Neuroticism and Vascular Response to Mental Load

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Article ID: WMC003951
Article Type: Research articles
Submitted on: 15-Jan-2013, 10:44:34 PM GMT  Published on: 16-Jan-2013, 02:11:38 PM GMT
Article URL: http://www.webmedcentral.com/article_view/3951
Subject Categories: PHYSIOLOGY
Keywords: Personality, Neuroticism, Mental stress, Cardiovascular stress response

How to cite the article: Stoyanov Z, Boncheva I, Nikolova P, Ivanova M. Neuroticism and Vascular Response to Mental Load. WebmedCentral PHYSIOLOGY 2013;4(1):WMC003951

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Source(s) of Funding:
None

Competing Interests:
None
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Abstract

Various personality traits are thought to have an influence on stress reactivity. The studies aimed at elucidating the association between neuroticism and cardiovascular response to stress have produced contradictory data. The aim of the present study was to compare the vascular responses to mental load in low neurotic and high neurotic subjects. A total of 41 young volunteers (25 males and 16 females) were studied. The Eysenck Personality Inventory was used for assessment of neuroticism. The mental challenge was a combination of memory and mental arithmetic tasks. The values and the reactive changes of the photoplethysmographic index known as “module of elasticity” (ME) were used for assessment of the vascular stress response (higher values of ME indicate higher tonic tension of blood vessels). The ME before mental load had lower values in low neurotic group compared to the high neurotic group: 15.8 vs. 19.3 (t = 2.43; p = 0.02). During the mental load, ME reached higher values in high neurotic group (22.6) in comparison with low neurotics (19.1) (t = 2.00; p = 0.05). Baseline-to-task relative changes in ME were similar in both groups. It can be concluded that an association between neuroticism and anticipatory vascular stress response does exist.

Introduction

Mental stress is an integral part of modern everyday life and the peculiarities of individuals’ stress reactivity can be an important risk factor for health. For instance, exaggerated cardiovascular reactivity is thought to be involved in the pathogenesis of coronary atherosclerosis (1), and is considered as a predictor of essential hypertension (2, 3). There are suggestions that the degree of cardiovascular reactivity to psychological stress may be predictive of later development of cardiovascular disease (4,5).

Various personality traits are thought to have an influence on cardiovascular reactivity (6, 7). The attention of the researchers is focused mainly on personality dimensions closely associated with emotion, because the experience and the regulation of emotions have been associated with cardiovascular responses (8, 9). Neuroticism, one of the Big Five personality traits, is an indicator of proneness to negative affectivity (7). Several studies investigated the relationship between neuroticism and cardiovascular reactivity (10-12), but the results obtained to date are contradictory. Schwebel and Suls (13) found an association of neuroticism with heart rate reactivity to laboratory stressors, but not with blood pressure reactivity. Contrary to that finding, Kennedy and Hughes (14) found an association of neuroticism with blood pressure reactivity, but not with heart rate reactivity. Brody et al. (15) did not find a link between neuroticism and heart rate or blood pressure reactivity in subjects performing a mental arithmetic task. Jonassaint et al. (11) reported that in males neuroticism negatively correlates with vascular reactivity to mental stress. The exact relationship between neuroticism and cardiovascular reactivity has not been clarified yet. That’s why the aim of the present study was to compare the vascular responses to mental load in low neurotic and high neurotic subjects.

Methods

Participants

A total of 41 volunteers (25 males and 16 females), undergraduate students at Varna Medical University, took part in the experiment. Subjects ranged in age from 20 to 27 years. Written informed consent was obtained from subjects after the aim, methods and experimental procedure had been explained.

Assessment of neuroticism and experimental groups formation

The Eysenck Personality Inventory (EPI) was used for assessment of neuroticism. Neuroticism scores were subjected to descriptive statistics and the median was established. According to the median value (10 units) the subjects were divided into two groups: of low neurotic individuals (neuroticism scores below the median) and high neurotic individuals (neuroticism scores above the median) (16, 17). Four subjects with neuroticism scores equal to the median were excluded from sample. Thus the group of low neurotic individuals (mean neuroticism score 6.2) included 17 subjects (13 males and 4 females), and the group of high neurotic individuals (mean neuroticism score 14.2)
included 20 subjects (10 males and 10 females).

Physiological data acquisition

The volume changes of peripheral blood flow were monitored and recorded by means of infrared photoplethysmographic (PPG) probe attached by an adhesive collar onto the distal phalanx of the index finger of the participants. The record and processing of the physiological signal were made by using a probe, amplifier, hardware and AcqKnowledge software of Biopac System Inc (CA, USA).

Procedure

Experimental sessions were carried out in the time interval 10 am to 2 pm. The hand on which the PPG-probe was attached was tempered in advance for 10 minutes in water of 36°C. After the adaptation of the participants to the laboratory environment, in a sitting position, two 2-minute PPG recordings were made: the first one done before the mental load, and the second during mental stress. The laboratory stress was modelled through mental load, which consisted of a short-term memory task for digits combined with a mental arithmetic task (18).

Data reduction and statistical analysis

The physiological data from the second minute of the first record (made before the mental load) and the first minute of the mental load were analyzed, because some of our previous observations showed that the autonomic parameters in these minutes are most informative for the state (19). The parameters of 10 PPG complexes (every 6 seconds) were measured and averaged. The values and reactive changes \([\text{(task–baseline)/baseline}]\) of the photoplethysmographic index known as “module of elasticity” (ME) were used for assessment of the vascular stress response (Figure 1). Higher values of ME indicate higher tonic tension of blood vessels (20, 21). Data were statistically analyzed by means of GraphPad Prism 4.03 software (GraphPad Software, Inc.) An unpaired two-tailed Student’s t-test was used for between-group comparisons. A p<0.05 was considered significant.

Results

The results obtained on ME are presented in Table 1. The values of ME before the mental load had significantly higher values in high neurotic group than in low neurotic: 19.3 vs. 15.8 (\(t = 2.43; p = 0.02\)). In high neurotic group the ME was on the upper limit of the physiological range of 13 to 19 relative units (20). During the mental load, the ME increased in both groups reaching higher values in high neurotic group: 22.6 vs. 19.1 in low neurotics (\(t = 2.00; p = 0.05\)). Baseline-to-task relative changes in ME were similar in both groups.

Discussion

The results obtained confirmed that neuroticism has an effect on the level of tension of cardiovascular regulatory mechanisms. In laboratory stress conditions, before and during mental stress we established higher vascular tone in the high neurotic group. Our finding corresponds to the opinions that high neurotics have a more reactive sympathetic nervous system (22). Strictly speaking, our results are not in full agreement with literary data suggesting an association of greater reactivity to stress with higher neuroticism (23). According to some definitions, cardiovascular reactivity refers to the magnitude of cardiovascular responses to challenges (4). The magnitude of vascular response (baseline-to-task changes in ME) in our study did not differ between high neurotics and low neurotics. Other psychophysicists however pay attention to the period preceding the mental task. It can be characterized as a period of emotional, behavioral, and physiological arousal attendant to an impending challenge. According to Everson et al.(1) such elevations in cardiovascular function in anticipation of challenges reflect cardiovascular adjustments in response to psychological and behavioral stresses, and should be considered as a component of cardiovascular reactivity. Thus, the observed significantly higher vascular tone in high neurotics before and during mental load can be assumed to be a manifestation of both exaggerated anticipatory vascular response and vascular reactivity to mental stress.

What kinds of mechanisms underlie the relationship between personality and stress response, and neuroticism and vascular stress reactivity in particular, still remains an unsolved question. According to Flaa et al.(6), the possible mechanisms of psychophysiological reactivity, can be grouped in three main categories: mechanisms at cognitive-emotional level (based on the competencies of the cerebral cortex and limbic system), mechanisms at subcortical level (involving hypothalamic translation of emotional reactions into autonomic or endocrine outputs), and
mechanisms at peripheral tissue level (like altered receptor sensitivity). Many researches on the neuroticism provided support for such a point of view. A number of EEG studies have demonstrated that neuroticism is associated with greater activation of the right frontal lobe relative to the left (24,25). It is worth noting that the right hemisphere is more involved both in negative emotion processing (26,27) and in autonomic stress response control (28). In support of the suggested involvement of subcortical mechanisms is the established association of neuroticism with higher levels of adrenocorticotropic hormone and cortisol (7,29). Both stress hormones have cardiovascular effects (30, 31). Cortisol increases sensitivity of adrenergic receptors to norepinephrine and epinephrine, i.e. predisposes to increased cardiovascular reactivity. In this context it is important to mention that neuroticism has been linked to higher levels of norepinephrine (7).

However, the present research was not designed to study the intimate mechanisms underlying the association of neuroticism and cardiovascular stress response. Another limitation of the present study is the small number of the subjects studied. The small sample does not allow us to consider the sex differences established in some of studies on neuroticism and reactivity. We would like to limit our conclusion to the statement that there is an association between neuroticism and tension of cardiovascular regulatory mechanisms, particularly in stress conditions. Further research is needed to clarify the relationships between personality, stress reactivity and health.

References

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Illustrations

Illustration 1

Figure 1. Photoplethysmographic (PPG) index ME or $a:T$, where $a$ (thick arrow) is the duration (in msec) of the ascending part of the PPG-wave, and $T$ (dotted arrow) is the duration (in msec) of the whole PPG-complex. On the top chart: PPG record at rest. On the bottom chart: PPG record during mental load.
Illustration 2

Table 1. Values of ME (mean plus minus standard deviation)

<table>
<thead>
<tr>
<th></th>
<th>Before mental load</th>
<th>During mental load</th>
<th>Baseline-to-task change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low neurotics</td>
<td>15.8 ± 2.4</td>
<td>19.1 ± 4.8</td>
<td>0.21 ± 0.25</td>
</tr>
<tr>
<td>High neurotics</td>
<td>19.3 ± 5.5</td>
<td>22.6 ± 5.6</td>
<td>0.20 ± 0.24</td>
</tr>
</tbody>
</table>
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