

Integrative aspects of the relationship between stress and heart rate variability

Aspectos integrativos da relação entre o estresse e a regulação autonômica cardíaca

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ABSTRACT

The literature indicates stress as a response of the organism to a stimulation that requires enormous efforts to adapt to the changes in the environment and the body. When an individual is subjected to stress, the autonomic nervous system is triggered, the sympathetic pathway is activated, and the parasympathetic system is suppressed, which exerts several effects on the cardiovascular system and affects heart rate variability. This research aimed to conduct a literature review to find and analyze the studies that address clearly the implications of stress on heart rate variability. The methodology employed was an active search in the databases SciELO, PubMed and Lilacs. The results were five articles, most of which suggest a relationship between stress and heart rate variability. We observed that the majority of the studies indicated a strong association between stress and cardiac autonomic activity. The stress is present in the daily activities of the population, especially in labor. The subject is vast, however, were observed in the references the effects of stress on the body making it vulnerable to diseases. Thus, this information may contribute to the aid of preventive strategies against stress and diseases of the cardiovascular system.

Keywords: stress, physiological; autonomic nervous system; heart rate.

RESUMO

A literatura mostra que o estresse é uma resposta do organismo frente a um estímulo que o impõe a produzir um esforço mais elevado para se adaptar às circunstâncias que estão ocorrendo, tanto no ambiente como no organismo. Quando um indivíduo é submetido a tensão, o sistema nervoso autônomo é disparado, ativando a via simpática e o sistema parassimpático é suprimida, exercendo vários efeitos sobre o sistema cardiovascular e atingindo a variabilidade da frequência cardíaca. A presente pesquisa teve por objetivo realizar uma revisão de literatura, a fim de encontrar e analisar estudos que abordem de forma clara as implicações do estresse sobre a variação da frequência cardíaca. O método empregado foi uma busca ativa nas bases de dados SciELO, Lilacs e PubMed. Os resultados encontrados foram de cinco trabalhos, cuja maioria sugere uma relação entre o estresse e variações da frequência cardíaca. A maioria dos estudos demonstrou uma associação entre estresse e a atividade autonômica cardíaca. O estresse está presente nas atividades cotidianas da população, principalmente nas laborais. O assunto é vasto, porém, foram observados nas referências os efeitos do estresse sobre o organismo, tornando-o vulnerável a doenças. Assim, essas informações podem contribuir para o auxílio de estratégias preventivas ao estresse e a patologias do sistema cardiovascular.

Palavras-chave: estresse fisiológico; sistema nervoso autônomo; frequência cardíaca.

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INTRODUCTION

Stress involves a positive or negative response after a stimulation that requires us to make a greater effort than usual to adjust to what is happening, both in the environment and within the organism¹. Its signals change the physiological state of various organs such as the heart, stomach, kidneys, muscles, and the reproductive system². Its direct relationship with the body may initially be perceived by muscle tension, changes in sleep, feeding, and may be a triggering factor for some disturbances³. An excessive cardiovascular response under stress tends to cause structural cardiac changes, which pre-disposed to heart disease, hypertension, and other diseases that affect the heart⁴.

The cardiac system plays an active role in the adaptations to stress and is subject to neurohumoral influences, and despite the release of hormones to be a part of this mechanism the autonomic nervous system (ANS) plays a very important role⁵. Various functions of the body are related to the control of the autonomic activity, which branches into sympathetic and parasympathetic innervation to the human body in general, as well as the heart. The sympathetic system also participates actively in stress reactions, preparing the individual for fight or flight⁶.

Several lines of evidence indicate the sympathetic hyperactivity in hypertension, heart failure, and other diseases, whereas a reduction of parasympathetic function appears to contribute to increased blood pressure variability⁷. These sympathetic and parasympathetic systems interact constantly, and this relationship is reflected in heart rate variability (HRV)⁸.

The HRV is a conventionally accepted term to describe the variations between consecutive heart beats (RR interval durations)⁹. It is defined as the fluctuations in heart rate compared with the average heart rate, and it is a useful tool for assessing autonomic activity in the balance of sympathetic and parasympathetic components, and their effects on the cardiac control¹⁰. It is a noninvasive and cost-effective method^{11,12}.

In view of the above-mentioned consideration, we aimed to describe the relationship between stress and HRV.

METHODS

A search was conducted in active databases Scientific Electronic Library Online (SciELO), the Latin American and Caribbean Center on Health Sciences (LILACS), and National Library of Medicine Institutes of Health (PubMed) for 2 months, December 2012 to January 2013 using the following terms: "stress", "heart rate variability", "cardiovascular system," and "autonomic nervous system", both in Portuguese and English.

Inclusion criteria were clearly related to the theme, publication dated from 2008 and review articles were excluded, as well as studies that did not fit into these criteria.

RESULTS

The electronic search with the selected descriptors obtained 8,546 scientific papers. Initially, an analysis of titles, abstracts, and keywords prioritized studies with larger number of descriptors of interest. Among the remaining 53 studies evaluated, we excluded studies that did not address clearly the issue at hand, literature review and those that were published before 2008 and literature review.

Finally, five studies were selected; among them two were published in Brazil and other foreign works of authorship. The most relevant points and the main findings of these studies in relation to stress and its effects on HRV are detailed in Table 1.

DISCUSSION

Among the studies selected for this review, the majority stated that the presence of stress may have implications on HRV. However, it needs a larger number of researches that are directly related to this issue, even in other contexts, as stress is increasingly present in the routine life of the population.

In postmodern society, stress has turned into a common problem for health¹³. It has become a global epidemic and affects 90% of the world population¹⁴. With the perspective to prevent this epidemic and promote health, as well as improve the quality of life, we gathered and analyzed studies with this scope. In parallel, we opted for the method of HRV due to its wide dissemination in the scientific community. HRV is among the most used techniques to assess sympathetic and parasympathetic function in cardiovascular diseases⁷.

Table 1: Major research that indicates a relationship between stress and heart rate variability

Authors	Main findings
Taelman <i>et al.</i> ⁸	The results suggest changes in HR and HRV imposed in stressful situations. Thus, records of HR and HRV have the potential to measure stress levels.
Orsila <i>et al.</i> ¹⁵	There is an association between some of the parameters of HRV and perceived mental stress of the subjects. HRV values presented suggest increased stress in the morning compared with that in the evening.
Longhi and Tomaz ¹⁶	Levels of stress, anxiety, and depression did not show any effect on HRV parameters. In this sample, the incidence of these psychological variables was minimal or absent.
Petrowski <i>et al.</i> ¹⁸	The psychosocial stress impairs HRV and increased HR. The ANS was more pronounced in patients suffering from panic disorder compared with subjects without the disorder.
Pacetti <i>et al.</i> ¹⁹	The analysis of HRV showed predominance of sympathetic nervous system stimulation and increased heart rate, indicating high levels of stress during the simulation of a practical activity.

ANS: autonomic nervous system; HR: heart rate; HRV: heart rate variability

The study by Taelman *et al.*⁸, which aimed to analyze the influence of mental stress on HR and HRV, reported changes in both variables, both at rest and mental stress. The results showed that the variability of short-term — percentage of RR interval (RRi) adjacent with a difference greater than 50 ms — is lower in activities of mental stress than during rest. However, the parameter of long-term variability — standard deviation of normal RRi — did not differ significantly between the conditions analyzed. The survey also showed that the low and high frequency ratio (LF/HF) increased during mental stress tasks, though not significantly. This increasing trend may indicate a higher sympathetic activity in a state of mental stress compared with rest⁸.

In general, the information found by the authors suggests changes in HR and HRV in a situation of imposed mental stress. In addition, the records indicated the potential of these variables to measure stress levels to guide preventive measures to reduce diseases linked to it. Nevertheless, situations of mental stress may be present in everyday activities, for example, if the role of the worker coexists with obligations and responsibilities, and then, it may trigger stress depending on all circumstances experienced by the worker. According to Loures *et al.*⁵, mental stress is present in the routine of the individual, its effects are reflected in almost the entire body, and cardiovascular system ends up being deeply affected. However, it is noteworthy that there are numerous factors that may produce a stress state.

In this context, the research of Orsila *et al.*¹⁵ with employees of an electronics company emerges, in which the authors sought to find the HRV parameters related to mental stress. They concluded that there is an association between HRV parameters with the mental stress perceived by workers, once in the morning the HRV indexes — root mean square of the sum of squares of differences between adjacent RRi, triangular interpolation of NN interval histogram, and HF — were lower suggesting greater stress. In contrast, the same HRV indexes were higher overnight, indicating relaxation and reduced mental stress. Furthermore, the authors stated that the values of the low frequency and the LF/HF were higher in the morning and lower at night. These data also indicate greater mental stress during the morning and less stress during evening.

Within this framework of stress in the workplace, the results found by the Brazilian researchers Longhi and Tomaz¹⁶ with professionals and healthcare in intensive care units are presented. A majority of the recorded data were discrete levels of stress, anxiety, and depression, where these psychological variables were not correlated with changes in any of the measures in HRV. The researchers suggested emotional time service sector as a possible reason for the low level of these elements, which among professionals of the sample was 2.7 years. The authors also pointed that longer exposure to the work probably would cause a higher incidence levels of these psychological disorders, and consequently the possibility of more significant changes in HRV.

Moreover, it was noted that there were changes in the activity of the parasympathetic nervous system in relation to the intensity level of the duty. The sample population reported having at least 1-h break during the work shift and the level of intensity of the call most of the participants considered as mild, suggesting influences between the factors because the subject who termed the light shift rested more time and presented better HRV indexes¹⁶.

Thus, it is understood that one of the reasons that contributed to that may be the absence of stress and other emotional disorders. Exposure to stress triggers the ANS, activates the sympathetic system, and suppresses the parasympathetic system¹⁷. All of these conditions produce an increased release of plasma adrenaline and noradrenaline, which causes vasoconstriction, increased blood pressure, and decreased HRV⁸. The opposite is also true, the absence of stress maintains homeostasis of the organism, so that the professionals of the sample reported having enjoyed moments of rest, and work performed in the opinion of most of these subjects in the sample is light, and is therefore, favorable rates HRV by parasympathetic nerve activity as quoted by the researchers themselves.

The evaluation of the cardiovascular system and its variability were also considered along with other population profile, highlighting the work of German researchers. Petrowski *et al.*¹⁸ concluded in their study that many individuals with panic disorder compared with the subjects without this psychological disorders have an increased heart rate during a standardized test of psychosocial stress (Trier Social). However, in one HRV index analyzed, (LF/HF was elevated only in the group with panic disorder when performing experimental stress, whereas this change was not observed in the control group.

Other studies also indicate that there is an upward trend in LF/HF in situations of mental stress compared with situations of rest⁸. It is suggested that the sample participants with panic disorder are most vulnerable to this type of situation, due to the existing problems, while the group without the disorder seems to have made a better adaptability. Even with changes in HR, body signals issued reinstatement of homeostasis maintaining levels of LF/HF without apparent discrepancy.

Pacetti *et al.*¹⁹ argue that the profession of air traffic controller generates anxiety and stress, because these professionals are responsible for human lives, and also face the shortcomings of the operating system in the Brazilian air traffic, experiencing stressful conditions in their daily work. The results found by these researchers also showed that these professionals face stressful situations in their academic program as students. Analyzing the ANS activity by HRV during a practice simulation on radar revealed that the sympathetic nervous system was more stimulated, concomitant with decreased vagal tone compared with the area of the sympathetic component in the rest period. Heart rate was also increased during the training. By gathering this information is worth mentioning the study reviewing by Thayer *et al.*²⁰, which results in their research supported previous ideas that the vacant serves

as a structural and functional connection between the brain and heart, and also provide evidence for the importance HRV as a potential indicator of stress and health.

It is understood that mental stress may affect the cardiovascular system, as its effects seem to influence the activity of the ANS. However, the mechanism by which these reactions are induced can be distinguished from physical stress⁵. Thus, they are more studies on the implications of stress on all areas, that is, psychological, physical, and sociocultural factors that interrelate to form the end of the subject, as there is no consensus in the literature on differences between physical and emotional stress. To Farias *et al.*²¹ differentiate the physical stress of the psychological causes great difficulty in the prevalence of a holistic look.

CONCLUSION

This study analyzed some studies of domestic and foreign production related to the influences of stress on HRV. Most studies showed an association between stress and cardiac autonomic activity. Moreover, it is clear that stress is present in the daily activities of the population, especially in labor. The HRV method is a tool in the scientific world renowned for its numerous advantages, such as easy application and favorable cost-benefit ratio; therefore, they are among the most used techniques in evaluating the autonomic nervous system. It is important to note that the subject is vast; however, it was possible to ascertain the current literature about the effects of stress on the body which make it vulnerable to diseases. Thus, this information may contribute to assist in the preventive strategies against stress and diseases of the cardiovascular system.

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