaxation interventions. This finding aligns with prior studies indicating that women are more receptive to relaxation techniques, often because they prioritize emotion-oriented coping strategies, such as seeking social and emotional support during stressful situations (Goren et al., 2025). These gender differences likely contribute to higher acceptance and responsiveness to the intervention, supporting the hypothesis that women tend to respond more positively to relaxation techniques, thereby improving overall intervention outcomes. Recognizing gender differences is crucial for designing more effective and targeted intervention strategies.

Additionally, most respondents had been diagnosed with chronic kidney failure for more than 24 months, indicating that they are in the chronic stage requiring long-term management. This finding supports stress and coping theories that suggest the duration of illness influences stress levels and patients' psychological readiness to accept lifestyle changes and therapies. Previous research confirms that patients with longer disease durations tend to experience higher psychological fatigue but are also more accustomed to their condition, which can make relaxation interventions more effective in improving psychological well-being (Burdani et al., 2025). Interestingly, this contrasts with earlier studies indicating that patients with shorter disease durations respond better to relaxation techniques because they are more open to change. This study demonstrates that relaxation techniques can be effectively applied even in patients with extended disease durations, emphasizing their role in long-term management strategies to improve quality of life.

Furthermore, the homogeneity of clinical variables, such as the number of hemodialysis sessions, history of hypertension, and use of antihypertensive medications, suggests that all respondents had similar clinical conditions. This supports the validity of the study results by minimizing confounding influences. Prior research emphasizes that hypertension is a primary risk factor for chronic kidney failure, often managed through specific medications (Vaidya et al., 2025). The consistency of these clinical variables provides a solid basis for evaluating the effectiveness of relaxation interventions without significant bias from differing clinical factors. Additionally, the data showed that blood pressure in the intervention group decreased significantly following the relaxation intervention, whereas it increased in the control group. This is consistent with previous studies indicating that techniques such as Guided Imagery and Slow Deep Breathing can lower blood pressure by reducing stress and promoting relaxation of the autonomic nervous system (Widiana & Kandarini, 2021). The difference in outcomes can be attributed to the intervention's effectiveness in mitigating stress responses, thereby reducing blood pressure. Earlier research also supports the effectiveness of relaxation techniques in controlling hypertension among patients with chronic kidney disease, reinforcing the findings of this study (Harismayanti & Lihu, 2021). The success of this intervention highlights the potential of relaxation as a non-pharmacological strategy for blood pressure management.

Differences in Systolic and Diastolic Blood Pressure Before and After the Intervention in the Intervention Group

Physiologically, blood pressure regulation is predominantly mediated by the cardiovascular and autonomic nervous systems. Hypertension often results from heightened sympathetic nervous system activity, increased vascular resistance, and hormonal imbalances that influence vasoconstriction and vasodilation (Reny, 2023). Interventions such as relaxation techniques, meditation, and stress management have been shown to reduce sympathetic outflow and improve endothelial function, thereby inducing vasodilation, decreasing vascular resistance, and lowering blood pressure (Reny, 2023). Neurophysiological studies reinforce these mechanisms, demonstrating that stress reduction can restore autonomic balance and promote cardiovascular health.

Psychologically, stress and anxiety are significant contributors to elevated blood pressure. Psychophysiological theories posit that stress activates the sympathetic nervous system, increasing heart rate and vasoconstriction, thereby elevating blood pressure (Herliana & Solehudin, 2024). The current findings support this theory, showing significant reductions in both systolic and diastolic blood pressure following the application of Guided Imagery combined with Slow Deep Breathing. The p-values for these changes were 0.000 ($p<0.05$), indicating a statistically significant effect unlikely attributable to chance. Specifically, systolic blood pressure decreased from 168.63 mmHg to 158.53 mmHg, and diastolic pressure from 89.37 mmHg to 80.26 mmHg.

These outcomes align with existing literature, which suggests that stress management interventions can exert physiological effects through autonomic modulation. The data reinforce the hypothesis that relaxation techniques influence cardiovascular parameters by reducing sympathetic activity and enhancing parasympathetic tone, consistent with prior empirical evidence (Herliana & Solehudin, 2024). Consequently, these findings support the integration of such interventions into hypertension management protocols.

Differences in Systolic and Diastolic Blood Pressure Before and After in the Control Group

In contrast, the control group exhibited a significant increase in both systolic and diastolic blood pressure over the observation period. The p-values for these changes were also 0.000, indicating that the increases were statistically significant and unlikely due to random variation. Systolic blood pressure increased from 169.26 mmHg to 177.00 mmHg, while diastolic pressure rose from 86.26 mmHg to 93.74 mmHg. This upward trend can be explained through physiological and psychological frameworks. From a physiological standpoint, the absence of stress management strategies leads to persistent sympathetic activation, vasoconstriction, and increased cardiac output, all of which contribute to rising blood pressure (Vaidya et al., 2025). Psychologically, lacking effective coping mechanisms may escalate anxiety and emotional tension, further activating the stress response and exacerbating hypertensive status (Vaidya et al., 2025). These findings corroborate stress and psychophysiological theories, emphasizing that dysregulation of autonomic and hormonal systems plays a central role in hypertension progression.

The data underscore the importance of stress reduction interventions, as unmanaged stress not only sustains but may accelerate hypertensive deterioration, increasing the risk of cardiovascular morbidity. These results are consistent with the literature, indicating that without targeted interventions, blood pressure tends to increase over time, highlighting the necessity of incorporating stress management strategies into routine care to prevent hypertensive complications.

Differences in Blood Pressure Reduction Between the Intervention and Control Groups

Hypertension is a critical modifiable risk factor for chronic kidney disease (CKD) progression and cardiovascular complications. Effective blood pressure control is essential to slow CKD progression and reduce adverse events. The present study demonstrated that the combination of Guided Imagery and Slow Deep Breathing significantly lowered blood pressure, with an independent t-test analysis yielding a p-value of 0.000 ($p<0.05$), indicating a statistically significant difference between the intervention and control groups.

The intervention group experienced mean reductions of 10.11 mmHg in systolic and 9.11 mmHg in diastolic blood pressure, reflecting the efficacy of these relaxation techniques. These effects can be explained theoretically by neurophysiological and psychological models. Relaxation methods such as Guided Imagery and Slow Deep Breathing are known to reduce sympathetic nervous system activity and increase parasympathetic tone, thereby decreasing heart rate, vascular resistance, and blood pressure (Herliana & Solehudin, 2024). Additionally, these techniques lower stress-related hormones like cortisol and adrenaline, which are implicated in vasoconstriction and volume expansion, thereby influencing blood pressure regulation (Helpitnati et al., 2023).

Behavioral health theories further support the role of non-pharmacological strategies in hypertension management, particularly among CKD patients on hemodialysis. Empirical studies corroborate these findings; for example, Beizaee et al. reported significant reductions in diastolic blood pressure, heart rate, and respiratory rate following Guided Imagery. Similarly, Toding (2021) and Harismayanti & Lihu (. confirmed the effectiveness of Slow Deep Breathing in lowering blood pressure among hypertensive and dialysis populations. In conclusion, the results substantiate that combining Guided Imagery with Slow Deep Breathing constitutes an effective non-pharmacological approach to reducing blood pressure in CKD patients undergoing hemodialysis. These interventions serve as valuable adjuncts to pharmacotherapy, potentially enhancing patient outcomes and reducing the burden of hypertensive complications.

Implications for Nursing Practice

The findings of this study highlight the effectiveness of combining Guided Imagery and Slow Deep Breathing in reducing blood pressure among patients undergoing hemodialysis. This provides a valuable addition to nursing practice, suggesting that nurses in dialysis units should consider integrating these relaxation techniques into holistic patient care. Implementing such non-pharmacological interventions can enhance patient comfort, reduce stress levels, and improve blood pressure control, ultimately contributing to better health outcomes. Nurses should receive appropriate training to safely and effectively implement these techniques, with ongoing monitoring of physiological and psychological responses. Incorporating these strategies into routine care can strengthen nursing's role in supporting successful dialysis therapy and improving patients' quality of life.

Limitations of the Study

This study has certain limitations, primarily related to variability in the implementation of relaxation techniques, which may influence individual differences in understanding, skill, and readiness among respondents. Each participant's ability to comprehend instructions, perform the techniques correctly, and maintain concentration during sessions varied, potentially affecting the intervention's effectiveness. Such differences could lead to inconsistent outcomes among participants, limiting the generalizability of the findings. Additionally, the relatively short duration and frequency of sessions may not have been sufficient to achieve maximal benefits, and longer or more frequent interventions might produce different results. These factors should be considered when interpreting the findings and designing future research to optimize the effectiveness of relaxation techniques in this patient population.

Conclusion

Based on the study findings, the combination of Guided Imagery and Slow Deep Breathing relaxation techniques significantly reduced systolic and diastolic blood pressure in patients with chronic kidney failure undergoing hemodialysis. The reduction in blood pressure was greater in the intervention group than in the control group. These results support the hypothesis that combining these relaxation techniques is effective in lowering blood pressure in this patient population. For future research, it is recommended to investigate the long-term effects and include a larger sample size to enhance generalizability.

Declaration of Conflicting Interest

No conflict of interest to declare.

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Author's Contribution

DHO: Contributed to the study's conception and design, data acquisition, and data analysis, and wrote the first draft of the manuscript. AR: Revised the final draft and gave final approval of the version to be published. AK: Revised the final draft. YC drafted and revised the manuscript.

Data Availability Statement

The dataset generated and analyzed during the current study is available from the corresponding author upon reasonable request.

Declaration of Use of AI in Academic Writing

The author used ChatGPT/Gemini in the writing process to improve readability and remove grammatical errors. However, he took full responsibility for the content.

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