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ORIGINAL RESEARCH

Coherence: A Novel Nonpharmacological Modality for Lowering Blood Pressure in Hypertensive Patients

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Hypertension, blood pressure, anxiety, stress, coronary heart disease, heart attack, stroke, kidney disease, coherence, HeartMath, function, balance

ABSTRACT

This study examined the efficacy of teaching emotional self-regulation techniques supported by heart rhythm coherence training (emWave Personal Stress Reliever) as a means to quickly lower blood pressure (BP) in patients diagnosed with hypertension. Previous studies have demonstrated systemic reductions in BP in both high stress populations and patients diagnosed with hypertension using this approach, but to the best of our knowledge, an investigation of their ability to produce immediate reductions in BP had not been published in the medical literature.

The study was a randomized controlled design with 62 hypertensive participants who were divided into three groups. Group 1 was taking hypertensive medication, was taught self-regulation technique, and used heart rate variability coherence (HRVC) training devices. Group 2 was not yet taking medication and was trained in the same intervention. Group 3 was taking hypertensive medication but did not receive the intervention and was instructed to relax between the BP assessments.

An analysis of covariates was conducted to compare the effectiveness of three different interventions on reducing the participants' BP. The use of the self-regulation technique and the HRVC-monitoring device was associated with a significantly greater reduction in mean arterial pressure in the two groups who used the intervention as compared with the relaxation-plus-medication group. Additionally, the group not taking medication that used the intervention also had a significantly greater reduction in systolic BP than the relaxation-plus-medication group.

These results suggest that self-regulation techniques that incorporate the intentional generation of

positive emotions to facilitate a shift into the psychophysiological coherence state are an effective approach to lowering BP. This approach to reducing BP should be considered a simple and effective approach that can easily be taught to patients to quickly lower their BP in stressful situations. The technique should be especially useful when hypertensive patients are experiencing stressful emotions or reactions to stressors. It is possible that the BP reductions associated with the use of the technique leads to a change in the physiological set-point for homeostatic regulation of BP. Further studies should examine if large scale implementations of such heart-based coherence techniques could have a significant impact on reducing risk of mortality and morbidity in hypertensive patients.

摘要

本研究考察了以心律和谐训练 (emWave 个人压力释放器) 为支持传授自我调节情绪技巧以快速降低高血压患者血压 (blood pressure, BP) 的效果。此前研究证实, 高血压人群和被确诊的高血压患者使用这种方法均可降低全身血压 (BP), 而在此之前他们并没有接受过立即降低血压 (BP) 的能力调研。

本研究的设计是将 62 名高血压参与者分为三组进行随机对照研究。第 1 组服用高血压药物, 被传授自我调节技巧, 并使用心率变异性和谐 (heart rate variability coherence, HRVC) 训练设备。第 2 组未服药, 但接受相同的干预训练。第 3 组服用高血压药物, 但不接受干预训练, 并被指示在血压 (BP) 评估之间保持放松。

本研究进行了共变数分析, 比较三种不同的干预措施对降低参与者血压 (BP) 的有效性。就平均动脉压而言, 采用干预措施的两个小组较采用放松加药物治疗的小组显著降低, 显示出其与使用自我调节

技巧和心率变异性和谐 (HRVC) 监测设备存在联系。此外, 就收缩血压 (BP) 而言, 采用未服药但接受干预措施的小组也比采用放松加药物治疗的小组显著降低。

这些结果表明, 自我调节技巧采用有意识调动积极情绪的手段帮助达到身心和谐的状态, 是降低血压 (BP) 的一种有效方法。这种降低血压 (BP) 的方法被认为是一种可以轻松教会患者在紧张的情况下迅速降低血压 (BP) 的简单而有效的方法。这种技巧在高血压患者情绪紧张或应对压力时特别有用。使用该技巧降低血压 (BP) 可能会导致血压 (BP) 稳态调节生理设定点的变化。如果大规模实施这种基于内心的和谐技巧可能显著降低高血压患者的死亡率和发病率风险, 则应实施进一步的研究。

SINOPSIS

Este estudio examinó la eficacia de enseñar las técnicas de auto-regulación emocional, apoyadas por el entrenamiento de la coherencia de ritmos del corazón (emWave Personal Stress Reliever), como medio para reducir con rapidez la presión arterial (PA) en pacientes diagnosticados con hipertensión. Los estudios previos han demostrado reducciones sistémicas de la PA tanto en poblaciones con alto estrés como en pacientes diagnosticados con hipertensión, después de usar este enfoque pero no se ha investigado todavía la capacidad de causar reducciones inmediatas de la PA.

El estudio se llevó a cabo con 62 participantes hipertensos mediante un diseño controlado aleatorizado, que los dividió en tres grupos. El grupo 1 estaba tomando medicación para la hipertensión, se le enseñó la técnica de auto-regulación y utilizó aparatos de entrenamiento de coherencia de la variabilidad de la frecuencia cardiaca (heart rate variability coherence, HRVC). El grupo 2 no

tomaba todavía ninguna medicación y se entrenó en el mismo procedimiento. El grupo 3 estaba tomando medicación para la hipertensión, pero no recibió la intervención y se le enseñó a relajarse entre las evaluaciones de la PA.

Se realizó un análisis de covarianza para comparar la eficacia de los tres tipos distintos de intervención para reducir la PA de los participantes. El uso de la técnica de auto-regulación y del aparato de control de la HRVC se asoció a una reducción significativamente mayor de la media de la presión arterial en los dos grupos que utilizaron la intervención, en comparación con el grupo con la

medicación y la relajación. Además, el grupo que no tomaba medicación, pero que utilizó la intervención, mostró también una reducción significativamente mayor en la PA sistólica que el grupo con la medicación y la relajación.

Estos resultados sugieren que las técnicas de auto-regulación, que incorporan la generación intencional de emociones positivas para facilitar un cambio hacia el estado de coherencia psicofisiológico son un enfoque eficaz para reducir la PA. Este enfoque para reducir la PA se debe considerar un planteamiento simple y eficaz, que puede enseñarse fácilmente a los pacientes, para reducir rápidamente

su PA en situaciones de estrés. Esta técnica debería ser útil especialmente en los casos en los que los pacientes hipertensos sufren emociones estresantes o reacciones ante situaciones de estrés. Es posible que las reducciones de la PA, asociadas al uso de la técnica, causen un cambio en el punto fisiológico establecido, que controla la regulación homeostática de la PA. Los estudios adicionales deberían examinar si las implementaciones a gran escala de dichas técnicas de coherencia basadas en el ritmo cardíaco podrían tener un impacto significativo en la reducción del riesgo de mortalidad y morbilidad en los pacientes hipertensos.

Hypertension is considered one of the most prominent public health issues faced by the world today. It affects approximately 1 in 4 adults,¹ and current trends suggest that the number of adults diagnosed with high blood pressure (BP) is increasing.² High BP is a major risk factor for death and disability related to coronary heart disease, heart attacks, strokes, kidney disease, and vascular complications.¹ In addition, high systolic BP has been linked with decreased cognitive performance, memory loss, and the loss of healthy brain tissue.^{3,4} Conversely, reducing BP in hypertensive individuals has been found to significantly reduce the risk of death and disability and is therefore a critically important factor in long-term health and wellness.^{4,7}

There is considerable evidence to suggest that high BP is linked to persistent stress and the ways in which people cope.⁸⁻¹² Behavioral interventions that reduce stress and sympathetic arousal have been shown to be effective nonpharmacological treatments for hypertension; such treatments have been associated with clinically significant and sustainable BP reductions as well as lowered health-care costs.¹³⁻¹⁸

Interventions utilizing HeartMath self-regulation techniques and heart rhythm coherence monitoring technology to reduce stress and increase physiological stability and efficiency have been shown in a number of previous studies to significantly improve key markers of health and wellness, such as immune function,¹⁹ autonomic nervous system (ANS) function and balance,^{20,21} reductions in stress hormones,²² and reductions in both systolic and diastolic BP. For example, in a population of correctional officers with high workplace stress, reductions in total cholesterol, glucose, and both systolic and diastolic BP, as well as significant reductions in overall stress, anger, fatigue, and hostility, were found, which resulted in projected savings in annual health-care costs of \$1179 US per employee.²³ Another workplace study of employees with clinical

diagnoses of hypertension showed significant reductions in BP and a wide range of stress measures.²⁴ Reduced healthcare utilization and costs were also found in a study of pastors who used the coherence monitoring device (emWave) to support learning of the stress self-regulation tools. In addition to a number of significant improvements in stress and well-being measures, the group receiving the HeartMath training showed an overall decrease in health-care costs of 3.8% (resulting in an annual cost savings of \$585 US per participant); the control group had a 9% increase in health-care costs. The largest reduction in costs was related to reductions in medication for treating hypertension.²⁵ The studies briefly described above focused on long-term BP reductions; however, potential reductions of BP that may be directly associated with use of the techniques and the coherent state have not been previously investigated. This study was therefore undertaken to determine if immediate reductions in BP were associated with positive emotions and the coherent state. The research team believed that such a study would help inform a physiologically based theory of why positive emotions and the coherent state can lead to long-term reductions in BP and healthcare costs.

Our theoretical framework is grounded in the existence of a dynamic communication network between the cognitive, emotional, and physiological systems wherein the physiological state of coherence is reflected in increased harmony and a global order, viewed as a distinctive mode of function. Both positive and negative emotions are deeply rooted under our physiological processes that are related to fluidity and strain (stress) of the life process.^{26,27} Many of the difficult situations and challenges that one faces that can result in stressful feelings such as anger, irritation, anxiety, etc, have been linked to increased risk of heart attacks, hypertension, and cardiovascular disease.²⁸ On the other hand, positive emotions are associated with increased efficacy and stability in cardiovascular functioning.^{26,29,30} Thus,

techniques that allow patients to self-regulate emotions and induce a state of coherence may provide a novel nonpharmacological approach that can help control acute BP increases and hypertension.

The Institute of HeartMath (IHM) introduced the term physiological coherence to describe the degree of order, harmony, and stability in the various rhythmic activities within living systems over any given time period.²⁰ This harmonious order signifies a more coherent system whose efficient or optimal function is directly related to the ease and flow in life processes. By contrast, an erratic, discordant pattern of activity denotes an incoherent system whose function reflects stress and inefficient utilization of energy in life processes.^{20,26,27,31} In our experience in working with patients, we have also observed that positive emotions as opposed to negative emotions such as anxiety and anger are indeed reflected in heart rhythm patterns that are more coherent.

Physiological correlates of this coherence mode include a shift in autonomic balance toward increased parasympathetic activity, increased heart-brain synchronization, increased vascular resonance, and entrainment between diverse physiological oscillatory systems.²⁶

Based on the understanding of the physiological interactions between heart, brain, and emotional physiology, IHM has developed series of techniques to provide a systematic process that enables people to shift into a more coherent state and increase their ability to better self-regulate stress and improve performance.³²⁻³⁴ Most of these techniques include the intentional generation of a heartfelt positive emotional state combined with a shift in attentional focus to the area of the heart (where many people subjectively experience positive emotions). This shift in feeling allows the coherence mode to emerge naturally and helps to reinforce the inherent associations between physiological coherence and positive feelings. The coherent state indeed appears to be associated with the patient's subjective feeling of positive emotions. We have found that although the breathing rhythm can be used to induce a more coherent state, for some patients, the induction of a positive feeling was the key to their success in both shifting to a more coherent state and sustaining it for longer periods. These changes in rhythmic patterns are independent of heart rate (HR); that is, one can have a coherent or incoherent pattern at higher or lower HRs. Thus, it is the pattern of the rhythm (the ordering of changes in rate over time) rather than the rate (at any point in time) that is most directly related to emotional dynamics and physiological harmony.

The techniques used in the study draw on HeartMath's interventions that have been shown to be effective in reducing BP in individuals with hypertension. The objective of this training was to teach patients the ability to shift into a more coherent state in stressful situations in order to reduce acute BP increases.²⁴ Learning self-regulation skills can be facilitated with the use of heart rhythm coherence feedback monitors

that display heart rhythm in real time and determine the level of heart rhythm coherence achieved. Heart-rate variability (HRV) coherence feedback has been shown to significantly improve outcomes in a number of clinical populations such as patients with posttraumatic stress disorder,³⁵⁻³⁷ depression,^{38,39} asthma,⁴⁰⁻⁴³ congestive heart failure,^{44,45} hypertension,²⁴ anxiety,³³ fibromyalgia,⁴⁶ and insomnia.⁴⁷

The device used in this study was the emWave Personal Stress Reliever (PSR) (Figure 1), which helps patients acquire the self-regulation skills for reducing emotional stress by displaying their level of heart rhythm coherence in real time as they practice the techniques. The device uses either a fingertip or ear lobe sensor to detect the pulse wave. The device records the HR on a beat-to-beat basis (the interbeat interval). As patients practice the techniques, they can readily see and experience the changes in their heart rhythm patterns, which generally become smoother and more sine wave-like as they feel appreciation and other positive emotions. The real-time physiological feedback also essentially takes the guesswork out of the process of self-inducing a positive emotional state, resulting in greater consistency and effectiveness in practicing emotional shifts.

METHODS

The sample investigated in this study was selected at random from the cardiac center registry at the Prince Sultan Cardiac Center in Hufuf, Saudi Arabia, for potential inclusion in the study. The inclusion criteria for hypertension were a systolic BP of greater than 140 or a diastolic BP of greater than 90. Sixty-two patients were recruited to participate in the study. Prior to the experiment, the examiner explained to the patients the aim of the study and the procedures they would be asked to participate in.



Figure 1 The emWave Personal Stress Reliever.

This population of confirmed hypertension patients was then randomly divided into 3 groups. Group 1 (n = 30) was currently taking hypertensive medication as prescribed by their physicians, was taught the self-regulation technique called Quick Coherence (QC),³⁴ and practiced with the emWave PSR device (HeartMath LLC, Boulder Creek, California). Group 2 (n = 12) was not yet taking any medication to control hypertension and was given the same training and emWave practice. Group 3 (n = 20) was taking medication as prescribed and was asked to use a method of relaxation that was familiar to them.

The sex ratio was almost 50:50: 32 males vs 30 females. The age range of participants was between 24 and 85 years (mean age 55), and body mass index (BMI) ranged from 20 to 51 with a mean of 33 kg/m². Most of the participants were nonsmokers, and the number of diabetic patients was approximately equal among the 3 groups.

Patients were instructed to sit on a chair and rest for 10 minutes after which their BP, HR, and oxygen saturation (SpO₂) were measured. During the data collection procedure, the patient was asked to stay calm and rest the mind and body from any emotional concerns. Once the baseline data had been collected, the participants in groups 1 and 2 were reconnected to an emWave device and asked to use the steps of the QC technique to activate a positive feeling and increase their heart rhythm coherence levels as reflected in the emWave device. The technique has 3 basic steps: first, patients focus attention in the area of the heart; second, patients focus attention to the center of the chest and pretend they are breathing through this area; third, patients intentionally activate a positive feeling, such as appreciation or care for someone or some place. The emphasis is put on actually experiencing the positive feeling. The emWave PSR device has an indicator light that shows the current level of coherence as either red (low coherence), blue (medium coherence), or green (high coherence). The indicator changes from red to blue or green as patients successfully increase their coherence level. While rhythmic breathing exercises can help lower HR and have a calming effect, shifting attitudes and emotions neutralize and counter the effects of stress by actively adding to the process a positive feeling such as appreciation, care, or compassion.

After the patients had practiced using the QC technique for a 5-minute period, their BP, HR, and SpO₂ were again measured in same manner. For group 3, relaxation plus medication, the same data collection procedures were followed, with the exception that patients in this group were asked to sit quietly and to practice using a familiar method of relaxing for a 5-minute period.

We observed that only focusing on rhythmic breathing was difficult for some patients to maintain for more than about 1 minute. However, when these individuals were able to intentionally invoke a positive emotional state, they were usually able to maintain a more coherent state for greater periods of time. When

patients in groups 1 and 2 were having difficulty achieving the coherence state, the examiner encouraged them to try to forget about the hospital environment and to imagine themselves gathered with their families in a natural setting (eg, at a farm or in a park) and experience how that felt. In some cases, patients were also asked to recite Islamic prayers aloud. They were then asked to stop their tongue movements and focus only on the abstract meaning of the words and how they felt in their hearts (the Imam Ghazali method for contemplation) until they reached a state of transcendence wherein they felt connected to a higher power beyond themselves. When they were able to evoke a positive feeling, participants were typically able to shift into a more coherence state much easier.

Statistical Analysis and Results

Baseline characteristics for the 3 groups are presented in Table 1. A chi-square test was first used to compare the baseline characteristic of the 3 groups on gender, smoking status (nonsmoker, ex-smoker, and smoker), and diabetic status. The gender balance between the 3 groups did not significantly differ ($\chi^2 = 0.07$, $P = .97$). Smoking status also did not differ significantly between the groups ($\chi^2 = 2.747$, $P = .601$), nor did the ratio of diabetics ($\chi^2 = 0.523$, $P = .770$).

Table 1 Baseline Characteristics of the Three Groups

	Group 1 (N=30)	Group 2 (N=12)	Group 3 (N=20)
Age, years (SD)	54.8 (11.91)	51.0 (16.30)	50.5 (9.44)
Gender, % male	53	50	50
Smoking status			
Nonsmoker, %	80	67	75
Ex-smoker, %	3	17	5
Smoker, %	17	17	20
Diabetic, %	50	50	60

A single-factor analysis of variance comparison was used to test baseline differences for participants age, systolic and diastolic BP, mean arterial pressure (MAP, systolic + [2 x diastolic]/3), HR, and SpO₂. There were no significant differences in the ages of the participants in the 3 groups ($F = 0.906$, $P = .410$) or BP measure, as shown in Table 2.

A 1-way between-groups analysis of covariance was conducted to compare the effectiveness of 3 different interventions on reducing the participant BP (Table 3). The independent variable (grouping factor) was intervention type (group 1, coherence training plus currently taking hypertensive medication; group 2, coherence training alone; and group 3, relaxation plus currently taking hypertensive medication). The dependent variables consisted of systolic and diastolic BP, MAP, HR, and SpO₂ taken after the intervention was completed. Participants' preintervention measurements of systolic and diastolic BP, MAP, HR, and SpO₂ were used as the covariates. Bonferroni adjust-

Table 2 Baseline Comparisons of Three Groups' Outcome Measures

	Systolic BP (mm Hg)	Diastolic BP (mm Hg)	MAP (mm Hg)	Heart Rate (BPM)	SpO ₂ %
Group 1 (N=30)					
Mean	156.90	87.67	111.26	79.30	98.00
SEM	4.07	3.00	2.87	2.93	0.35
Lower 95% CI	148.56	81.53	105.39	73.31	97.29
Upper 95% CI	165.24	93.81	117.14	85.29	98.71
Group 2 (N=12)					
Mean	142.50	81.42	101.78	78.67	98.67
SEM	5.60	3.77	4.08	5.71	0.51
Lower 95% CI	130.18	73.11	92.79	66.09	97.54
Upper 95% CI	154.82	89.73	110.76	91.24	99.79
Group 3 (N=20)					
Mean	153.20	93.65	113.50	80.10	98.60
SEM	4.33	3.30	3.07	2.68	0.28
Lower 95% CI	144.14	86.74	107.07	74.49	98.00
Upper 95% CI	162.26	100.56	119.93	85.71	99.20
Between-groups ANOVA					
Mean Sq	881.39	576.29	550.79	8.24	2.99
F	2.07	2.45	2.56	0.03	1.06
P<	NS	NS	NS	NS	NS

Abbreviations: ANOVA, analysis of variance; BP, blood pressure; BPM, beats per minute; CI, confidence interval; MAP, mean arterial pressure; NS, not significant; SEM, standard error of the mean; Sq, square.

ment for between-groups pairwise comparisons are presented in Table 4.

Preliminary checks were conducted, and no violation of the assumptions of homogeneity of regression slopes was found. As shown in Table 3, after adjusting for preintervention scores, there was a significant difference between intervention groups on postintervention systolic BP ($F=4.06, P>.05$), a solid medium effect (partial eta squared = .125). As shown in Table 4, the pairwise comparisons show a between-group difference; postintervention in systolic BP for group 2 (coherence training alone), which was significantly lower than that of group 3 (relaxation plus current medication) ($P<.05$). There was also a significant difference between groups on postintervention MAP ($F=4.61, P>.05$), partial eta squared = .139, indicating a strong effect with group 1 (coherence training plus current medication) having significantly lower MAP than group 3 (relaxation plus medication), ($P<.05$). Postintervention MAP was also significantly lower in group 2 (coherence training alone) than group 3 (relaxation plus current medication), ($P<.05$). No significant between-group differences were found for

Table 3 Results of the Between-groups Analysis of Covariance

Post-study Between-groups Results					
	Systolic BP (mm Hg)	Diastolic BP (mm Hg)	MAP (mm Hg)	Heart Rate (BPM)	SpO ₂ %
Group 1 (N=30)					
Mean	137.75	82.35	101.01	78.43	98.84
SEM	2.12	1.12	1.14	1.27	0.22
Lower 95% CI	133.51	80.11	98.74	75.90	98.40
Upper 95% CI	141.98	84.59	103.29	80.97	99.28
Group 2 (N=12)					
Mean	132.49	82.22	99.72	77.44	98.55
SEM	3.34	1.80	1.82	2.00	0.33
Lower 95% CI	125.80	78.61	96.07	73.43	97.88
Upper 95% CI	139.18	85.83	103.37	81.45	99.21
Group 3 (N=20)					
Mean	144.00	86.35	105.70	78.14	98.58
SEM	2.52	1.40	1.38	1.55	0.26
Lower 95% CI	138.95	83.55	102.94	75.03	98.06
Upper 95% CI	149.05	89.14	108.47	81.25	99.09
Between-groups ANCOVA					
Mean Sq	516.41	104.07	172.45	4.19	0.53
F	4.06	2.78	4.61	0.09	0.40
P<	.05	NS	.05	NS	NS
Eta Sq	0.125	0.087	0.139	0.003	0.014

Abbreviations: ANCOVA, analysis of covariance; BP, blood pressure; BPM, beats per minute; CI, confidence interval; MAP, mean arterial pressure; NS, not significant; SEM, standard error of the mean; Sq, square.

diastolic BP, HR, or SpO₂. The preintervention-to-postintervention changes in systolic, diastolic, and MAP are illustrated in Figure 2.

DISCUSSION

This study was designed to evaluate a short-term BP reduction strategy in confirmed hypertensive patients who were briefly taught how to intentionally shift to and maintain a more coherent state by self-generating a heart-focused positive emotional state, facilitated via the handheld emWave device.

The results showed that use of the QC technique was associated with significant short-term reductions in BP and that patients could quickly learn and use the technique to shift into a more coherent state. We also found that using the emWave device was a highly effective method to facilitate to the patient's ability to make the shift, as it provided an objective measure of their success in achieving coherence.

Patient levels of emotional stress are clearly an important and modifiable risk factor for acute and

Table 4 Preintervention-to-postintervention Mean Differences^a

	Mean Difference				
	Systolic BP (mm Hg)	Diastolic BP (mm Hg)	MAP (mm Hg)	Heart Rate (BPM)	SpO ₂ %
Group 1 vs Group 2					
Mean	5.26	0.13	1.29	0.99	0.29
SEM	4.01	2.12	2.16	2.37	0.40
P<	NS	NS	NS	NS	NS
Group 1 vs Group 3					
Mean	-6.25	-4.00	-4.69	0.29	0.26
SEM	3.29	1.79	1.78	2.00	0.34
P<	NS	NS	.05	NS	NS
Group 2 vs Group 3					
Mean	-11.51	-4.13	-5.98	-0.70	-0.03
SEM	4.19	2.32	2.32	2.54	0.42
P<	.05	NS	.05	NS	NS

^a Bonferroni adjustment for multiple comparisons.
 Group 1, intervention + current medication.
 Group 2, intervention only.
 Group 3, relaxation + current medication.

Abbreviations: BP, blood pressure; BPM, beats per minute; MAP, mean arterial pressure; NS, not significant; SEM, standard error of the mean.

chronic adverse cardiovascular disorders. Even though there are only a few well-controlled studies of stress-reduction in the management of patients with or at risk for cardiovascular disease, ample evidence exists for a strong and consistent association of acute and chronic psychological stress with cardiovascular risk factors such as hypertension and insulin resistance and with outcomes such as ischemia, arrhythmia, and pump failure.²⁸ There is no doubt that stressful situations can cause BP to spike temporarily, but there is no widespread agreement yet that a consistent pattern of these stress-related transient BP increases can cause long-term high BP. In other words, can all those short-term stress-related BP spikes add up to changing an internal BP set-point and cause high BP in the long term?

Physiological set-point models have a long history in medicine and were expanded to include emotional experience, perception, and behavior by Karl Pribram in the late 1960s.⁴⁸ Simply put, in Pribram's model, a memory or stable pattern of activity is formed and maintained in the neural architecture of the brain as we gain experience both in internal self-regulation and in interacting with the external environment. These stable patterns are updated and modified as we encounter new experiences and learn how a certain action usually leads to a specific result. All ongoing or current sensory input to the brain from both the internal and external sensory systems is compared to these stable patterns. These stable patterns create a set of "expectancies" against which breathing, eating, drinking, sleeping, alertness and sexual and other behaviors are evaluated.

Pribram also suggested that physiological control

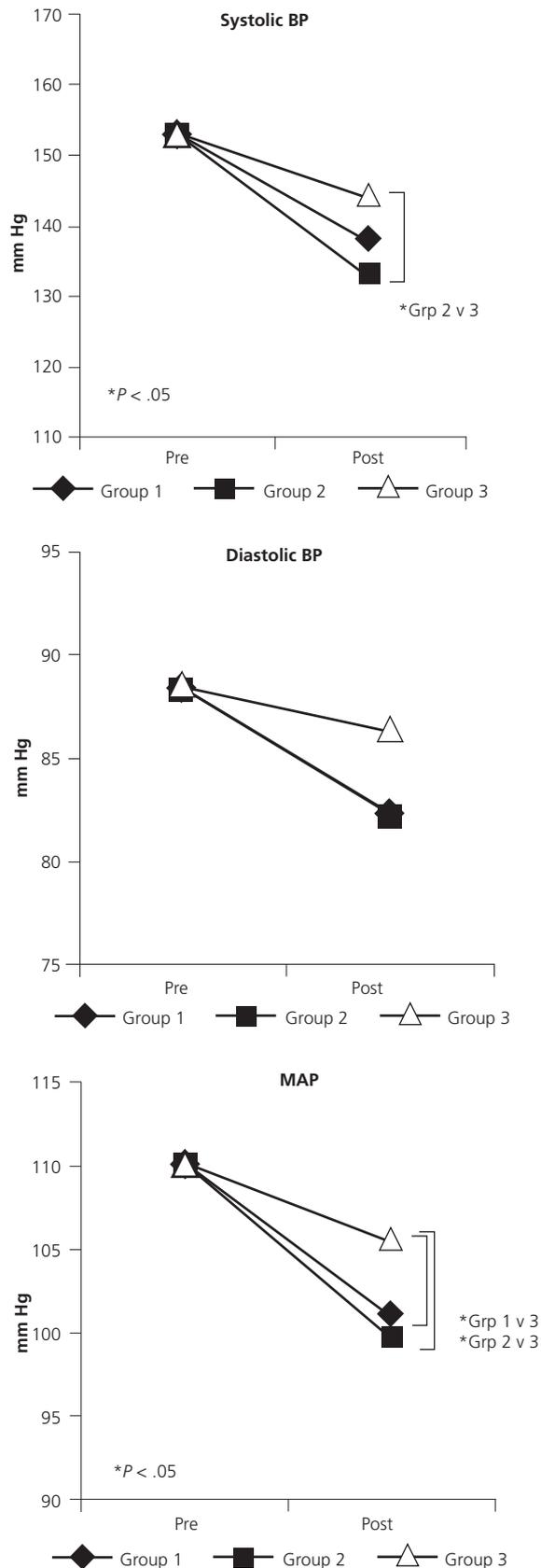


Figure 2 Preintervention-to-post intervention changes in systolic, diastolic, and mean arterial blood pressure (BP).

Abbreviation: MAP, mean arterial pressure.

systems work in the same way and that neural circuits at the brain stem level regulate the patterns or set-points to which physiological parameters such as BP or respiration rate are compared. Importantly, he also showed that there are significant interactions between the neural systems that contain the set-points that regulate emotion and behavior and the systems that regulate physiological systems. The degree of match or mismatch between current inputs and the set-point then regulates and controls the level of activity (arousal) in the descending branches of the autonomic system.

Monitoring the alterations in the rates, rhythms, and patterns of afferent traffic is a key function of the cortical and emotional systems in the brain. Pribram was well aware of the influence of afferent input from the heart and other organ systems in determining the set-points, or what becomes the familiar pattern, as far back as 1969, when he wrote

Visceral feedback constitutes, by the nature of its receptor anatomy and diffuse afferent organization, a major source of input to this biasing mechanism; it is an input which can do much to determine set-point. In addition, cardiovascular and autonomic events are repetitiously redundant in the history of the organism. They vary recurrently, leading to stable habituations; this is in contrast to external changes which vary from occasion to occasion. Habituation to visceral and autonomic activity makes up, therefore, a large share. . . of the stable base-line from which the organism's reactions can take off.^{48(p322)}

These set-points establish a background against which BP, hormonal balance, and all regularly recurring behaviors are initiated and maintained. For example, when we sense a mismatch between our actual HR and the habituated HR, we generate a feeling (eg, excitement or anxiety if HR is accelerated). The specific feeling experienced may reflect the nature of the mismatch. Importantly, a mismatch may be registered not only due to changes in HR but also due to changes in the pattern of the afferent traffic.

Although input originating from many different bodily organs and systems is involved in the processes that ultimately determine emotional experience, it has become clear that the heart plays a particularly important role. The heart is the primary and most consistent source of dynamic rhythmic patterns in the body. Furthermore, the afferent networks connecting the heart and cardiovascular system with the brain are far more extensive than the afferent systems associated with other major organs.

Additionally, the heart is particularly sensitive and responsive to changes in a number of other psychophysiological systems. For example, heart rhythm patterns are continually and rapidly modulated by changes in the activity of either branch of the ANS, and the heart's extensive intrinsic network of sensory neu-

rons also enables it to detect and respond to variations in hormonal rhythms and patterns.⁴⁹ In addition to functioning as a sophisticated information processing and encoding center,⁵⁰ the heart is also an endocrine gland that produces and secretes hormones and neurotransmitters.⁵¹⁻⁵⁵ Thus with each beat, the heart not only pumps blood but also continually transmits dynamic patterns of neurological, hormonal, pressure, and electromagnetic information to the brain and throughout the body.²⁶

The repeating rhythmic patterns generated by the heart, whether they are ordered or disordered, become familiar to the brain. At the brain-stem level, these patterns are compared to set-points that control BP, affect respiration rate, and control the flow of activity in the descending branches of the ANS. From there, these signals cascade up to a number of subcortical centers—such as the thalamus, hypothalamus, and amygdala—that are involved in the processing of emotion.

Recent findings confirm that there is indeed a set-point for mean long-term BP that is regulated by the nervous system rather than the generally accepted model that the renal output curve determines the set-point for long-term arterial BP regulation. Osborn has provided compelling arguments for a central nervous system-based set-point for long-term arterial BP⁵⁶ and in recent articles by Zanuto et al,^{57,58} it was shown that when all of the cardiovascular receptors (baro-, chemo-, and cardiopulmonary) are deinnervated, sustained hypertension results. Zanuto has also provided evidence that nucleus tractus solitarius acts as a compactor and controls the set-point for mean atrial BP, which is consistent with Pribram's model. In addition to physiological causes, they also point out that hypertension can be caused by a set-point shift due to influences for higher-level pathways, such as behavioral activities and autonomic responses to stress and emotional situations. It is our perspective that if set-points that are maintained in the higher levels of the brain are not reset, medications such as beta-blockers that target downstream pathways may result in other physiological systems being activated in order to maintain BP at the set-point.

If it is possible to shift the set-point around which multiple physiological systems attempt to regulate mean BP upward, it should also be possible to shift the set-point downward. We hypothesize that a resetting of set-point in the neural architecture can be accomplished through a constant pattern of activating a positive emotional state and shifting into a more coherent state, which in turn decreases BP. As previous studies have shown, practice of heart-focused emotional self-regulation techniques has resulted in systemic reductions in BP and shown to be an effective treatment approach to reducing hypertension.^{23,24} Therefore, this study was intended to determine if use of the techniques and the coherent state in particular could be associated with significant short-term reductions in BP. This was of interest to us because coherence training offers a novel nonpharmacological

modality that could be used to control hypertension and improve self-regulation of stress.

In addition to the behavioral and physiological perspectives described above, the association of heart focus and positive emotions with the coherent state was particularly attractive to us due to the highly regarded beliefs and traditional knowledge that exists in our Islamic culture, especially in Sufism. It is worthy of mention that the strongly held view that the heart holds the secrets and mysteries that link the body with the mind and soul are also present in many of the ancient wisdoms and world's cultures such as Judaism's Yesod, Christian and Buddhist mysticism, and Indian (Prana) and Chinese healing systems.⁵⁹ Given the central role of the heart in creating coherence and positive emotions, it is not surprising that one of the strongest common threads uniting the views of diverse cultures and religious and spiritual traditions throughout human history has been the universal regard for the human heart as the source of love, wisdom, intuition, and positive emotions. Sadly, the ability to incorporate such strong views and beliefs held by many of our patients into the treatment process to facilitate the healing process is missing in most modern medicine approaches.

The exploration of new paradigms for the prevention and treatment of heart diseases (eg, hypertension) based on the new perspectives of the wider role of the heart or what many call the spiritual heart or intuitive heart in healing, spirituality, has been extensively discussed in numerous presentations during 3 successive international "Heart: The King of Organs" conferences organized by Al Abdulgader in Saudi Arabia, which have attracted luminaries in this area from around the world.

A new generation of scientists like McCraty and colleagues at IHM are taking seriously the perspective that the heart is more than a pump that sustains life.^{26,27,48,60-66} It is my perspective that there is much to be gained by scientific inquiries that connect modern medicine with traditional and spiritual ideas about the heart, and this study with hypertensive patients is one part of an ongoing effort to explore this vision and adopt new clinical approaches. It is possible to capitalize on the mysteries of the heart that connect cognitive, emotional, and physiological processes in the treatment of patients with a wide range of health challenges such as hypertension.

CONCLUSIONS

The results of this study suggest that self-regulation techniques that incorporate the intentional generation of positive emotions and increased psychophysiological coherence are an effective approach to lowering acute BP. The coherent state can be facilitated and easily measured in clinical settings with the emWave heart rhythm coherence monitoring device. Outcomes were achieved within a relatively brief timeframe among a diverse patient population. We also found that paced breathing was difficult for some patients to maintain for more than about 1 minute. However,

when these individuals were able to intentionally invoke a positive emotional state, they were typically able to maintain a more coherent state for greater periods of time. Clearly, positive emotions can shift the heart's pattern of activity into a more coherent mode that results in increased physiological efficiency, greater emotional stability, and reduced BP among hypertensive patients.

We hypothesize that a consistent pattern of short-term BP reduction in combination with emotional shifts can result in the lowering of an internal set-point of BP, which would explain previous studies that have associated use of the self-regulation techniques with systemic reductions in BP. Self-regulation and heart rhythm coherence training offer a novel nonpharmacological modality that is culturally appropriate and could be used to control hypertension and improve self-regulation of stress. This approach to reducing BP should be considered a simple and effective to approach that can easily be taught to patients. The techniques should be especially useful when hypertensive patients are experiencing stressful emotions or reactions to stressors.

Further studies should examine if large-scale implementation of such heart-based coherence techniques could have a significant impact on reducing risk of mortality and morbidity in hypertensive patients. Such implementations could contribute important findings that have the potential to improve the quality of human life globally.

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