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Factors Influencing Heart Rate Variability

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Abstract

The measurement and analysis of heart rate variability (HRV), which is based on the variation between consecutive NN intervals, has become an established procedure over the past two decades. A decrease in HRV has been shown to correlate with an increase in mortality. HRV is influenced by a number of physiological factors such as various diseases. Awareness of these mediators or confounders is of great importance in the analysis and assessment of HRV both in scientific studies and in clinical practice. This document, which is based on a selective survey of references and supplemented by information from national and international guidelines, presents the main endogenous, exogenous and constitutional factors. A decrease in HRV has been observed not only in connection with non-influenceable physiological factors such as age, gender and ethnic origin, but also in conjunction with a large number of acute and chronic diseases. Numerous lifestyle factors have both a positive and a negative influence on HRV. There are also physical influences that affect HRV. They must on no account be disregarded. Although the list of the factors is long and not all of them have yet been fully studied, awareness of them is of crucial importance in the measurement of HRV (both under laboratory conditions and during medical practice), its analysis and its assessment. More research also needs to be carried out to close knowledge gaps.

Key words: autonomic nervous system; heart rate; analysis; sympathetic; parasympathicus

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Introduction

The measurement and analysis of heart rate variability (HRV), which is based on the variation between consecutive NN intervals, has become an established procedure over the past two decades[1-4] since the publication of the first guidelines[5]. Not only have there been advances in recording technology (smaller, more mobile, more accurate devices)[6], but NN intervals can now also be measured by small chest strap and pulse watch systems[7,8]. Technological developments have decreased the costs of recording and analysis and have facilitated outpatient applications.

The variability of the successive differences between the NN intervals depends on sympathetic and parasympathetic influences. Mathematical algorithms can be used to calculate various HRV parameters from a time series of successive NN intervals. It is customary to make a distinction between so-called HRV parameters of the time domain and frequency domain and so-called non-linear HRV parameters[5,7,9].

A decrease in HRV has been shown to correlate with an increase in mortality, for example after myocardial infarcts[10-12], after bypass operations[13], or in connection with cardiac insufficiency[14].

HRV is influenced by a number of physiological factors such as various diseases. Awareness of these mediators or confounders is of great importance in the analysis and assessment of HRV both in scientific studies and in clinical practice.

Methods

This document, which is based on a selective survey of references and supplemented by information from national and international guidelines[5,7], presents the main endogenous, exogenous, and constitutional factors. The references primarily cover metaanalyses and systematic reference surveys on the subject and is supplemented by extensive cohort studies.

Results

In addition to non-influenceable physiological parameters, a number of factors emanate from the lifestyle habits of the test persons, from the consequences of these habits and from external circumstances. A host of diseases go hand in hand with a decrease in HRV, while the influence on the vegetative nervous system can be regarded more as a result of diseases and only rarely as the potential cause of this decrease.

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Physiological factors
Non-influenceable physiological factors include age, gender and circadian rhythm. A person's HRV first increases sharply until they reach the age of one and continues to increase considerably until they reach the age of 15, while the resting heart rate decreases[15]. Their HRV then decreases as they grow older[16-18]. It also seems clear that there is a difference between men and women in the way the autonomous nervous system is regulated and thus in the sympathetic-parasympathetic balance, and this manifests itself in differing HRVs[16,19-26]. This difference between the genders seems to become less prominent when people reach the age of 50, a fact that is attributed to the postmenopausal hormonal changes that take place in women[27,28]. HRV, like a number of other physiological parameters, is subject not only to age and gender, but also to a circadian rhythm[29]. This must be taken into account in particular with short-term measurements ranging from a few minutes to a few hours are made. HRV increases at night and decreases considerably during the morning hours.

Genetics
While a genetic disposition of the HRV is discussed in twin studies[30], Riese et al.[31] did not establish any connection between eight key genes for the presence of acetylcholine receptors as part of the autonomous nervous system and the HRV level in an analysis of several cohort studies involving a total of 6,470 test persons.

In contrast, ethnic origin seems to have an influence on HRV. In a metaanalysis based on a systematic reference survey involving 17 studies and a total of 11,162 test persons, Hill et al.[32] established a significantly higher short-term resting HRV in Afro-American test persons than in American test persons of European origin.

Diseases
The effects of various diseases on HRV have been examined in many studies. HRV is lower throughout among patients with the diseases concerned than among healthy test persons.

Sepsis
There is evidence that HRV decreases among people with severe acute diseases, including multiple organ failure, and that this decrease correlates with an increase in mortality[33,34].

Heart diseases
A decrease in NRV has been found among people with heart disease and cardiac insufficiency[35] or who have suffered a heart attack[1]. It has been known since the mid-1980s and was confirmed in a meta-analysis that a decrease in HRV correlates with an increase in mortality[10]. Also Hypertension reduced HRV[36].

Lung diseases
People with a chronic obstructive pulmonary disease (COPD) also seem to have lower HRV[37] and the degree to which the HRV is lower correlates with the severity of the COPD.

Renal diseases
HRV is also shown to be lower in patients with chronic kidney insufficiency than in healthy controls[38].

Psychiatric diseases
People suffering from a series of psychiatric symptoms such as anxiety disorder[39], panic attacks[39,40], posttraumatic stress disorders[41], epilepsy42, anorexia[43], borderline personality disorder[44] and depressions[39,45,46] have been found to have lower HRV parameters.

It is in discussion if the reduction of HRV in patient with depression is caused by the depression itself or by the medication. O´Regan et al. have shown in a study with 4,750 peoples from Ireland that the medications lead to be the factor that reduced the HRV.[47] On the other hand Yeh et al. have detected, that the depression itself reduced the HRV and not the medication. They compared 618 patients with a major depression with 506 healthy peoples[48.]

Metabolic diseases
HRV is also shown to be lower among people with metabolic diseases such as diabetes mellitus[2,4]. With respect to the metabolic syndrome, however, only women have been found to have lower HRV, and not men[49].

Other diseases
While HRV studies concern a wide range of other diseases, there are at present only isolated studies on a major share of these diseases and most of them cover small groups of patients. A systematic review has revealed that only headaches[50] correlated with a decrease in HRV.

Diseases with no influence on HRV
Systematic reviews have revealed that some diseases, e.g. rheumatoid arthritis, cause no clear changes in the HRV of those suffering from them[51].

Lifestyle habits
In addition to these non-influenceable physiological factors, there are further factors, notably those related to the lifestyle habits of the test persons. These can have both a positive and a negative influence on HRV. They include physical fitness or sporting activity, increased body weight, which is sometimes negatively associated with the first two factors, active and passive smoking and regular alcohol abuse. People who have an active lifestyle and maintain a good or high level of physical fitness or above-average sporting activity can achieve an increase in their basic parasympathetic activity and thus an increase in their HRV[52-56]. Cumulative or too intensive sporting activity (e.g. competition series, overtraining syndrome), however, brings about a decrease in HRV[52,54]. In contrast, an elevated body weight or elevated free-fat mass[57] correlates with a decrease in HRV. Both active and passive smoking lead to an increase in HRV[58]. Regular chronic alcohol abuse above the alcohol quantity of a standard drink for women or two standard drinks for men reduces HRV, while moderate alcohol consumption up to these quantities does not change the HRV and is not associated with an increase[59].

External factors
In addition to climatic conditions and job-related parameters, several harmful substances and medications also have a direct or indirect influence on HRV. Climatic factors lead to changes in HRV due to the physiological reaction of the vegetative nervous system. Heat increases sympathetic nervous system activity, reducing HRV[60,61]. Long-term exposure to cold (e.g. at work or during the winter months) has not been found to have an influence on HRV[60,62,63] due to adaptation effects, e.g. after 60 days. Exposure to noise likewise leads to a decrease in HRV because it increases sympathetic nervous system activity[64-66]. Induced pain also results in a lowering of HRV due to the activation of the physiological sympathetic nervous system[67].

Night shift work over many years results in lower HRV due to the chronodisruption[68-70]. There seems to be a connection here between the length of time a person has done such shift work and the degree of the decrease in HRV.

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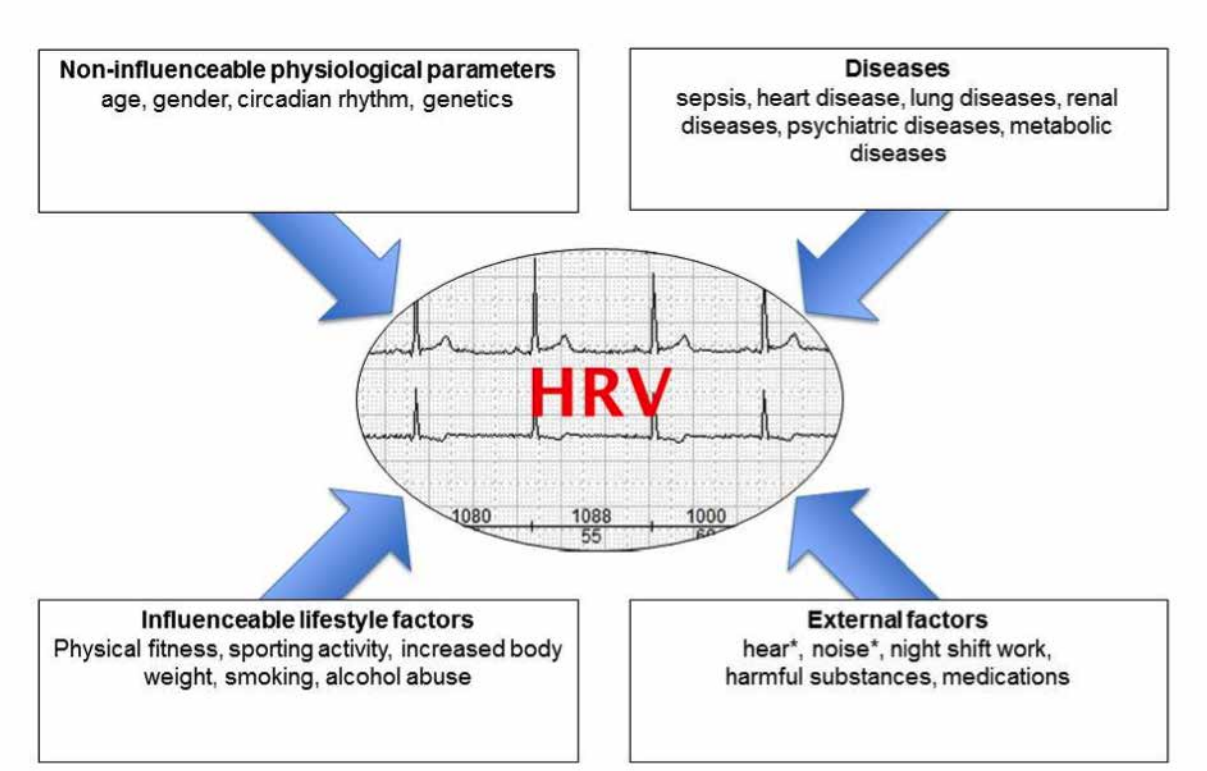

Fig. 1. The different factors influencing HRV grouped into four main areas, * = HRV decrease as a result of a physiological reaction to a physical stimulus. Provides a summary of the results referring to the factors and covers the four main areas, i.e. non-influenceable physiological factors, illnesses, influenceable lifestyle factors, and external factors.

Some harmful substances (including acute diesel inhalation[71], chronic exposure to lead[72-73], cadmium[74] and neurotoxic styrene[75,76]) and some medications (e.g. beta blockers, ACE inhibitors, antiarrhythmics and psychotropic drugs[5]) have been found to have a direct or indirect influence on HRV. In contrast, a systematic review by Gribble et al.[77] merely revealed indications that exposure to mercury brings about a reduction in HRV. With respect to the effects of very early exposure to mercury, only a 14-year follow-up study involving children from the Faroe Islands has established an association between reduced HRV among children of seven and fourteen years of age and the mercury content in the umbilical cord blood at their births only[77,78].

Summary

A decrease in HRV has been observed not only in connection with non-influenceable physiological factors such as age, gender and ethnic origin, but also in conjunction with a large number of acute and chronic diseases. Numerous lifestyle factors have both a positive and a negative influence on HRV. There are also physical influences that affect HRV. These must on no account be disregarded. Although not all the factors on the list have yet been fully studied, awareness of the many factors is of crucial importance in the measurement of HRV (both under laboratory conditions and during medical practice), its analysis and its assessment.

Declarations of Interest

The authors declare no conflicts of interest

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The authors agree to abide by the requirements of the "Statement of publishing ethics of the International Cardiovasular Forum Journal"[79].

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