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Effects of Emotional Stimuli on Cardiovascular Responses in Patients with Essential Hypertension Based on Brain/Behavioral Systems

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ABSTRACT

Introduction: Effects of emotional stimuli on hemodynamics in patients with essential hypertension based on brain/behavioral systems have not been studied broadly.
Methods: Eighty five essential hypertensive male patients who had completed Carver-White BIS/BAS scale were enrolled to the study. Later, 25 BIS and 25 BAS patients were selected and their blood pressure and heart rate were recorded prior to stimuli induction. Participants were then exposed to stressor pictures. After that, 15 minutes of relaxation and cognitive tasks were performed. Finally, the participants were exposed to pleasant pictures. The blood pressure and heart rate were recorded after presenting of 2 stimuli.
Results: Our study showed that BIS patients achieved higher scores in diastolic blood pressure and heart rate in comparison with BAS patients after presenting stressful stimuli. Also, BAS patients achieved lower scores in systolic blood pressure and heart rate in comparison with BIS patients after presenting pleasant stimuli.
Conclusion: In summary, BIS patients experience negative emotions more than BAS patients. Therefore, the role of induced mood states is important in relation to physical health.

Introduction

Cardiovascular diseases are the leading cause of morbidity and mortality in various countries worldwide. Being important at all stages of human life, cardiovascular diseases are still very common.[1] Heart diseases, due to a combination of physical and psychological stressors such as pain, loss of health, loss of job, extreme sensory deprivation, imminent death, and varying degrees of psychological reactions like hopelessness, fatigue, and fear cause a feeling of worthlessness, and low self-esteem in patients.[2] Hypertension is a phenomenon that has an important role in cardiovascular diseases.[3-5] This phenomenon is a public health problem and its prevalence throughout the globe, particularly in developed countries is rising.[6] Worldwide, out of every 8 deaths, one is due to hypertension, making it the third leading cause of mortality in the world.[7]

One of the factors suggested as a predictor of heart diseases, and the subject of many studies is stress.[8] Stress is one of the factors that affect the autonomic nervous system (especially, the sympathetic nervous system). Stress can be regarded as a non-specific response of a living creature to any demand or need, while the stressor is any stimulus that can lead to stress (person's response). Our relationship with the environment is affected by many material and psychological elements. But they depend on our response to the social and environmental stressors as well.[9]

Causes of death have changed dramatically since the early 20th century. Studies reveal that 70% to 80% of diseases are associated with stress. Diseases associated with lifestyle including cardiovascular diseases and cancers that cause people's death are related to stress response.[10] Hu *et al.* argue that reacting to stress ends in physiological changes, reduced health, and increased illness.[11]

The role of positive emotions in coping is currently a subject of interest to researchers. It is possible that positive and negative emotions could coincide in stressful situations, and in fact this is what happens in reality. For instance, positive emotions can neutralize some of the unpleasant complications of negative emotions, especially the physiological ones. In a study, when people were talking about their relationship with their spouses who had died six months earlier, they had a sincere smile on their lips, however, two years after the incidence, signs of grief had diminished and their relationship with others was better (normal). In another study, it was revealed that those who are able to find positive meanings after a traumatic event, for instance spiritual growth or valuing life, can respond more rationally to experimental stress

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stimuli (in vitro).[12]

In recent years, there has been a deluge of psychological studies on the relationship between negative emotions and brain-behavioral systems and heart diseases, particularly essential hypertension.[13]

Gray, in accordance with different reward and punishment systems in the brain and personal differences in sensitivity to various stimuli, identified three brain-behavioral systems that underlie differences in personality. Furthermore, the dominance and activity of each of these systems in a person leads to different emotional states and provokes different modes of confrontation. These systems are behavioral activation system that is related to positive emotions, behavioral inhibition system that establishes anxiety and fight or flight system that generates rage, fear and panic.[14] The physiological-psychological evidence states that both motivational systems of activation/inhibition are affected by the sympathetic and parasympathetic branches of the automatic nerves that actively work opposite each other.[15] Gray and Mc Naughton believe that sensitivity of behavioral inhibition system is the predictor of person's negative emotional stresses in stressful situations, regardless of the nature of stressors, and it seems, behavioral inhibition predicts a person's poor and passive coping.[16] The results of studies by Gray, Mc Naughton, Guth, and Sharon consider the activity of the behavioral inhibition system to be associated with heart diseases, and believe this to be due to creation of negative emotions and increased activity of sympathetic system.[16-18]

Despite the importance of psychological factors in the incidence of heart diseases, unfortunately, only a few studies have been conducted in Iran in respect of the relationship between pleasant and stressful stimuli and brain-behavioral systems with this disease. While these parameters may not singularly affect the incidence of heart diseases, in combination, they amplify each other's effects. To address this shortfall, and considering the diverse and sometimes conflicting findings about the relationship between attributes of personality and essential hypertension, the present study examined the relationship between the parameters mentioned and essential hypertension. Since by identifying the relationship between these parameters and hypertension, and comparing the results with healthy people, we can effectively reduce the rate of essential hypertension by increasing awareness, providing correct information to those at risk, implementing clinical interventions like psychological counseling with the aim to provide skills necessary to deal with stress, reducing risky behaviors and encouraging people to change their lifestyle.

Materials and Methods

The participants in this study initially included 85 male patients with essential hypertension that received relevant information and explanation with respect to the objectives of the study and the questionnaire. After presentation of all the necessary explanations, first, the short form of Carver & White brain-behavioral systems questionnaire was performed on the participants, and ultimately 50 male patients with essential hypertension (25 BIS patients and 25 BAS patients), who had scored higher marks in the questionnaire than the rest were selected (matching participants in terms of demographic parameters). Before presentation of stimulus, participants' heart rate and blood pressure were measured and recorded. Then, in order to assess the effect of stress on blood pressure and heart rate, they were exposed to stressful stimuli. These stimuli included 13 slide images of war crimes shown over 3 minutes, (14 seconds each) presented on laptops. After presentation of these slides, participants' blood pressures and heart rate were measured by a digital brachial sphygmomanometer. They were then rested for 15 to 20 minutes. While resting, participants performed a cognitive exercise (successive subtraction of 7 from 100) to neutralize the effect of previous stimulus. Subjects were then exposed to pleasant stimuli that included 13 slide images of children under a year old over 3 minutes (14 seconds each). After presentation of these slides, blood pressure and heart rate of the subjects were measured again by a digital brachial sphygmomanometer. Once the procedure had ended, the results obtained from blood pressure and heart rate readings were examined and the data were prepared for final analysis. This questionnaire, with 24 self-reporting items was designed by Carver & White in 1994.[19] The BIS sub-scale includes 7 items that measure behavioral inhibition sensitivity or response to threat and feeling of anxiety when faced with signs of threat. The BAS sub-scale includes 13 items and measures behavioral activation system sensitivity. The items are in the 5-option Likert style; with score 1 indicating 'very true for me' to score 5 indicating 'very false for me'. In a study by Atrifard, BIS internal consistency was 47%, BAS internal consistency was 47% and its other sub-scale like response to reward, drive, and fun-seeking were 73%, 60%, and 18% respectively.[20] For data analysis, descriptive statistics with measures of central tendency (mean and standard deviation) and inferential statistics with multivariate covariance analysis (MANCOVA) were used.

Results

Table 1 shows the descriptive statistics of both participating groups. At two stages (pre-test and post-test), the increase in blood pressure and heart rate was higher in BIS patients compared to BAS patients. The results of covariance analysis of cardiovascular response in two groups are presented in Table 2. In this analysis, pre-test scores were statistically controlled. It can be seen that there was a significant difference between the two groups in diastolic blood pressure ($P<0.001$) and heart rate ($P<0.018$) after presentation of stressful stimulus. But the difference between the groups in systolic blood pressure after stressful stimulus was insignificant. Table 3 presents the difference in means between two groups, in which diastolic blood pressure (*P*<0.001) and heart rate (*P*<0.018) increased significantly in BIS patients compared to BAS after stressful stimulus. Also, systolic blood pressure (*P*<0.033) and heart rate (*P*<0.013) significantly reduced in BAS patients after pleasant stimulus compared to BIS patients. In other areas, the difference was insignificant. To ensure normal distribution of data and compliance with conditions of use of parametric statistics, the Kolmogrov-Smirnov test was utilized, and results obtained indicated normal distribution of data (*P*>0.05). The BOX test was used to examine the assumption of equality of covariance parameters, and the assumption was verified by the results with no significant difference between them (*P*>0.05). To verify the assumption of equality of population groups' variances, Lawn test was employed, and results indicated equality of variance parameters and no significant difference between them (*P*>0.05). Additionally, the regression slope test was used to determine presence or otherwise of a linear relationship between pre-test and post-test scores, and results showed that there was no significant interaction between the groups and pre-test scores in systolic and diastolic blood pressures and heart rate. In other words, the regression slopes were homogeneous and the assumption was proven.

Discussion

In line with Gray & Mc Naughton[16] findings, the present study showed that sensitivity of behavioral inhibition system is predictor of negative emotion stresses in stressful situations, regardless of the natural stressors. Also, it seems behavioral inhibition is predictor of person's poor and passive coping. The results of studies by Gray & Mc Naughton[16], Guth[17], and Sharon[18] regard activity of behavioral inhibition system to be associated with heart diseases, and believe this to be due to negative emotions and sympathetic system activity. Eyesneck[21] claims that neurotic people have higher levels of activity in sympathetic area of the autonomic nervous system. This is the body's warning system that responds to stressful events by increasing respiratory rate, heart rate, blood flow to muscles, and release of adrenaline. In fact, neurotics react with excitement to event unimportant to others, which can simultaneously activate behavioral inhibition system, and according to Gray & Mc Naughton's findings, highly active behavioral inhibition system leads to anxiety attributes in personality. Experimental studies have also shown that activity of behavioral inhibition system is associated with high cortical arousal, particularly in right hemisphere of the brain, and electroencephalography (EEG) and neuronal imaging data reveal that the presence of threatening stimuli is related to higher arousal of

Table 1. Mean and Standard deviation of systolic and diastolic blood pressure and heart rate divided into groups, and time

Component	After pleasant stimuli Mean ± SD	After stressful stimuli Mean ± SD	Before stimulus Mean ± SD	After pleasant stimuli Mean ± SD
Systolic blood pressure in BIS patients	139.06 ± 5.1	145.93 ± 8.69	135.6 ± 8.69	139.06 ± 5.1
Diastolic blood pressure in BIS patients	89.6 ± 7.09	106.23 ± 7.32	91 ± 10.25	89.6 ± 7.09
Heart rate in BIS patients	89.13 ± 4.65	90.8 ± 8.09	83.4 ± 8.45	89.13 ± 4.65
Systolic blood pressure in BAS patients	125 ± 5.38	136.26 ± 8.88	133.4 ± 10.91	125 ± 5.38
Diastolic blood pressure in BAS patients	84.2 ± 5.75	76.81 ± 6.68	79.46 ± 7.36	84.2 ± 5.75
Heart rate in BAS patient	66/26 ± 5.76	77.2 ± 10.68	77.8 ± 8.72	66/26 ± 5.76

BIS patients= Behavioral Inhibition System patients , n=25
BAS patients= Behavioral Approach System patients , n=25

Table 2. Results of covariance analysis (Systolic and Diastolic blood pressure and Heart rate) in BIS & BAS patients

Dependent variable	F	sig	Partial Eta Squared
Systolic blood pressure after stressful stimuli	0.194	0.663	0.008
Diastolic blood pressure after stressful stimuli	17.125	0.001	0.407
Heart rate after stressful stimuli	6.441	0.018	0.205
Systolic blood pressure after pleasant stimuli	2.225	0.148	0.082
Diastolic blood pressure after pleasant stimuli	1.23	0.283	0.046
Heart rate after pleasant stimuli	0.395	0.535	0.016

DF=1, P≤0.05

Table 3. Paired comparison groups in systolic and diastolic blood pressure and heart rate

Dependent variable	Group	Group	Mean difference	Std. Error	Sig*
Changes in systolic blood pressure (stressful stimuli)	BIS patient	BAS patient	2.074	4.706	0.663
Changes in diastolic blood pressure (stressful stimuli)	BIS patient	BAS patient	11.947	2.887	0.001
Changes in heart rate (stressful stimuli)	BIS patient	BAS patient	10.596	4.175	0.018
Changes in systolic blood pressure (pleasant stimuli)	BIS patient	BAS patient	9.879	6.554	0.033
Changes in diastolic blood pressure (pleasant stimuli)	BIS patient	BAS patient	-6.009	9.364	0.524
Changes in heart rate (pleasant stimuli)	BIS patient	BAS patient	10.966	9.658	0.013

*P≤0.05

the right prefrontal cortex, whilst neuroticism is also associated with relatively high activity of the right frontal.[16] Stress can also cause heart diseases through physiological changes.[22] It seems stress has direct effects on the coronary arteries and heart muscles. In response to stress or exposure to a threatening or dangerous situation, heart rate increases, blood pressure rises, and many other changes in other body systems occur. For instance, skin blood vessels tighten, muscles contract and blood flow to the brain and muscles increases. As a result of these changes, heart rate rises and the heart's oxygen requirement increases, which can cause heart attack or angina (chest pain) in people with heart diseases.[22] Moreover, stress can cause increased blood clotting capability. This clot can partially or completely block a coronary artery, leading to a heart attack. Also, with increased hormones (adrenaline) in response to stress, together with increased blood flow, they can damage the lining of arteries and thicken or toughen vessel walls (once healed), thus preparing the grounds for creation of plaque. All these cases can explain why people with heart diseases in stressful situations are affected by angina, and also why these attacks more often occur in such circumstances.[22]

Several studies have shown the importance of sympathetic activity and its subsequent effect on cardiovascular diseases.[23] There is considerable evidence in support of the association of sympathetic reaction with cardiovascular diseases. For example, rise in heart rate is caused by sympathetic heart activity, and is inhibited by parasympathetic heart activity. Heart rate can also be caused by the effect of activities independent of the autonomic system. In normal heart condition, parasympathetic effects promote health, self-regulation, and a state of calm behavior that protects the heart and diminishes sympathetic reaction in stress. Conversely, reduced parasympathetic control of heart rate is associated with cardiovascular diseases, causing elevated blood pressure, and death.[23]

The results of this study also reveal a significant reduction in systolic blood pressure and heart rate in BAS patients compared to BIS after presentation of pleasant stimulus.

In line with these findings, Rafienia *et al*. found that in positive moods, systolic blood pressure reduces compared to negative mood conditions.[24] This could concur with Gray's forecast in relation to sensitivity to reward in BAS patients.[25] But, in opposition to results of the present study, Lewis *et al*. [26] showed that there was no significant difference between the subjects' mean heart rate in positive and negative mood conditions.

According to Eyesneck hypothesis, extrovert people are more sensitive to positive stimuli than introvert people. If this hypothesis is correct, then extroverts are more responsive to induced positive emotions (affects) than introverts.[27] In his hypothesis, Gray expresses high sensitivity of BAS people to indications of reward, which somehow reflects early arousal component of extroversion.[28,29]

Based on Gray's hypothesis, it can be concluded that people with hypertension respond more strongly or quickly to new stimuli, innate fear stimuli, and conditional aversive stimuli than normal people with behavioral inhibition outputs (impaired current behavior) with increased arousal (that can be continuation of the impaired action). Also, in these conditions, increased attention to the environment when more information is received, especially about new elements in environment, is more observed in hypertensive people than in normal people.[30]

Study limitations and recommendations

Like other studies, the present study was also faced with limitations that affect generalization of its results. Firstly, this study was conducted on people over 40 years of age only; secondly, the participants were all male; and finally, the sample size was small. It is recommended that in future studies, all age groups be included, of both sexes, and with larger sample size.

Conclusion

In relation to Gray's hypothesis, it can be asserted that, since BIS patients experience more negative emotions than BAS patients, BIS patients have higher diastolic blood pressure and heart rates compared to BAS patients. Thus, in addition to medical treatment to better control blood pressure and prevent pressure fluctuations throughout the day, BIS patients should also receive psychological counseling and training.

Ethical issues: This study was reviewed and confirmed by the ethics committee of Tabriz University of Medical Sciences.

Conflict of interests: The authors declare no conflicts of interest.

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