QLINE AND PHYSICAL AND MENTAL STRESS ASSESSMENT

QLINE DANTEST STRESS ASSESSMENT

CONTENTS

WHAT IS STRESS?

Stress means different things to different people. In common language, people recognise a state of having too much expected of them, of being under pressure or strain, of being barely able to cope with some external demand which is both excessive and prolonged. It has a number of synonyms, but they all carry the connotation of unreasonable demands being placed on the individual in an emotional, mental or psychological sense.

A similar concept underlies the term stress in the physical sciences, a deforming force exerted on an object or structure that, if not resisted, would damage or destroy the object. The analogy is graphic and obvious. Scientists in the biological and health sciences also use stress in similar manner with subtle differences. They refer to environmental demands that affect an organism which, if not resisted, would damage or destroy it. It can also be applied to whole environmental systems. The common theme is an external factor that, if not resisted, would damage or destroy the system.

Why, in medical parlance, is stress therefore not universally measured, analyzed and treated? Why, indeed, has it often been denigrated or ignored or consigned to a fringe area of medicine? The answer is that doctors tend only to believe that which they can measure, observe and classify. It is this lack of physical presence, this inability to biopsy, photograph, probe or quantify which has led to stress not having been considered a part of conventional medicine for so long.

Despite the ignorance and disinterest that much of conventional medicine has shown to the study of stress, recent developments in physiology and bio-mathematics has led to increased insights into measuring the effects of stress on the body. This can also allow us to estimate not only the impact of stress on the body, but also how much reserve capacity is left to cope with further stress, whether it be physical stress (such as heat, cold or exercise) or psychological stress.

The body has an autonomic nervous system that is a complex series of neural connections connecting all organs to the brain to control their whole internal environment. This autonomic nervous system is both our major defense against stress and the system that demonstrates the principal symptomatic manifestation of stress in its early stages.

The autonomic nervous system is conventionally divided into two parts in a yin/yang balance: the sympathetic, which activates organs, getting them ready to cope with exercise or other physical stress; and the parasympathetic, which controls background "housekeeping" functions in the body. Activating the sympathetic nervous system will speed the heart, constrict blood vessels to less important organs such as the skin, and increase breathing and alertness. This system also dilates the eye, raises body temperature by burning off fat and causes heightened activity of motor nerves, producing, for example, the classical tremor and sweating of anxiety. Palpitations can be sensed and indeed frankly, irregular heart beating can result. Breathing rate increases and this can cause carbon dioxide to be blown off, rendering the arterial blood more alkaline, which in turn makes nerves hyper-excitable, leading to unpleasant sensations such as tingling or numbness, classically around the mouth and at finger tips. There is a resultant constriction of blood vessels to the brain that can cause dizziness and a feeling of faintness. Many of these sensations in themselves make the person feel even more anxious, thereby worsening the initial stimulation of the sympathetic system.

The counterbalancing system to the sympathetic is the parasympathetic system. This system controls internal organs at times of relaxation when, for example, the subject is in quiet sleep or rest. It harmonizes heart, blood vessel and breathing patterns causing, classically, a slow heart rate, relaxed blood vessels and slow, deep breathing. The gut and skin get a good blood supply in this situation and background functions, such as digesting food are facilitated when this system is most active. Much has been known of these systems for decades but they have historically been very difficult to measure in patients, leading to less knowledge of their role in health and disease.

A dramatic advance in the study of stress responses has been that mathematical analyses of biological rhythms have allowed us a window to the working of these autonomic systems. The complex interaction of the heart blood vessels, lungs and central nervous system means that physiological parameters such as heart rate are not stable but fluctuate in a complex but not random way.

Imagine a house with central heating. It needs a thermostat to keep temperature stable at the desired level, and it must cope with windows and doors being opened, letting in cold air. The thermostat must sense a reduction in room temperature and then switch up the heating to correct this. Inevitably, there will be a delay before the temperature returns to the desired level and also, inevitably, the temperature will often overshoot the desired level before the increased temperature is sensed to switch the heater lower again. The net effect is that the temperature, which was stable until a window is opened, initially falls, then rises, then overshoots, then falls again, then overshoots, continuing to oscillate far beyond the time of the initial change in temperature. Depending on the characteristics of the thermostat and the heater, this oscillation in room temperature can continue for long periods, or even permanently. The behavior as measured by the rhythmic fluctuations of temperature depends on the characteristics of the thermostat, such as its gain (the extent to which it senses small changes in temperature to produce large increases in heating output) and its delay (the speed with which it responds to a temperature change).

In the body there are multiple sensors like our theoretical home thermostat. They measure things such as heart rate, blood pressure, body temperature and the biochemical and oxygen and carbon dioxide contents of the blood. There are multiple sensors for each measurement, each with a different sensitivity and a different delay characteristic. The net effect is that each measure (heart rate, blood pressure, breathing rate etc.) is not stable but, rather, oscillates not at one frequency but at several different frequencies simultaneously. These oscillatory rhythms can be deconstructed mathematically to uncover the underlying sensitivities and delays of each sensor and the activity of the nerves that attach to these sensors. These sensors and their nerves are the mechanistic elements of the two halves of the autonomic nervous system described above: the sympathetic and the parasympathetic. By measuring these oscillations we can tell how active these two parts are; how active and how much reserve they have. For example, an active sympathetic will reduce the extent of the classical 4-second heart rate oscillation and relatively increase the amount of cycling at one cycle every 10 seconds. In contrast, the parasympathetic activates the 4-second rhythm and suppresses the 10-second rhythm.

These rhythms are of interest not only in what they tell us about the functioning of the body, but also because they have major medical uses. In patients recovering from a heart attack, in patients suffering from heart failure and in very sick patients on an intensive care unit the amount of the 4 second rhythm fluctuation in heart rate has been shown repeatedly to be a powerful predictor of survival. Those patients with reduced 4-second fluctuations are much more likely to die than those with more evidence of this rhythm. Treatments that increase this parasympathetic 4-second rhythm, such as beta-blockers, angiotensin converting enzyme inhibitors and physical exercise training, have been associated with better survival and those that reduce this rhythm to worsen survival.

In a similar way, natural or life-style induced changes in the activity of the parasympathetic and sympathetic systems can tell us about the physiological health of the individual, how much stress they are experiencing and how much reserve they maintain. We now have the opportunity to open a new branch of medical science: the accurate measurement of stress, stress responses and reserves to cope with stress and to tests. This will help us develop treatments to reduce stress, to avoid its damaging effects and to increase our stress resisting reserves.

This dossier summarizes much of what we have learnt and introduces techniques that may help in alleviating the effects of stress. Much has been learnt, but much remains to be learnt. We have in recent years made a good start in correcting this neglected part of medical science, the science of stress and its treatment.

INTRODUCTION

A large body of evidence leads us to the conclusion that chronic stress can affect mental and physical well being. The exact mechanism by which it imposes these detrimental effects is unknown. In the scientific and medical literature the list of physical diseases contributed to by stress is ever increasing. These include hypertension, coronary disease, sudden cardiac death from cardiac arrhythmia, gastric and duodenal ulceration, cancer due to immune suppression (Marshland et al 1995) and even Alzheimer's disease. These diseases arise not only from a direct effect of persistent stress itself but also from lifestyle habits such as smoking, excessive alcohol and overeating, which are at least in part attempts to find stability and coping mechanisms in our stressful environment.

Accepting that bad lifestyle habits contribute to disease, how does stress per se translate to a physical or mental detrimental effect at the cellular or homeostatic regulatory level?

The use of heart rate variability (HRV) is explained and how its measurement yields not only a measure of current stress but also more importantly the individual's stress reserves or stress vulnerability.

For over 40 years scientific research into how the action and interaction of the body's autonomic nervous system can be detected and analyzed in such a way as to give an insight into the body's total state of physical and mental health. As a result of this research program, an extensive patient study has been conducted, including a further study over the past 17 years of the behavioral patterns, and particularly the physiological responses to stress. This work generated a considerable database of individual patient studies, which has established the "normal" HRV level for any individual, taking gender and age into account. The final outcome of this research is a highly sophisticated clinical system that uses HRV to assess and predict certain disease states. One of the proven applications is to detect and accurately measure stress and perhaps more importantly, stress reserves or stress vulnerability.

The Qline™ system has been developed purely to monitor the stress, stress reserves and autonomic balance of individuals. The system and equipment has been "tried and tested" by qualified clinicians operating over the past 10 years. This HRV monitoring equipment indexes the autonomic nervous system (ANS) and more specifically the sympathetic/parasympathetic nervous system balance. The balance between these two systems is an indicator of the body's reaction to external and internal demands.

Whereas homeostasis reflects the regulation of internal organs and the maintenance of internal balance by the parasympathetic nervous system (PNS), stress reflects subjugation of internal needs in response to external demand.

This new concept in understanding how the body reacts physiologically to stress highlights the need to measure PNS activity as an index of stress vulnerability. Historically, scientists have attempted to measure stress by measuring the activity of the sympathetic nervous system (SNS), which represents only one of the two important components of the autonomic response. However, by monitoring the activity of both components of the ANS it is possible to define not only current stress but also the stress reserve of the individual: the latter being a more useful measure, as it identifies an individual's susceptibility to the effect of stress.

The new concept forms the basis of our scientific monitoring capability. Furthermore, this document cites the scientific evidence that individuals who are chronically stressed have less heart rate variability, which is associated with reduced parasympathetic nervous system activity.

In addition to the physiological Qline™ indicator, we score stress/anxiety and depression by way of selected questionnaires. We also quantify lifestyle stress by a brief lifestyle inventory, so that the healthcare professional can assess and counsel on any factors likely to be making significant contributions to a person's stress, e.g. smoking, alcohol, caffeine, diet and nutritional state (including nutritional supplements taken), exercise and sleep. The scientific evidence for the impact of these lifestyle factors on stress is also contained in this dossier.

Stress is an inescapable consequence of everyday living and everyday social interaction. At the clinic we aim to quantify stress levels and to identify individuals who are vulnerable to ill health due to compromise of stress reserves. The objective of Qline™ is to promote better stress coping strategies for individuals, informing them how to gain control of their ANS and their body's stress response, and also building stress reserves through appropriate lifestyle changes.

HEART RATE VARIABILITY AND STRESS VULNERABILITY

VAGAL TONE AND STRESS

The ANS regulates homeostatic function. In general the PNS promotes functions associated with growth and restoration. In contrast, the SNS promotes increased metabolic output to deal with challenges from the external environment. The PNS deals primarily with anabolic activities concerned with restoration and conservation of bodily energy and the resting of the vital organs e.g. constricting the pupil to shield the retina from excess light and slowing heart rate to give cardiac muscle longer periods for rest.

The SNS and PNS are reciprocally innervated and their responses are co-ordinated to provide the appropriate internal environment to meet shifts in both internal and external demands. The PNS is modulated primarily by internal changes in the viscera. The SNS is primarily activated by changes in external environment via somatic afferent nerve fibres.

Whilst the PNS optimizes the function of the internal organs, the SNS attempts to optimize the organism's relationship with the environment. So, for example, external challenges such as temperature change, noise or pain will produce attenuated PNS tone and increased SNS activity. Because the ANS is an integrated system comprising both peripheral and central neurons, measuring the peripheral visceral activity e.g. the heart, provides a window to the brain structures that regulate visceral function and state.

In the maintenance of bodily functions and in the reaction to stressful situations ANS afferents are crucial. Afferent feedback from visceral organs often regulates PNS tone and has little impact on SNS tone. ANS responses to external stimuli, including pain or attention, produce a decrease in PNS tone. There is a complementary increase in SNS tone only if the stimulus is of a high intensity and prolonged duration. In response to metabolic demands, the two branches of the ANS often function synergistically to maximize cardiovascular output. During exercise, therefore, there is a progressive decrease in PNS tone and a parallel increase in SNS tone. However, the ANS is not merely a response system awaiting external challenges before it acts. Rather, the ANS is continuously servicing the visceral afferents in an attempt to maintain homeostasis and promote physiological stability.

This regulatory process is primarily mediated by the PNS. The ANS is involved in the physiological expression of stress. Shifts in ANS activity that disrupt homeostasis may contribute to the negative physiological influences of stress. Because the PNS is integral to regulation of homeostasis, virtually independently of the SNS, it would be more sensitive to stress than the SNS. One confounding variable in defining stress is individual differences in responsiveness or vulnerability to a stressful event. The same stressor might not elicit a stress response in one person but do so to a large degree in another or the same person may respond differently at different times. Stress therefore cannot be defined in terms of the stressor and observed response, but also needs to encompass the physiological state of vulnerability of the person at that time.

THE MODERN UNDERSTANDING OF STRESS AND ANS

The central nervous system (CNS) mediates the distribution of resources to deal with internal and external demands. Perceptions and assumed threats to survival may promote a massive withdrawal of PNS tone and a reciprocal excitation of SNS tone. The trade-off between internal and external needs may be used in developing definitions of stress and homeostasis. In this model stress and homeostasis are interdependent. Homeostasis reflects the regulation of the internal organs and stress reflects the subjugation of internal needs in response to external needs. This is why measuring PNS tone may provide the indexing variable for defining stress and stress vulnerability.

Stress and stress vulnerability can therefore be defined in the absence of major shifts in SNS tone. In research assessing stress in neonates in healthy children, withdrawal of PNS tone to a stressor is paralleled by an increased expression of SNS tone. However, in severely compromised children they may not exhibit SNS reactivity and SNS tone might be low. These children generally have low PNS tone and very little PNS reactivity. Clinically, they would be described as chronically stressed and physiologically unstable. Thus PNS tone withdrawal in relation to SNS tone may define stress and high PNS tone prior to the stressor would represent low stress vulnerability, whilst low PNS tone would represent high stress vulnerability. Individuals therefore exhibiting problems of homeostasis will have the greatest stress vulnerability.

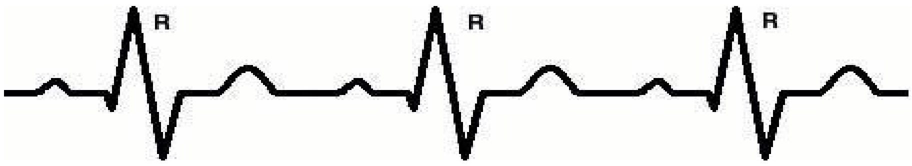
In many physiological systems efficient neural control is manifested as rhythmic physiological variability, and within normal parameters the greater the amplitude of oscillation, the healthier the individual. The greater the amplitude of organized rhythmic physiological variability, the greater the response potential or possible range of behavior. Individuals with attenuated physiological variability would then exhibit a lack of physiological and behavioral flexibility in response to environmental demands. This was the situation observed with severely ill infants.

Stimulation of other PNS afferents seems to give a reflex increase in cardiac vagal tone and therefore the latter seems to reflect the general PNS input to the viscera.

The most readily available measure of PNS activity is derived from heart rate pattern in response to breathing i.e. respiratory sinus arrhythmia. The heart rate increases with inspiration and decreases during expiration under the control of efferent parasympathetic impulses along the vagus nerve. Heart rate patterns, like behavioral processes, are dependent on the status of the nervous system and the quality of neural feedback. Stress results in a disorganization of the rhythmic structure of both behavior and autonomic state. Thus, measures of cardiac vagal tone provide a window into the central processes necessary for organized behavior. If vagal tone is a sensitive index of the functional status of the nervous system, then we would predict that individuals with greater vagal tone would exhibit a greater range of competent behaviors.

The pattern of heart rate reflects the continuous feedback between the CNS and the peripheral autonomic receptors. The primary source of HRV is mediated by phasic increases and decreases in neural efferent output via the vagus nerve to the heart. The greater the range of the phasic increases and decreases, the “healthier” the individual. An attenuation in the range of homeostatic function is paralleled by a reduction in vagal tone.

HRV is a marker of the efficiency of neural feedback mechanisms and may index health status or the individual’s capacity to organize physiological resources to respond appropriately. Thus, the better the “organised” physiological variability, the greater the range of behavior. States characterized by attenuated vagal influences should be paralleled by reduced behavioral flexibility in response to environmental demands. So, not only the basal level of vagal tone (measurable during sleep) is important but also the vagal responsivity during sensory and cognitive challenge. Individuals with greater vagal responsivity as exemplified in larger heart rate acceleration also exhibited fewer signs of distress.



Heart Rate Variability as a Marker of ANS Activities

HRV is based on the time difference between each heartbeat (R-wave) (as above), i.e. the beat-to-beat variability. Each R-wave represents a contraction of the heart and corresponds to the pulse. The beat-to-beat variability is affected by autonomic nervous system activity.

Normally the heartbeat should vary from beat to beat under direct control of both the SNS and PNS (the SNS speeds and the PNS slows the heart rate). HRV is the result of the interaction between these 2 systems. It is accepted by scientists that this interaction at the heart is a reflection of ANS balance or imbalance in the body in general. For example, SNS dominance at the heart is therefore an indication of a general sympathetic dominance in the autonomic nervous system. This would indicate a system under chronic stress and a vulnerability to further stresses. An overactive ANS is an indicator of a system under current stress, with a balanced ANS being important to effective stress coping.

More recent research highlights how our personality and thought processes influence health and also HRV. Sustained positive effective states lead to a clear and definable mode of physiological function that appears to facilitate the body's natural regenerative processes. Physiological coherence – a sine-wave-like pattern in the heart rhythm, increased heart/brain synchronisation and entrainment between diverse physiological systems occurs after positive thought focus, and positive emotions can produce extended periods of this physiological entrainment.

A healthy physiological system has the following characteristics:

- Efficient neural control
- Rhythmic physiological variability within normal limits
- Greater response-potential to challenge
- Greater range of response behavior

Attenuated physiological variability is associated with a lack of psychological and behavioral flexibility in response to environmental demand. A reduction in HRV is therefore not only an indication of a lack of physiological variability, but also in its broad sense a reflection of reduced psychological and behavioral flexibility.

Although our understanding of the meaning of HRV is far from complete, it seems to be a marker of both dynamic and cumulative load. As a dynamic marker of load, HRV appears to be sensitive and responsive to acute stress. Under laboratory conditions, mental load (including making complex decisions, and public speech tasks) have been shown to lower HRV. As a marker of cumulative wear and tear, HRV has also been shown to decline with the aging process. Although resting heart rate does not change significantly with advancing age, there is a decline in HRV, which has been attributed to a decrease in efferent vagal tone and reduced beta-adrenergic responsiveness. By contrast, regular physical activity (which slows down the aging process) has been shown to raise HRV, presumably by increasing vagal tone.

In short, HRV appears to be a marker of two processes, relevant to the conceptualization of allostatic load: (1) frequent activation (short term dips in HRV in response to acute stress); and (b) inadequate response (long-term vagal withdrawal, resulting in the over-activity of the counter-regulatory system --in this case, the sympathetic control of cardiac rhythm).

Several studies have now suggested a link between negative emotions (such as anxiety and hostility) and reduced HRV. Cross-sectional association between anxiety and reduced HRV (as assessed by two time-domain measures). Lower HRV in individuals who were "highly anxious" according to the Minnesota Multiphasic Personality Inventory.

FACTORS THAT CAN AFFECT STRESS

A change in the heart rate from start to finish of the test can distort the reading. Hence, we recommend a 10 minutes settling period prior to measurement. A standing posture increases the LF component in HRV due to sympathetic predominance, whereas supine posture enhances the HF vagal component. Controlled respiration at frequencies less than normal breathing rate enhances vagal modulation of HRV. Respiratory sinus arrythmia (vagal tone) increases during the night and decreases in the morning.

In contrast, the baroreflex mediated HRV decreases during the night and exhibits a rapid early morning increas. During sleep there is a higher sympathetic tone during REM sleep and a higher vagal tone during non-REM sleep. The latter is probably due to slower and more regular breathing in non-REM sleep. Vagal tone was significantly decreased during continuous performance suggesting that attending to environmental demand would lead to a decreased in vagal tone.

EFFECTS OF DRUGS

Angiotensin converting enzyme inhibitors augment low frequency HRV in dogs (Akselrod et al 1985). Several studies have shown that tricyclic antidepressants decrease HRV, whereas paroxetine and fluvoxamine (newer selective serotonin reuptake inhibitors) did not (Rechlin 1994; Jacobsen et al 1984). It is likely that the suppressant effect of the tricyclic antidepressants is mediated by their anti-cholinergic effects. One would predict that any drug having this effect should reduce HRV due to inhibition of vagal tone.

Beta-blockers such as propranalol have been found to reduce the low frequency component of HRV without influence on high frequency (Akselrod et al 1985). In normotensive adults, atenolol augments the vagal component of HRV (Cook et al 1991). In patients with hypertension atenolol was found to reduce both high and low frequency components of HRV. (Guzzetti et al 1988). A similar decrease in sympathetic activity was seen in post myocardial infarction (MI) patients with metoprolol (Bekheit et al 1990).

Calcium-channel blockers have various effects on HRV. While diltiazem reduces low frequency HRV to the same extent as beta-blockers in post MI patients, nifedipine does not. (Bekheit et al 1990). This may explain the reduction of mortality post-MI by beta-blockers and diltiazem but not calcium antagonists, such as nifedipine (Muller et al 1984; Multicentre diltiazem post-infection trial research group 1988).

Other drugs that negatively influence HRV, are sedatives, analgesics and anaesthetics. The HRV reduction by these drugs is thought to be established predominantly through central nervous system depression. Diazepam and other benzodiazepines attenuated the vagal component of HRV and are thought to do so by a CNS action at the GABA receptor (Adinoff et al 1992; Halliwill and Billman 1992).

HRV decreases with age with attenuation of the vagal component in adults (Shannon et al 1987; Lipsitz et al 1990). Others have shown more pronounced HRV decline in the low frequency band (Jennings & Mack, 1984). However, the ratio between high and low frequency HRV appears to remain stable with age (Conny et al 1993).

Increased levels of fitness were found to be associated with increased HRV in 15-83 year olds compared with sedentary controls (De Meersman 1993). In athletes at rest the vagal component of HRV was higher and the low frequency (sympathetic) band lower. Furthermore the LF/HF ratio returned to pre-exercise levels within 5 minutes in athletes compared with 15 minutes to notice any decrease in this ratio in controls.

Patients with congestive heart failure and coronary artery disease had an increased LF/HF ratio due to attenuated vagal tone and augmented sympathetic tone (Sopher et al, 1990). In essential hypertension an enhanced sympathetic activity and reduced vagal activity has been found (Goldstein 1983).

Patients with polyneuropathy due to diabetes mellitus, chronic alcoholism or Guillain-Barré Syndrome also have decreased HRV.

In diabetics there is evidence that parasympathetic damage occurs more commonly than sympathetic damage and this may occur before clinical symptoms of neuropathy are evident. (Conny et al 1993). Diabetic patients with chronic renal failure have a strong reduction in HRV at all frequency ranges, predominantly of the PS (Zoccali et al 1982; Axelrod et al 1987;

Cloarec-Blanchard et al 1992).

Smoking is associated with an acute and transient decrease in cardiac vagal tone. Heavy smoking can cause long term decreases in cardiac vagal function (Hayano et al 1990).

THE HRV AND STRESS RELATIONSHIP

OCCUPATIONAL STRESS AND HRV

Utilizing HRV occupational stress research could integrate the strengths of understanding provided by the aforementioned research traditions to illuminate how workplace psychosocial stressors contribute to the development of chronic disease – through defined physiological pathways related to cardiac regulation by the autonomic nervous system.

Studies utilizing HRV measures for investigating the physiological impact of occupational stress in the work place are now very frequent. A variety of methods have been utilized to categorize occupational stress as well as to measure HRV.

DEPRESSION AND STRESS

Since 2000 there are many more reports in the literature on depression and HRV. This reflects the potential interest in this tool as a measure of the mind-body interaction and as a possible way of defining how mood state manifests its well-established effect on cardiovascular health (in particular stress, depression and anxiety). Nearly all the recent studies on depression and heart disease document increased cardiovascular morbidity and mortality in patients with depressive symptoms or major depression. This implicates depression as an independent risk factor in the pathophysiologic progression of cardiovascular disease, rather than merely a secondary emotional response to cardiovascular illness.

Studies have suggested that the relative risk of major depression with cardiovascular disease varies from 1.5 to 4.5. This seems to apply both to the development of cardiovascular disease and death after an index myocardial infarction. In patients with angiographic evidence of coronary artery disease, the presence of a major depressive disorder was the best single predictor of cardiac events during the 12 months following diagnosis. A decrease in HRV may mediate this effect.

Depression scores were established in healthy students. On the basis of their scores, students were categorised as being in a high or low depression group. Parasympathetic nervous system responses were measured by measuring high frequency HRV in response to an acute stress (a challenging speech task) and a forehead cold pressor test. Those in the high depression group had significantly greater reductions in HF during the speech task and smaller increases in HF during the forehead cold pressor task than those in the low depression mood group. Women were found to have significantly greater reductions in HF during the speech task and smaller increases in HF during the forehead cold pressor test than.

MOOD, PERSONALITY AND STRESS

Levels of hostility have been shown to affect HRV. Women with high hostility scores demonstrated less blood pressure and heart rate rises during confrontational discussions than women of low hostility scores. Greater blood pressure response was observed with positive than with negative feedback (as estimated on the hostility rating). Analysis of coping styles suggested that high hostility subjects may be less reactive due to withdrawal and lack of engagement during the task, while low hostility subjects may show greater engagement, especially when encouraged by positive feedback. Individuals with high hostility scores and patients with anxiety and depression have low HRV and may be at increased risk of death from coronary heart disease and arrhythmias.

HRV was investigated in eight Type A and eight Type B women during a 30minute psychomotor task. The results suggested that the sympathetic nervous system in Type A individuals was more stimulated during the task, and although there was no difference in task performance between the 2 groups, Type A subjects felt a greater subjective mental workload than did Type B individuals.

Both in laboratory conditions and in the workplace, techniques to engender positive thought processes in individuals have been demonstrated to produce a significant improvement in HRV. Emotions such as hostility and anger produce a sympathetically dominated HRV, whereas feelings of appreciation shift the HRV power spectrum in the opposite direction. It has been shown that people who express positive emotions show less life stress and are less likely to become ill.

WORK PERFORMANCE, PRODUCTIVITY AND STRESS

Stress results primarily from unmanaged emotions. Factors such as anxiety, worry or fear are disablers of performance.

States of peak performance have a measurable physiological correlate. A physiological state characterised by improved and coherent heart rhythm leads to measurable improvement in organizational performance, including heightened decision-making ability, quality of work, management and time efficiency.

A physiological state of entrainment, where HRV patterns, brain activity and respiration synchronize with each other, correlates with a state of peak performance. This same state is also associated with a reduction in stress-related symptoms, including tachycardia, tension and various aches and pains. These positive effects are best achieved during conditions of positive emotional management.

Various corporate-based studies have demonstrated that coherent heart rhythm with improved HRV profiles is associated with overall improvement in health and well-being (82%), reduced anger (62%), less worry (70%), less fatigue (87%) and feeling happier (68%). There was a 44% reduction in desire to leave the company and a 52% decrease in desire to quit the job. Listening skills improved 65%, decision-making ability increased 100%, efficiency increased 86% and creativity by 119% (Grove, 2000). These HRV-based studies report an increased capacity to recognize and manage stress and negative emotions, both in the workplace and outside it. Substantial reductions in items reflecting burnout and physical stress symptoms were also noted.

Recent scientific, medical and organizational research suggests that the turbulence of change and transformation and subsequent feelings of being overwhelmed, under-resourced, time pressured and stressed, substantially prevent individuals, teams and organizations from optimum performance. Research has also shown that a rise in physical symptoms is a leading indicator of productivity losses. For example, hypertension (high blood pressure) has been strongly linked with decreases in cognitive performance and memory loss.

There is now increasing evidence that the physical symptoms of stress are linked negatively to workplace effectiveness. Techniques that improve HRV in individuals have been shown to benefit organizations by increasing productivity, reducing health care costs, lowering absenteeism and improving retention. Pilot studies have shown that executives with stage 1 and 2 hypertension have been able to restore their blood pressure to normal without medication, by learning techniques that regulate their HRV.

It would seem that the heart is more powerful in improving one's ability to succeed than the mind. The heart as a source of electromagnetic energy is 40 to 60 times greater than the brain and carries intricate messages that affect people's emotions, physical health and quality of life. These can be measured up to 18 inches away from the body. Furthermore, the heart is an intelligent system that profoundly affects brain processing. This two-way communication between the heart and the brain directly affects perception, reaction speeds and decision-making ability.

We know that when people are off balance emotionally they often have impaired brain functions. Engendering appreciative thoughts and positive emotions not only has a beneficial impact on the sympathetic and parasympathetic nervous system balance, measured by QLine® as ANS/HRV, but also provides the foundation to dramatically boost performance, without burning out in the process. Positive feelings, such as appreciation, progressively increase heart-brain synchronization and therefore create a healthier HRV profile. Workplaces known for caring, appreciative climates are more productive, encouraging greater retention and innovation. Whilst an attitude of frustration and anger is known to inhibit cortical function, and to produce incoherent heart rhythm signals, appreciative or caring attitudes are proved to enhance cortical function and produce ordered and coherent signals from the heart. There is an associated shift away from stress patterns to those that are more calm and balanced.

WORK STRESS

Work stress has been repeatedly associated with an increase in cardiovascular disease and especially where there is a lack of individual control.

Vagal tone was assessed as a possible determinant of work stress effects comparing HRV and model of work stress. High imbalance represents a combination of high effort and low reward at work. High over commitment on the other hand represents an exhaustive work-related coping style indexing the inability to unwind. Findings were adjusted for differences in posture and physical activity between the 2 work stress groups. High imbalance was associated with a higher heart rate during work, a higher systolic blood pressure during both work and leisure time and a lower vagal tone on all 3 days of measurement. Over-commitment was not associated with an unfavorable ambulatory profile. The study suggested that the detrimental effects of work stress are partly mediated by increased heart rate reactivity to a stressful day, an increase in systolic blood pressure, and lower vagal tone.

The effects of positive mood, negative mood, demand, satisfaction, demand-satisfaction ratio and time of day were correlated with HRV throughout the working day. Need for control had a negative effect on HF HRV after controlling for time of day effects i.e. subjects with a high need for control have lower vagal control of the heart. In the long run these subjects may be considered at increased health risk due to a reduction in the protective effects of vagal tone.

An increased risk of coronary heart disease has been described in shift workers. The exact mechanisms behind this increased risk are not well understood but it is possible that the unphysiological timing of physical activity and food intake in relation to circadian rhythms may be important. Lower values of HRV were present when a job task was performed at night compared with values obtained when the work was performed in the morning and evening. They suggested that the continuous weekly changes of time of maximum and minimum in the cardiac sympathetic and vagal autonomic control might play a role in the excessive rate of cardiovascular disease that has been described. Shift workers were also found to display significantly reduced standard deviations of HRV during sleep compared with those of daytime workers.

Competitiveness, as in sport (golf), suppresses HRV and this suppression was still evident 3 hours after competition. It may be that competitiveness at work may also reduce HRV, though there do not appear to be studies at this time that have addressed this possibility.

Workers reporting a high noise level at work compared with a low work noise level also displayed an elevated adjusted mean %LF during work.

HRV TRENDS IN PHYSICAL ILLNESS

Loss of normal autonomic nervous system control of heart rate and rhythm is now recognized to be an important risk factor for adverse cardiovascular events.

Significant high frequency decreases in HRV occurred from 60 minutes before ischemic events in male patients with stable coronary heart disease who had ambulatory ECG recording. Low frequency decreases began at 4 minutes before the ischemic event. It was also observed that ischemic events occurring at high mental activities were preceded by depressed high frequency HRV levels compared with events at low mental activity. It was concluded that autonomic changes consistent with vagal withdrawal can act as a precipitating factor for daily life ischemia and particularly in episodes triggered by mental activities.

On the basis of HRV studies it has been suggested that atrial fibrillation can be preceded by autonomic imbalances affecting either the sympathetic or parasympathetic divisions of the autonomic nervous system. Increased sympathetic activity is associated with lower ventricular fibrillation threshold and an increased risk of ventricular fibrillation, in contrast to increased parasympathetic activity, which protects the heart.

Migraine sufferers were divided into those with and those without disabling headaches. Disabled migraine cases had significantly reduced HRV compared with non-disabled migraine cases and controls ($p<0.01$). Whilst this apparent autonomic dysfunction may play a causal role the authors rightly concluded that this dysfunction could also be a consequence of frequent disabling headaches.

Patients with irritable bowel syndrome (IBS) and healthy controls were studied with HRV. In the supine position, the VLF (very low frequency) component of HRV was significantly higher. On changing from supine to standing normal subjects showed a raised VLF and LF, indicating raised sympathetic tone, whereas HF remained unchanged. Similarly IBS patients showed an increase in VLF and LF on standing up but the HF was also raised. On deep breathing normal subjects had a significant increase in HF with significant reduction in VLF and insignificant reductions in LF. In IBS subjects, HF remained constant while LF and VLF were reduced. In IBS the median sympatho-vagal outflow ratio was significantly lower in the standing position and higher in the deep breathing mode. In summary it would appear that IBS patients have reduced sympathetic influence on HRV in response to orthostatic stress and reduced parasympathetic modulation during deep breathing.

INTERVENTIONS SHOWN TO IMPROVE STRESS

Lifestyle rehabilitation (particularly smoking cessation and regular exercise) after myocardial infarction for 3 months has been shown to improve sympatho-vagal balance favourably with a shift towards higher parasympathetic tone. Furthermore, this favourable effect persisted after one year.

In older people greater physical fitness is associated with significantly higher total power and HF component of HRV measured at rest.

Emotional self-management skills and in particular emotional competence skills designed to intercept stressful responses and during emotionally challenging situations. Behavioral outcomes were assessed using the Achievement Inventory Measure. Following the program students exhibited significant improvements in stress and anger management, work management and focus, and relationships with family, peers and teachers.

These improvements were sustained over the ensuing 6 months. As compared to the control group, trained students demonstrated significantly increased HRV and more rhythmic sine-wave heart rhythm patterns during recovery. On the basis of this and other work the authors state that this physiological response pattern was due to increased parasympathetic activity and that this heart rhythm coherence is associated with improved cognitive performance, emotional balance, mental clarity and several positive health outcomes.

Relaxation states, as achieved by myofascial trigger point massage therapy to the head and neck was able to significantly increase the parasympathetic component of HRV. Controlled breathing, particularly that associated with abdominal breathing, has been demonstrated to increase HF power of HRV. Meditation reduces sympathetic and increases parasympathetic components of HRV. Immediately and one hour after listening to relaxing music for 20 minutes HF HRV was significantly increased and heart rate and respiratory rate were significantly decreased in patients who were hospitalized after acute myocardial infarction.

In summary, it is likely that an ability to control HRV could well alleviate negative mood states in people seeking assistance for inadequate stress responses, anxiety or depression. Since there is a clear association between negative mood states and heart disease the efficacy of any psychological intervention to reduce the risk of heart disease would be improved if it focused directly on improving autonomic nervous system imbalance characterized by SNS dominance and low HRV. Furthermore, since an increasing number of physical ailments appear to be associated with autonomic nervous system imbalance the potential application of HRV to monitor this balance is enormous.

DRUGS AND HRV

Candesartan, the angiotensin II receptor antagonist, was found to have no effect on HRV after 4 weeks of treatment of patients with heart failure, at which time it did however have a significant blood pressure lowering effect (Vaile et al, 2001).

Tricyclic anti-depressants have been shown to reduce HRV, whereas the selective serotonin inhibitor, paroxetine, has been shown to normalise HRV (Gorman & Sloan, 2000).

In patients with decompensated heart failure (New York Heart Association functional class III and IV) beta-blockers significantly improved the HF component of HRV by 41% (Aronson & Burger, 2001).

Allopurinol at doses which are known to reduce oxidative stress, appeared to have no significant effect on resting autonomic tone, as indicated by time domain HRV or on dysrhythmia count in stable heart failure patients (Shehab et al, 2001).

The use of clozapine in schizophrenic patients is associated with significantly higher heart rate, lower HRV, higher LF and lower HF components of HRV compared with patients taking olanzapine or haloperidol (Cohen et al, 2001).

CONCLUSIONS

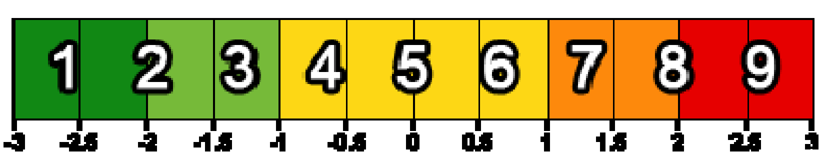
Taking all this research together we can make the following conclusions:

Stress, anxiety and depression are associated with reduced HRV, with sympathetic dominance and loss of vagal tone appearing to be the trend. This trend, with a loss of protective vagal tone, would explain the increased vulnerability to cardiovascular disease and sudden cardiac death that has been documented in these psychological states.

An increasing number of physical illnesses also appear to be associated with sympathetic dominance, reduced vagal tone and reduced HRV. This pattern does not seem to be a reaction to disease symptoms, but may be a contributing or predisposing factor to the underlying disease process. Vagal tone and the physiological processes that determine its efficiency clearly have a lot more do with vulnerability to disease than has previously been contemplated. It is likely that further study of the various frequency components of HRV will lead to much fruitful information on subtle physiological regulatory mechanisms that maintain health and on how the compromise of these regulatory processes may lead to disease processes.

The role of mood, emotions and thought processes (positivity and negativity) are often ignored or placed in the background when addressing an individual's well-being and recovery process. But more recent research, particularly involving HRV, is demonstrating the profound potential gain that can be achieved on the basic physiological regulatory processes that govern health by addressing an individual's emotional response and employing simple techniques to alter the negative thought processes that often accompany and color our responses to challenge and stress. Of course, we have always acknowledged the close interplay between mind and body, but HRV may yet prove to be the "simple" tool by which we can examine the interface and coherence between mind and body.

PHYSICAL AND MENTAL STRESS ZONES



GREEN ZONE READINGS

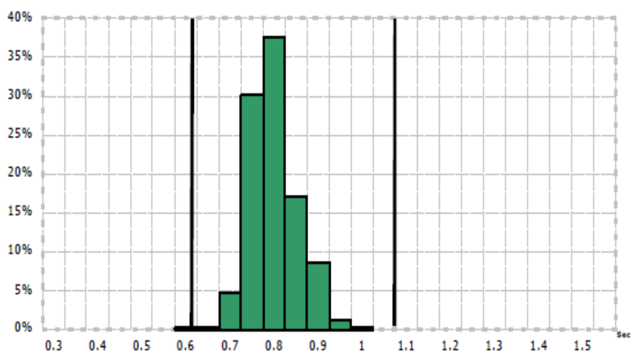
The Balanced Autonomic Nervous System – A healthy Stress balancing system

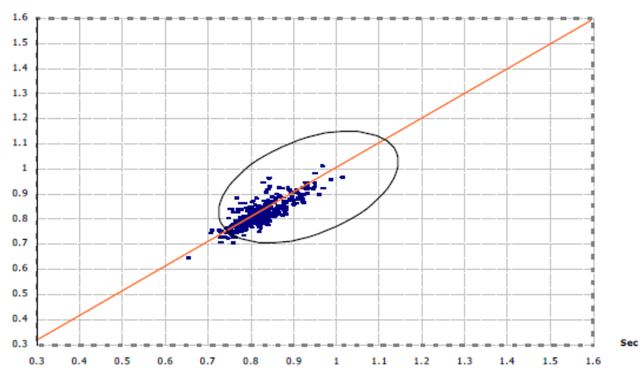
Green zone readouts. Represent individuals with a good balance between the sympathetic and parasympathetic components of the ANS, who respond well to challenge and have good stress reserves. The scattergram shows good dispersion of activity and the histogram is centrally located and normally distributed. It also represents a picture of good health, since a balanced ANS generally means a system that is regulating well. These respondents are more able to move in either direction to process a mental or physical challenge with a return to a balanced system more quickly after a challenge than someone with a non-balanced ANS. A person functioning well in business is one who has green zone readout with a slight sympathetic dominance. An example of this sort of readout is shown below.

1)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





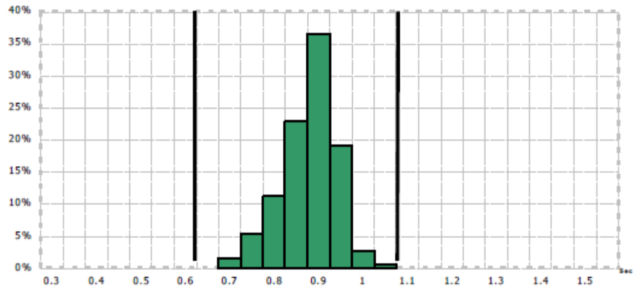
Comment

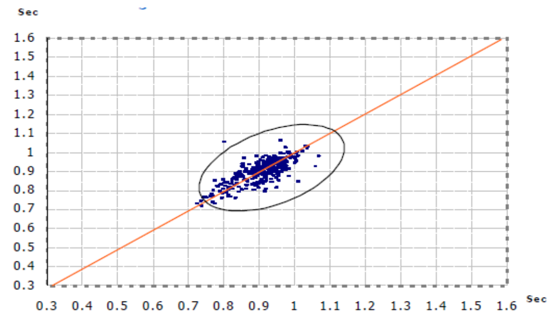
Note the central position of the histogram, its relative bell-shape and the reasonable spread of points within the oval of the scattergram. These patterns indicate a normal autonomic nervous system balance.

2)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





Comment

A good example of a normal reading. Note the patterns as discussed previously indicative of good autonomic balance.

YELLOW ZONE READOUTS

The following examples are of overall yellow zone readouts.

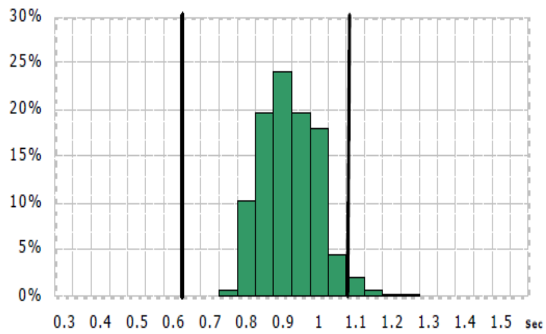
These represent the next level of deviation away from the healthy HRV and more extensive autonomic imbalance.

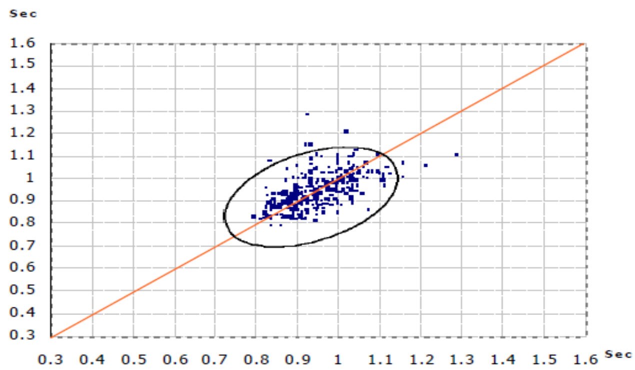
This happens when there is current stress on the body's regulatory mechanisms and does not necessarily imply a bad profile, but possibly current strain. This will show as a yellow zone reading with either an increase in both sympathetic and parasympathetic nervous system activity or a parasympathetic predominance. It is seen as an increased total power in the analysis representing increased nervous system activity. If this occurs in conjunction with a rise in sympathetic activity it is normal and healthy and may only represent a temporary reaction to mental and/or physical challenge. A persistently overactive autonomic nervous system due to unrelenting challenge can lead to either of the two scenarios above and exhaustion of reserves. These individuals need to relax more and take more recreation in order to achieve more balance. An overactive ANS can often be seen in athletes, in which case it does not necessarily represent an abnormality. An example of this sort of readout is shown below.

3)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





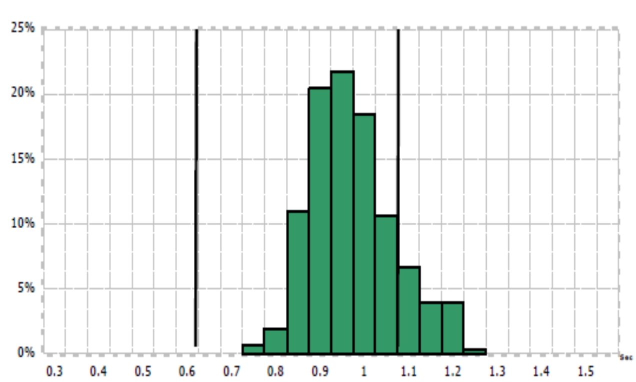
Comments

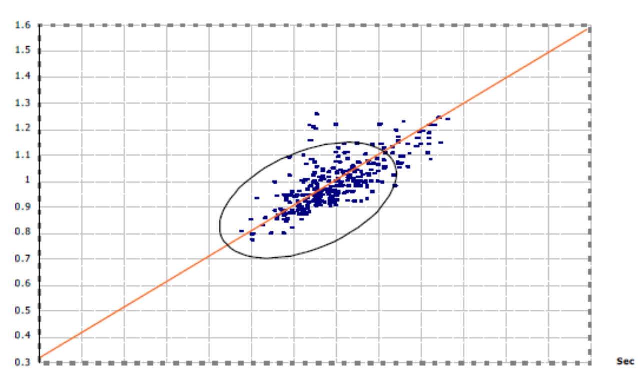
Here we see the opposite spectrum where the autonomic imbalance is due to parasympathetic predominance. Notice the broad scattergram with less height and also the more diffuse spread of points on the scattergram. This is mild parasympathetic predominance.This is due to activation of parasympathetic reserves to deal with a challenge. This could be a temporary affair as the histogram is fairly central. This situation can occur due to having a cold or due to menses in a woman.It could also be due to fatigue or excessive physical demand.

4)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





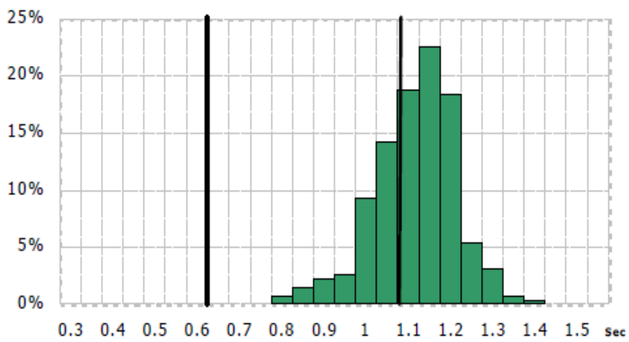
Comment

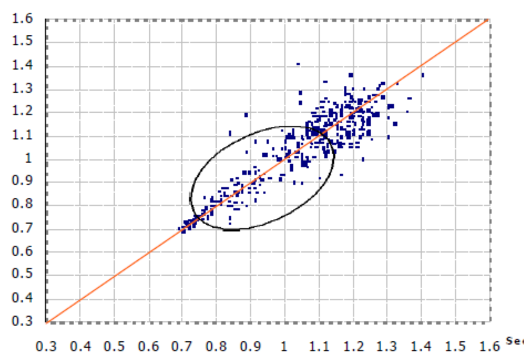
Note that although the histogram is central, that the scattergram shows a clustering of points and that the histogram also shows the same lack of variation in HRV .The overall imbalance here is in favour of sympathetic nervous system predominance.

5)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





Comment

Note the clear sympathetic nervous system predominance here with the tall narrow leftward-displaced histogram. The scattergram confirms the trend with clustered points and again leftward displacement due to the associated relatively fast heart rate. This situation is synonymous with a relative exhaustion of parasympathetic reserves leading to a sympathetic dominance particularly in the presence of reduced total power.

PHYSICAL STRAIN/EXHAUSTION READOUTS

There are certain HRV patterns that indicate an active strain on parasympathetic reserves.

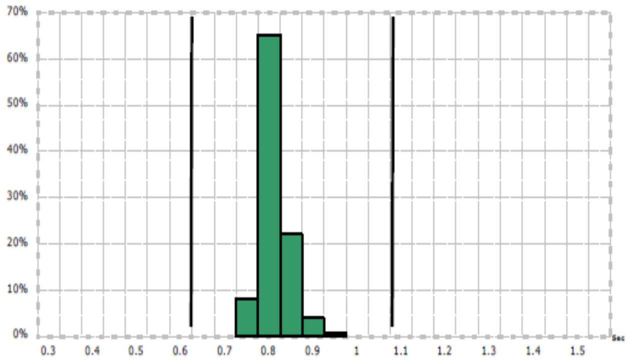
This pattern is often seen in physical overstrain (as in over training in athletes or fitness fanatics), current illness e.g. flu, menstruation in women, fatigue or anxiety. The questionnaire section should help to clarify which of these, if any, apply.

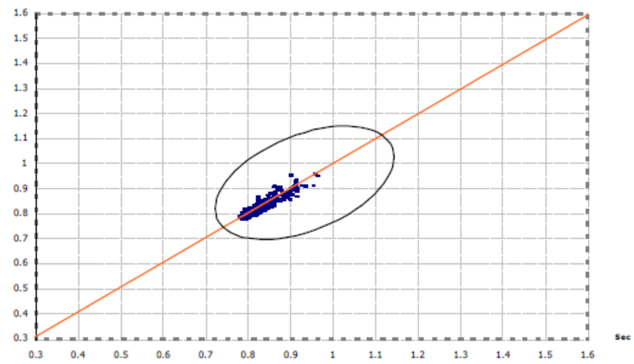
The typical pattern is one showing an excessive HRV, often with scatter of points outside the oval on the scattergram and a broad-based histogram confirming excess parasympathetic nervous system activity.

6)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





Comment

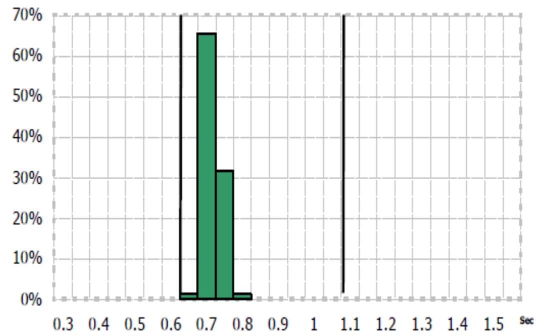
Excess variation in the histogram and scattergram. This is parasympathetic predominance with rightward movement of both histogram and scattergram due to bradycardia. This may represent a temporary situation of facing a physical challenge such as current illness or menstruation in a woman etc. The only way to be sure is to repeat the reading when the client is well again.

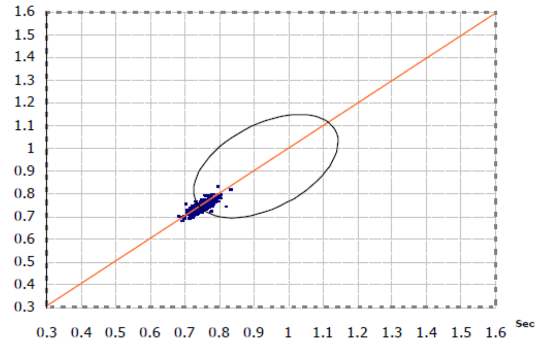
7)

Also indicates chronically stressed reserves and a reduction in the efficiency of action of parasympathetic nervous system compensatory activity. It can also be caused by retention of anger. This will be shown as either a red zone reading or a yellow zone reading, depending on the degree of compromise of reserves. It is also observed as a reduction in variation on the scattergram and histogram, but less markedly so than in the exhausted state described above. Research has shown that in this state there is also increased vulnerability to cardiac and other illnesses. It is the profile seen in someone who is chronically stressed or chronically anxious. Again, these are individuals who are more vulnerable to burnout and measures should be taken to target resources to them.

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





Comment

Excess variation in the histogram and scattergram. This is parasympathetic predominance with rightward movement of both histogram and scattergram due to bradycardia. This may represent a temporary situation of facing a physical challenge such as current illness or menstruation in a woman etc. The only way to be sure is to repeat the reading when the client is well again.

RED ZONE READOUTS

The following examples are of overall red zone readouts.

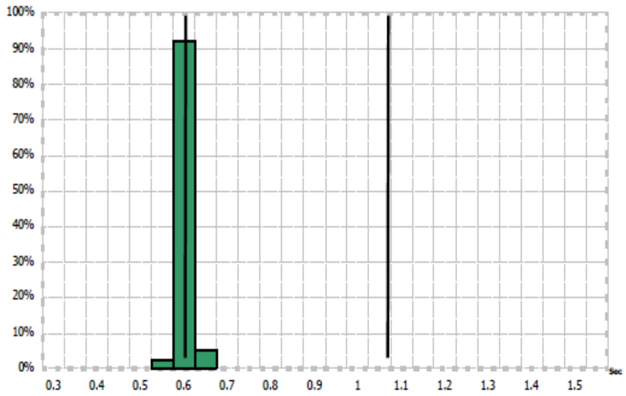
These represent the most significant level of deviation away from the balanced HRV and more extensive autonomic imbalance with exhaustion of reserves. In our experience the health of clients in this zone is at risk and they all have been encouraged to have a health screen as well as make any necessary lifestyle changes.

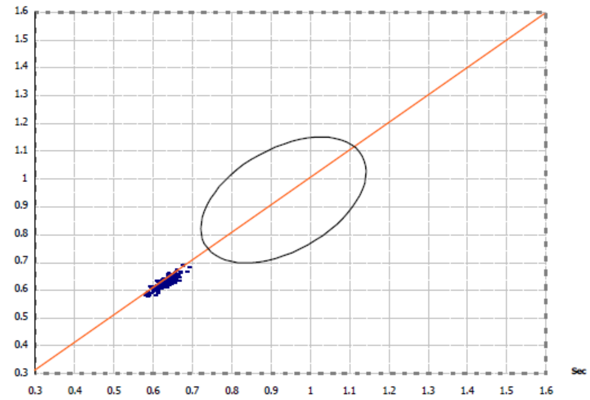
Means that the autonomic nervous system is not responding well to challenges, usually because of exhaustion of reserves after having to meet chronic stress on the body's balancing mechanisms. It is seen as a red zone readout, with markedly reduced variation on the scattergram and histogram. These individuals are vulnerable to the effects of stress and are the ones most likely to get sick, physically or mentally. They will suffer burnout if measures are not taken to address negative lifestyle issues and stress and anger coping strategies.

8)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





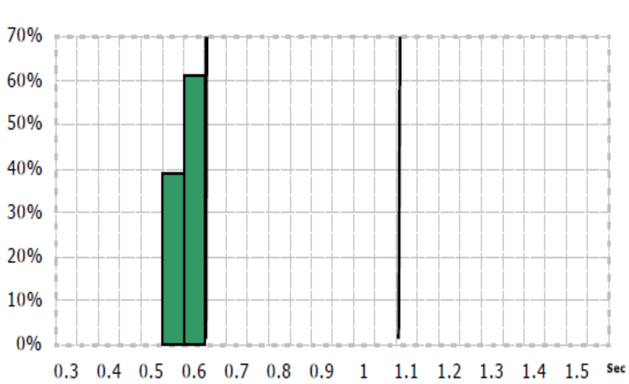
Comment

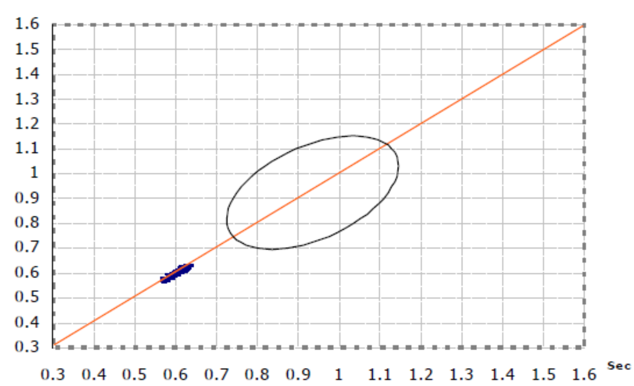
Ninety percent of data occurring within a very narrow range of variability and points on the scattergram are clustered together confirming very low HRV. This as a stable rhythm i.e. when there is very little HRV. Notice also the tachycardia evident by the leftward shift on both charts, consistent with sympathetic dominance. Because of this profound sympathetic dominance the client was referred to his GP and found to be diabetic.

9)

Measure of distribution of your heart rate. Deviation to the left shows tachycardia or fast heart rate; to the right shows bradycardia or slow heart rate. Central location (normocardia) is normal heart rate.

Measure of degree and direction of change in your HRV. The oval represents the normal change. Points clumped together indicate little HRV and presence of stress. Points outside the oval indicate excessive HRV that has several possible causes.





Comment

Another example of sympathetic dominance with reduced compensatory parasympathetic reserves with reduced HRV.