DOI: 10.7860/JCDR/2024/65351.19113

Original Article

Physiotherapy Section

Effects of Galvanic Skin Resistance Biofeedback on Perceived Stress in Individuals with High Blood Pressure: A Quasi-experimental Study

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ABSTRACT

Introduction: According to the World Health Organisation (WHO), hypertension is one of the leading causes of premature morbidity and mortality, both in industrialised and developing countries. Patients with arterial hypertension are advised to make lifestyle adjustments, such as increasing physical activity and reducing stress. Nowadays, a variety of relaxation techniques are used to reduce stress and tension. The practise of Biofeedback (BF) is regarded as a successful treatment for this purpose.

Aim: To investigate the effect of Galvanic Skin Resistance Biofeedback (GSRBF) on perceived stress.

Materials and Methods: In present quasi-experimental study, 53 individuals with high blood pressure, including prehypertensive and hypertensive individuals {Blood Pressure (BP) >120/80 mmHg}, were included. Participants were recruited from various Medical and Physiotherapy Outpatient Departments (OPD) of private and Government hospitals and clinics in Veraval, Gujarat, India, from March 2022 to September 2022. Basic demographic data was collected, Blood Pressure (BP) was measured, and the Perceived Stress Scale (PSS) was administered. Participants were then connected to the GSRBF instrument and instructed to relax using a relaxation response technique. After 12 sessions, BP was measured again, and the PSS was administered. As the data were not normally distributed, a t-test was performed at a significance level of 95% ($p<0.05$).

Results: The analysis revealed a significant decrease in PSS scores following GSRBF sessions, with a p-value of <0.05. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) also showed a significant reduction, with a p-value of <0.05.

Conclusion: The GSRBF demonstrated a significant reduction in perceived stress among individuals with high blood pressure, and it also showed a significant reduction in SBP and DBP. The present study provides valuable insights into the potential of GSRBF as an adjunct therapy for managing hypertension and promoting overall well-being.

Keywords: Diastolic blood pressure, Hypertension, Systolic blood pressure

INTRODUCTION

High Blood Pressure (BP), or hypertension, is a prevalent medical condition affecting millions of individuals worldwide. Chronic stress is recognised as a major contributing factor to the development and progression of hypertension. Biofeedback (BF) techniques, such as Galvanic Skin Resistance Biofeedback (GSRBF), have gained attention as non pharmacological interventions to manage stress-related disorders. GSRBF provides real-time feedback on the body's physiological responses, particularly the galvanic skin response, which can be indicative of stress levels [1].

Globally, 10% to 15% of people have hypertension. Very mild hypertension affects 70% of patients with hypertension (DBP between 90 and 105 mmHg). In India, hypertension is one of the country's biggest health problems and causes approximately 1.1 million fatalities per year (uncertainty index: 0.9-1.3 million) [1]. It accounts for 10.8% of all fatalities and 4.6% of all years lived with a Disability-adjusted Life Years (DALYs) [2].

According to the World Health Organisation, hypertension is one of the leading causes of premature morbidity and mortality, both in industrialised and developing countries [3]. Patients with arterial hypertension are advised to make lifestyle adjustments, such as increasing their physical activity and reducing their stress [4].

Psychological stress highly affects severe depression, cancer, arthritis, and cardiovascular disease [5]. Stress and its psychological impacts are common sources of concern in modern society and are an inevitable part of existence [6]. People are more susceptible to illness when they are under stress because they are unable to meet external obligations, leading to psychological and physical changes [7]. The rise in occupational stress has contributed to an increase in psychosomatic conditions, such as arterial hypertension [8,9].

Nowadays, a variety of relaxation techniques are used to reduce stress and tension. The practise of BF is regarded as a successful treatment for conditions ranging from hypertension to epilepsy. Through BF, patients gain control over their bodily responses [10]. BF has been used to treat mild to moderate essential hypertension.

The effectiveness of BF is associated with the development of neuronal connections and the potential for future direct access to them. BF provides stress reduction techniques to help clients manage their stress. This strategy appears to work best when stress plays a significant role [11].

Stress and lifestyle diseases like hypertension have become a part of daily life due to hurried way of life. Most hypertension patients are prescribed medications that they must take for the rest of their lives. The cost of the drugs and their side effects are the two most significant disadvantages of pharmacological therapy. Therefore, any actions that can help reduce blood pressure without the use of medication are welcome. BF and other relaxation techniques may be helpful in this situation. It was hypothesised that GSRBF is effective in reducing perceived stress in individuals with high blood pressure. The main objective of BF is to control blood pressure and reduce the need for medication by minimising stress [12]. The present study is part of a larger project aiming to explore the potential benefits of GSRBF on perceived stress in individuals with high blood pressure.

MATERIALS AND METHODS

In present Quasi-experimental study conducted from March 2022 to September 2022, individuals of both genders aged 18 years or older, who were patients at various Medical and Physiotherapy Outpatient Departments (OPDs) of private and Government hospitals and clinics in Veraval, Gujarat, India, were included. Ethical clearance was obtained from the Institutional Ethics Committee (IEC no. NCP/213B/2020) prior to the start of the study, and informed consent was obtained from all participants.

Inclusion criteria: Patients with BP ≥120/80 mmHg (including prehypertensives and hypertensives), or a known history of hypertension, or newly diagnosed hypertension were invited to participate in the study.

Exclusion criteria: Individuals with certain conditions, such as infections, severe psychiatric co-morbidities, recent heart-related issues, peripheral arterial occlusive disease, patient refusal, or any other hindering factors, were excluded from the study.

Participants who met these inclusion and exclusion criteria were selected using a convenient sampling technique. Participation was voluntary.

Sample size calculation: The sample size was calculated with 90% power using the formula [13]: Sample size $(n)=2SD^2(Z_{\alpha/2}+Z\beta)^2/d^2$, where SD (Standard deviation) is obtained from previous studies or pilot study, $Z_{\alpha/2}=Z0.05/2=Z0.025=1.96$ (from Z table) at a type 1 error of 5%, $Z_\beta=Z0.20=1.282$ (from Z table) at 90% power, and d=effect size=difference between mean values. This calculation was based on the SD (5.57) of SBP from a similar previous study [10].

Study Procedure

A total of 53 individuals who received GSRBF training were included in the study. The intervention protocol consisted of 12 sessions (6 days/week for 2 weeks). Participants were provided with details about the study, and oral consent was obtained. Basic demographic data such as age, gender, and Body Mass Index (BMI) [14] were collected. Firstly, BP (SBP and DBP) was measured with participants in a sitting position, and the average of 2-3 measurements was recorded. The Perceived Stress Scale (PSS) was then filled out to assess perceived stress levels. Participants were instructed to relax in a sitting position with their back supported and hands at their sides, palms facing upward.

Perceived stress scale [15]: The PSS is a widely used psychological tool for evaluating stress perception. It measures how individuals perceive the level of stress in their life circumstances. The questions are designed to assess the sense of unpredictability, chaos, and burden that participants believe they experience in their lives. The scale includes direct questions about the current level of experienced stress. Participants were asked to respond to 10 questions on a scale of 0-4, where 0=Never; 1=Almost Never; 2=Sometimes; 3=Fairly often; 4=Very often.

Individual scores on the PSS range from 0 to 40. Higher scores indicate higher perceived stress levels. Scores from 0 to 13 are considered low stress, 14 to 26 as moderate stress, and 27 to 40 as high perceived stress.

Galvanic Skin Resistance (GSR): GSR is a type of electrodermal response. It refers to changes in the electrical properties of a person's skin that occur as a result of the interaction between environmental events and the individual's psychological state. GSR is a method of measuring the autonomic nerve response as a parameter of sweat gland function [16].

The participant was seated comfortably on a chair in front of a GSR machine. Before electrode placement, the area to be treated was cleaned thoroughly with an alcohol solution to reduce skin resistance. Electrodes were then attached to the index and ring fingers using Velcro tape. The balancer on the machine was adjusted to 0, and the participant was instructed to relax voluntarily while using visual feedback from the machine. The GSRBF session lasted for 15-20 minutes.

Participants were taught the "Relaxation Response" technique [17], which aimed to induce voluntary relaxation during the session. They were instructed to breathe slowly and rhythmically until it became natural. Once settled, they were guided to gradually and completely relax each muscle in their body, starting from their toes and moving upwards to their face. Inhalation was done through the nose, and participants were encouraged to be mindful of their breathing. To maintain focus, they were instructed to vocalise the word "one" loudly during exhalation. This relaxation exercise was continued for 15 to 20 minutes.

Throughout the study, the participant was connected to a BF device that continuously displayed the electrical resistance of their skin. This was depicted through a visual signal on the device, with red lights indicating stress and blue lights indicating relaxation. The number of red lights represented the level of stress, while the number of blue lights reflected the level of relaxation. Changes in skin resistance provided an accurate measure of the participant's level of relaxation.

As the participant relaxed, their skin resistance increased, resulting in changes in the visual signal on the BF device. This immediate feedback served as positive reinforcement, encouraging the participant to continue progressing in the right direction and maintaining a state of relaxation throughout the session. Thus, the participant was instructed to continue with the relaxation techniques or relax further when they observed changes in the lights, depending on the appearance of red or blue lights.

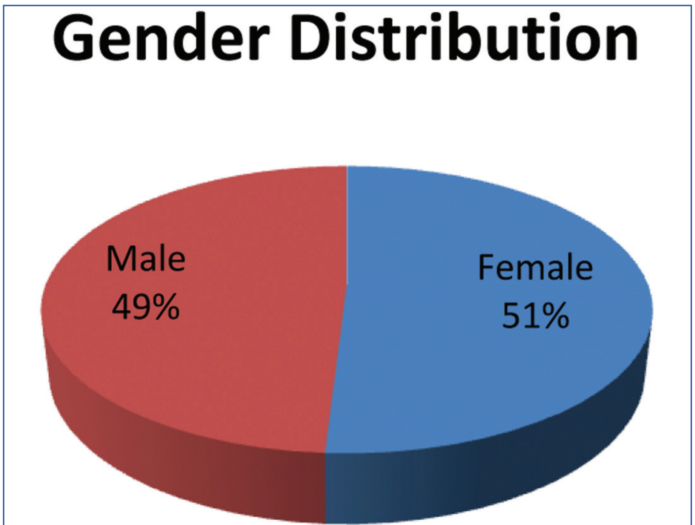
Outcome measures such as PSS, SBP, and DBP were assessed at the beginning of the first session and after the completion of the 12^{th} session (i.e., on day 1 and day 12 of the intervention).

STATISTICAL ANALYSIS

Statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 25.0. The Shapiro-wilk test was used to assess the normality of the data, and it was found that the data were not normally distributed. Therefore, a t-test was used to examine the effect of GSRBF on perceived stress ($p<0.05$).

RESULTS

A total of 53 participants were included in the study, consisting of 27 females and 26 males [Table/Fig-1]. The participants' characteristics, including age, gender, BMI, and baseline SBP, DBP, and PSS, were recorded [Table/Fig-2].



[Table/Fig-1]: Gender-wise distribution.

Parameters	Mean±SD	Range	
		Minimum	Maximum
Age (years)	49.87±12.26	28.00	72.00
BMI (kg/m²)	26.27±3.02	19.50	33.80
SBP (mmHg)	134.26±9.98	110	158
DBP (mmHg)	85.13±4.48	76	100
PSS (mmHg)	23.87±5.20	13	38

[Table/Fig-2]: Baseline general and clinical characteristics.

The results of present study revealed a highly significant decrease in PSS, with a total mean difference of 5.49 compared to the baseline mean. According to the t-test, there is a significant effect of GSRBF on perceived stress in individuals with high BP, with p<0.05 [Table/Fig-3].

PSS	Mean±SD	Total mean difference	Std. Error mean	95 % CI of the difference		t-value	p-value
				Lower	Upper		
Pre	23.87±5.204	5.49	0.318	4.852	6.129	17.249	<0.001
Post	18.38±4.087						

[Table/Fig-3]: Mean values for PSS, Standard error (Std. error), CI (Confidence Interval) of PSS Pre and Post, t and p-value of t-test.
PSS: Perceived stress scale

The change in SBP and DBP from the 1st session to the 12th session showed a mean difference of 8.68 and 4.26, respectively. Additionally, GSRBF demonstrated a significant difference in both SBP and DBP, with p<0.05 [Table/Fig-4,5].

SBP	Mean±SD	Total mean difference	Std. Error mean	95 % CI of the difference		t-value	p-value
				Lower	Upper		
Pre	134.26±9.977	8.68	0.649	7.378	9.981	13.381	<0.001
Post	125.58±7.629						

[Table/Fig-4]: Mean values for SBP, Standard Error (Std. Error), CI (Confidence Interval) of SBP Pre and Post, t and p-value of t-test.
SBP: Systolic blood pressure

DBP	Mean±SD	Total mean difference	Std. Error mean	95 % CI of the difference		t-value	p-value
				Lower	Upper		
Pre	85.13±4.481	4.26	0.414	3.433	5.095	10.301	<0.001
Post	80.87±3.386						

[Table/Fig-5]: Mean values for DBP, Standard error (Std. error), CI (Confidence Interval) of DBP Pre and Post, t and p-value of t-test.
DBP: Diastolic blood pressure

DISCUSSION

According to the definition, stress is a condition in which an organism's ability to adapt is strained, leading to psychological and biological changes that may increase the risk of illness. The link between stress and hypertension has long been theorised, as stress can elevate blood pressure and serum cholesterol levels [18].

The aim of present research was to investigate the effects of GSRBF on perceived stress in individuals with high BP. The findings revealed that after undergoing 12 sessions of GSRBF training, there was a significant decrease in perceived stress.

These results are consistent with previous research indicating that GSRBF has a beneficial impact on physiological responses to stress. Agnihotri H et al., demonstrated significant improvements in GSR and reduced anxiety levels through BF-assisted relaxation training [19]. Similarly, McGinnis RA et al., provided further support for the use of BF and relaxation techniques in patients with type 2 diabetes, resulting in reduced depression and anxiety [20]. Together, these studies highlight the positive effects of BF and relaxation techniques on both physical and psychological well-being.

The exact mechanism by which GSRBF and other BF and behavioural approaches work is not fully understood. It is believed that these techniques may have acute effects on cardiac output and heart rate, while total peripheral resistance may decrease over time. BF-assisted relaxation is thought to reduce sympathetic nervous system activity, leading to reduced responsiveness of norepinephrine. This relaxation response promotes physiological processes such as decreased stress hormone levels and vasodilation, contributing to lower BP [12].

Studies by Kumar M et al., on GSRBF in various populations have shown significant improvements in stress management. High-stress students experienced improvements in muscle tension (p=0.27), respiratory rate (p=0.01), and GSR (p=0.35) [21]. Patients with type 2 diabetes showed decreased blood glucose levels (p<0.05) and anxiety scores (p<0.05) [22]. GSRBF reduced anxiety (t=5.089; p<0.001) and stress (F=46.850; p<0.001) in patients with type II diabetes [23]. GSRBF relaxation effectively manages anxiety and stress.

There is strong evidence supporting the connection between chronic stress, coping mechanisms, and high BP in humans. Chronic mental stress is associated with increased activation of the sympathetic-adrenomedullary axis and elevated levels of blood noradrenaline and adrenaline. Chronically elevated levels of adrenaline have been linked to growth and development, and hypertension patients have been found to have increased sympathetic tone and decreased parasympathetic tone compared to healthy individuals [24].

Combining conventional pharmaceutical therapy with BF therapy is logical because an imbalance in the body's regulating systems is one of the main causes of hypertension [11]. Relaxation therapy, which involves guiding the patient to achieve a state of both muscle and mental deactivation, is one of the non pharmacological methods used to treat hypertension [25].

In present study, GSRBF also demonstrated a significant decrease in both SBP and DBP after each session. This finding is supported by a review study that examined the effects of GSRBF on BP [26], which indicated that GSRBF appears to be more effective in reducing SBP and DBP compared to no intervention or other behavioural interventions for essential hypertension. Additionally, Paran E et al., reported a noticeable improvement in BP (p<0.02) and a reduction in medication usage [27]. Mogra AL and Singh G observed lower SBP and DBP readings when combining yogic relaxation with 30-minute GSRBF training over a two month period [28].

The combination of structured relaxation techniques and GSRBF training has been shown to enhance parasympathetic dominance and effectively lower BP in people with hypertension. GSRBF training involves monitoring Skin Conductance (SC) to provide feedback on physiological responses. When these approaches are used together, they promote parasympathetic dominance and help regulate Heart Rate (HR) and BP. Intervention studies have provided evidence of significant reductions in BP, presenting a non pharmacological option for managing hypertension [29].

The present findings regarding the interaction between BF and relaxation techniques are significant, as relaxation itself has been shown to have beneficial effects on reducing perceived stress and BP in hypertensive patients. According to Benson's relaxation theory, the integrated relaxation response, which involves decreased metabolism, slower breathing rate, and decreased BP and HR in association with feelings of calmness and control, occurs when the individual focuses on a mental device like a sound or a fixed gaze at an object and returns to that focus when intrusive thoughts arise. Therefore, it is possible that the effects of BF can be attributed to this general relaxation response and enhanced by relaxation training [30].

In a study conducted by Palekar TJ et al., 40 physiotherapy students with a perceived stress score of 20 or higher participated in a 3-week GSRBF training programme [10]. The study measured various outcomes, including pulse rate, respiratory rate, BP, and perceived stress. The reduction in perceived stress was evaluated using the PSS 10 scale. The findings of the study indicate a highly significant decrease (p<0.001) in both physiological responses (pulse rate, respiratory rate, and BP) and perceived stress levels after the participants underwent GSRBF training.

Several factors may influence the response and one's self-perceived level of stress. Although the participants in present study had identical BP ranges, the response may vary depending on the stressor and individual personality factors, which may explain the wide range of stress levels observed among individuals. Prior to experiencing moderate levels of self-induced stress, most individuals first experience high levels of perceived stress. While there isn't a completely validated method for measuring stress, questionnaires and other self-administered scales, including visual analogue scales, continue to be the most helpful tools for epidemiological investigations. However, it should be noted that individuals can intentionally inflate or underestimate their perceived stress levels [31].

Relaxation techniques induce a relaxation response in skeletal muscles, leading to the release of tension. This in turn causes the skeletal muscles' tension to be released. This slows down the mind, boosts blood flow to the extremities; decreases BP and HR, and promotes slower, deeper breathing. By stimulating the Parasympathetic Nervous System (PSNS), the relaxation response counteracts the effects of the Sympathetic Nervous System (SNS). It is worth noting that the SNS also influences the renin-angiotensin-aldosterone system, which regulates BP and stress [25].

In a study conducted by Khanna A et al., in hypertensive subjects, the GSRBF training group showed a significant reduction in SBP values (p<0.05) on the first day, but had no effect on DBP on the first day. On day 10, there was a noticeable difference between the pre- and post-session SBP and DBP levels. The study included two other groups: the Progressive Muscle Relaxation (PMR) group and the Control group. The results indicated that over the course of 10 days, both the GSRBF and PMR groups experienced a significant decrease in pulse rate and anxiety levels. While GSRBF training was found to lower BP after a training session, PMR training was shown to be more effective in doing so, while GSRBF was found to be more effective in reducing respiratory rate [32].

In conclusion, GSRBF training reduces perceived stress in individuals with high blood pressure by decreasing the effects of the SNS and increasing the effects of the PSNS. The present study suggests that GSRBF can be used as a supplementary relaxation therapy for hypertension. These techniques involve slower, deeper breathing, improved blood flow, reduced BP, and mental relaxation. They help balance the effects of the SNS by stimulating the PSNS. Furthermore, utilising GSRBF can help lower the overall direct and indirect costs of hypertension treatment, considering the significant financial burden hypertension poses on communities.

Limitation(s)

Since, present study was conducted in a hospital setting, the study participants may not fully represent the general population, which limits the generalisability of the findings.

CONCLUSION(S)

Based on the findings of present study, it can be concluded that GSRBF is statistically effective in improving cardiovascular parameters, including SBP and DBP as well as PSS in patients with high BP. GSRBF training, aided by GSR feedback, effectively assists individuals with high BP in managing their condition. By providing real-time feedback on their body's responses, it empowers them to control their stress levels. This training significantly reduces both SBP and DBP, which are key indicators of hypertension, while also reducing perceived stress and increasing a sense of control among participants. Therefore, GSRBF has a significant effect on reducing perceived stress in individuals with high BP. In summary, GSRBF is a promising approach for improving cardiovascular health and reducing stress in individuals with high BP. Further research with a larger sample size drawn from the community is recommended to validate these findings and determine the most effective stress-reducing training protocol.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: May 13, 2023
- Manual Googling: Aug 18, 2023
- iThenticate Software: Nov 14, 2023 (4%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **May 10, 2023**
Date of Peer Review: **Jul 19, 2023**
Date of Acceptance: **Nov 16, 2023**
Date of Publishing: **Mar 01, 2024**