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STRESS

Measuring Stress by Vyvo Technology Wearable Devices

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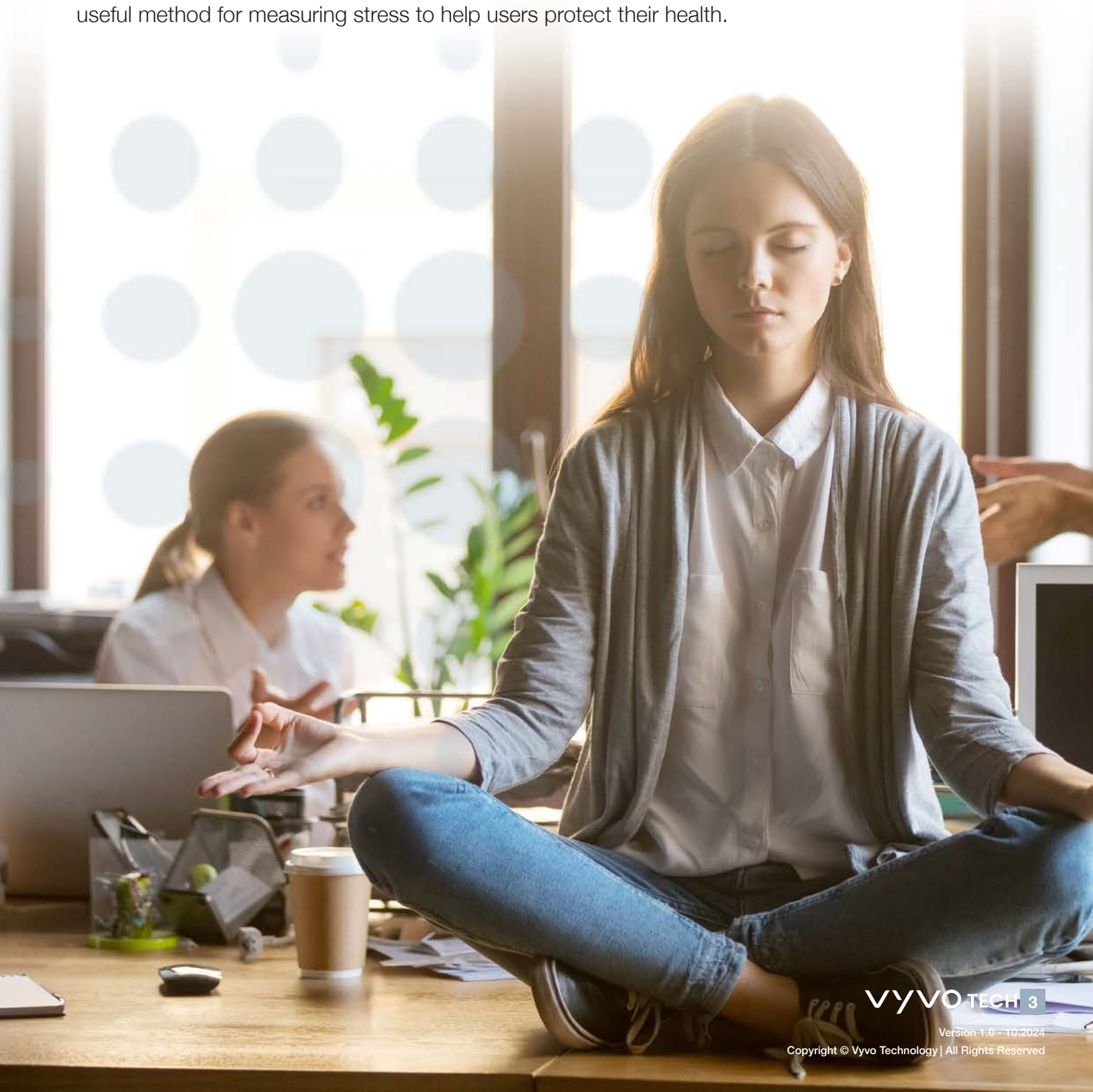
Abstract

Stress is the body's defensive mechanism for addressing social and environmental threats and stimuli. Most reactions to stress are controlled by the autonomic nervous system and operate unconsciously. As chronic stress is acknowledged as a risk factor for mental illnesses and disease states, including cardiovascular disease, efforts to detect, address, and reduce stress can lead to improved health outcomes. Heart rate variability, a measure of the variation in time between adjacent heartbeats, can serve as a useful proxy for measuring stress; research has shown that low variability is associated with high stress.

Photoplethysmography, an optical method for measuring changes in blood volume in a bed of tissue, is an effective and accurate way to measure HRV and therefore detect moments of stress. Equipped with medical-grade PPG functionality, Vyvo Technology wearable devices provide a highly useful method for measuring stress to help users protect their health.



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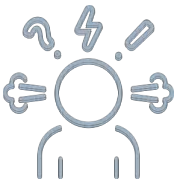
Impact of Stress on Health

Stress can be defined as an organism's physiological, biological, and psychological defensive response to environmental stressors. In humans, many of these responses are prompted by the autonomic nervous system (ANS) and are designed to protect the person from harm. The ANS "is a control system that acts largely unconsciously and regulates bodily functions," including heart rate.[1]

While stress, as defined, serves a valuable function, chronic stress can impact health, known as "allostatic load," the "cumulative burden of chronic stress and life events." Guidi et al have shown that "allostatic load and overload are associated with poorer health outcomes."[2]



More specifically, "Psychosocial stress is a major risk factor for morbidity and mortality related to a wide range of health conditions and has a significant negative impact on public health."[3] Research has shown frequent exposure to stressors is a significant risk factor for cardiovascular disease, sleep disorders, stroke, obesity, depression, diabetes, Alzheimer's disease, and drug addiction.[4]

Given this negative impact on human health, equipping people to identify and address stress as early as possible can help them better cope with challenges and thereby avoid undesirable health outcomes. This doesn't imply ***eliminating*** stress, but rather giving people mechanisms and knowledge to navigate challenges. In their study, Can et al stated, "stress must be discovered in early stages to refrain from more damage and impede it from being chronic."[5]

The Basics of Heart Rate Variability

Heart rate refers to the number of heart beats in a minute, while heart rate variability (HRV) is a measure of the variation in time between adjacent heartbeats. “The fluctuations in HRV value reflects neurocardiac function of the body as it is generated through heart-brain connection and ANS dynamics.”[6]

Unlike blood pressure and other measurements, and perhaps counterintuitively, high HRV is desirable. “Higher HRV has been found to be associated with reduced morbidity and mortality, and improved psychological well-being and quality of life.”[7]

Rob Verkerk, PhD, executive and scientific director of Alliance for Natural Health, explained it this way:

> “It might seem odd that variability is a good thing. But the heart is no metronome. The variability is part of the natural tension that exists in so many areas of biology that gives rise both to balance and responsiveness. Our stress response allows us to adapt and respond to ever changing and often risky environments.”[8]

When a healthy person is in a relaxed state - when the parasympathetic nervous system should prevail, such as during sleep - HRV will tend to increase. “On the other hand, HRV naturally decreases during stress, when elevated sympathetic activity helps the body keep up with the demand. Thus, HRV is typically higher when the heart is beating slowly, and lower when the heart starts to beat faster, for example during stress or exercise.”[9]

HRV and Stress

HRV is a useful indicator of overall health and more specifically for stress. Aimie-Salleh et al observe, “Heart rate variability (HRV) is a physiological measurement that can help to monitor and diagnose chronic diseases such as cardiovascular disease, depression, and psychological stress.”[10]

Kim et al found that “the current neurobiological evidence suggests that HRV is impacted by stress and supports its use for the objective assessment of psychological health and stress.”

Additionally, “Low HRV is associated with impaired regulatory and homeostatic ANS functions, which reduce the body’s ability to cope with internal and external stressors.”[11]

Further emphasizing the link between HRV and stress, Brosschot et al concluded, “Prolonged worrying were associated with high HR and low HRV, not only during waking but also during the subsequent nocturnal sleep period.”[12]

Measuring HRV with Photoplethysmography

Given that HRV is a suitable proxy for stress, measuring and deciphering HRV gives people an insight into their mental and physical state. HRV can easily be captured through photoplethysmography (PPG), which uses “multiple wavelengths of light to illuminate the skin and photodiodes to measure the reflected light, thereby inferring changes in blood volume by measuring changes in light absorption.”[13]

PPG is a well-known and broadly accepted technique for capturing health metrics related to blood volume, and doing so with reliable accuracy. In their study, Natarajan et al concluded, “A comparison of RR intervals (ie, the time between successive heart beats) from a wrist-based PPG device and an ECG device showed that PPG data from wrist devices were accurate enough for both HRV analysis and to differentiate between sinus rhythm and atrial fibrillation cases.”[14]

Aimie-Salleh et al support this observation:

> *Several studies have shown that the cardiovascular parameters collected through PPG systems are highly correlative and comparable to the measurements taken through standard ECG system. This proves that despite not being able to illustrate exact cardiac waveforms or ectopic beats, PPG could serve as better alternative for portable heart monitoring device.*[15]

PPG also has the advantage of convenience, as wearable devices can be built with the needed hardware. On this subject, Giorgi et al conclude that "wearable sensors could represent an ideal substitute for laboratory technologies for a real-time assessment of human performances in ecological settings" and that "the possibility to detect stress in an unobtrusive way is one of the most promising aspects of wearable devices."[16]

For their study, Can et al developed a "a multi-level stress detection system" utilizing a PPG-equipped wearable device and a proprietary algorithm, ultimately achieving "promising results."[17]

Their system was designed to "measure the heart activity by measuring blood flow during the heart's pumping actions. Heart activity signal is composed of different peaks and valleys. R peak is the most prominent one, which is used to calculate heart rate variability." They obtained 90.40% accuracy with one off-the-shelf wearable and 84.67% with another.[18]

Stress Measurement with Vyvo Technology Wearable Devices

Vyvo Technology completely agrees with Giorgi et al, who stated, “consumer wearable devices are optimal candidates for health and well-being monitoring.”[19] Using PPG functionality, Vyvo Technology has included stress monitoring in its wearable devices. These wearables are equipped with PPG functionality for measuring numerous parameters, including HRV.

With analysis of the HRV measurement through Vyvo Technology proprietary algorithm, Vyvo wearables can detect increased stress levels and alert the device user. The user can then apply mental health and stress-coping best practices. This knowledge can also prompt the user to seek the involvement and advice of their doctor, if needed.

Conclusion

The connection between stress and HRV, and the ability to measure and report HRV with photoplethysmography, enables the accurate measurement and detection of stress in users of Vyvo Technology wearable devices. This valuable insight into personal health helps device users take action to protect their health and wellbeing.

Legal Disclaimer

Unless otherwise specified, Vyvo Technology wearable devices and related services are not medical devices and are not intended to diagnose, treat, cure, or prevent any disease. With regard to accuracy, Vyvo Technology has developed products and services to track certain wellness information as accurately as reasonably possible. The accuracy of Vyvo Technology products and services is not intended to be equivalent to medical devices or scientific measurement devices.

Consult your doctor before use if you have any pre-existing conditions that might be affected by your use of any Vyvo Technology product or service.

Useful Terms

Heart Rate Variability (HRV): Variation in the time interval between heartbeats, measured in milliseconds. High variability - for example a low heart rate upon waking and a higher rate during exercise — is considered a hallmark of good health.

Autonomic Nervous System (ANS): a control system that acts largely unconsciously and regulates bodily functions, including heart rate.

Photoplethysmography (PPG): An optical way to measure blood volume changes in a bed of tissue, such as a finger or earlobe. Obtained by illuminating the skin and measuring light absorption.

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