HEART RATE VARIABILITY, PHYSICAL ACTIVITY AND DAILY EUSTRESS AND DISTRESS AMONG FINNISH EMPLOYEES

Ilmari Ritari

Master`s Thesis
Sport and Exercise Psychology
Faculty of Sport and Health Sciences
University of Jyvaskyla
Spring 2024

ACKNOWLEDGEMENTS

To Montse Ruiz Cerezo, for the knowledge shared across several courses in our Master´s program. To Keegan Knittle, for valuable insights and expertise, which elevated the quality of this Master´s thesis. To Finnish employees who took part in the data collection phase of this thesis, for their time and efforts.

To my classmates and friends from the PsyAct International Master´s program, for the great moments and memories shared alongside these studies. I am rooting for you all in your future endeavors.

With gratitude to my parents, for supporting me in this journey.

ABSTRACT

Ritari, I. 2024. Heart Rate Variability, Physical Activity and Daily Eustress and Distress among Finnish Employees. University of Jyvaskyla. Faculty of Sport and Health Sciences. Sport and Exercise Psychology. Master´s thesis, 70 p., 3 appendices.

The interaction between heart rate variability (HRV), physical activity (PA) and perceived stress levels has gained research interest in recent years due to its multifaceted implications for occupational health and wellbeing. This study examined the relationship between HRV and perceived stress levels among Finnish employees while also assessing the potential moderating effect of PA on this interplay. The objective was to enhance the empirical understanding of these physiological and psychological constructs, thereby contributing to a more nuanced comprehension of the mechanisms through which HRV and PA may influence, or be influenced by, individuals´ subjective experiences of stress.

This quantitative study employed the Bittium Faros wearable device for continuous HRV monitoring across three consecutive working days, alongside self-reported PA levels and stress perceptions through modified versions of the Godin Leisure-Time Physical Activity Questionnaire and the Valencia Eustress-Distress Appraisal Scale, respectively. The cohort of the study (n = 41) encompassed a broad spectrum of occupational roles spanning multiple sectors within Finland. Data derived from these measures were subjected to both correlation analysis and multilevel modeling data analyzing methods, in the purpose of dissecting the relationships and hierarchical interactions among the studied variables.

In alignment with previous studies, the present study revealed that moderate intensity PA (MPA) increased well-being based on its positive correlation with the HRV parameter SDNN. Interestingly, both low intensity PA (LPA) and MPA exhibited a negative relationship with eustress, indicating that PA may not serve as an efficacious strategy for inducing a state of eustress. Furthermore, the participants who engaged more in LPA reported elevated distress levels. As it is unlikely that LPA causes distress, this result warrants further investigation of the underlying factors that can influence distress levels. Additionally, this study strengthened the existing knowledge, that increased values of HRV parameters SDNN and RMSSD correlate with reduced distress levels. However, the anticipated moderating effect of PA on the HRV-stress relationships did not receive empirical validation.

This thesis contributed to the growing body of knowledge on stress management, positing that HRV and PA constitute valuable tools for the comprehension and managing stress. Nonetheless, the dynamic interplay among these variables and their impact on perceived stress is rather complex. Future research should explore the specific types and intensities of PA that optimally facilitate stress management, and how individual and organizational determinants influence the efficacy of stress management strategies.

Keywords: heart rate variability, physical activity, eustress, distress

CONTENTS

ABBREVIATIONS

ANS	autonomous nervous system
HR	heart rate
HRV	heart rate variability
HRVB	heart rate variability biofeedback
LPA	low intensity physical activity
MLM	multilevel modeling
MPA	moderate intensity physical activity
PA	physical activity
PNS	parasympathetic nervous system
RF	resonance frequency
RMSSD	root mean square of successive differences
RR	oscillations between consecutive instantaneous heartbeats
RSA	respiratory sinus arrhythmia
SDNN	standard deviation of normal-to-normal intervals
SNS	sympathetic nervous system
VEDAS	Valencia Eustress-Distress Appraisal Scale
VMPA	vigorous and moderate intensity physical activity
VPA	high intensity physical activity

1 INTRODUCTION

The interplay between both physiological and psychological well-being is a focal point in understanding stress (Föhr et al., 2016b; Jarvelin-Pasanen et al., 2018; Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). Heart rate variabilily (HRV) is the variation of time between consecutive heart beats (Föhr et al., 2016b; Pinna & Edwards, 2020; Steffen et al., 2017). HRV has been identified as a robust tool to assess alterations of the autonomous nervous system (ANS) (Jarvelin-Pasanen et al., 2018; Peabody et al., 2023). A further method to manage stress, also well documented, is physical activity (PA). Accumulating empirical evidence posits that PA of varying intensities (i.e., light, moderate or vigorous) can serve as a tool to mitigate stress levels (Bischoff et al., 2019). Consistent participation in PA enhances cardiovascular health, culminating in the body´s increased capability to modulate physiological responses to stress (Bischoff et al., 2019; Mucke et al., 2018). Evidence suggests that engagement in PA does not undermine occupational performance. Rather, it tends to enhance the efficacy in professional settings (Jackson & Frame, 2018). Furthermore, all the other external factors beyond the work life in individuals' lives (i.e., outside work life) can modify the levels of stress. This makes stress detection complex, and more theories and methodologies to detect stress are needed (Facey et al., 2015; Fatisson et al., 2016; Jarvelin-Pasanen et al., 2018; Peabody et al., 2023; Ratnawat & Jha, 2014).

It has been documented that there are clear patterns of alterations in HRV that correlate with situations perceived as stressful (Peabody et al., 2023). In previous studies, measuring subjective experience with a questionnaire combined with HRV analysis has yielded insights signifying that these respective variables are connected (Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). Numerous studies have been made about the effects of HRV, PA and stress. Considering stress, an overwhelming number of studies have explored distress, leaving the knowledge of eustress rather limited. Importantly, a minimal quantity of studies has integrated these three elements within one singular study, especially in the context of Finnish employees.

Hereby, the objective of this study was to fill this gap by investigating potential influencing variables (i.e., HRV and PA) that may significantly affect perceived stress levels. By adopting this comprehensive lens that includes both physiological and psychological measurement, this

research aimed to uncover nuanced insights into how PA might modulate the relationship between HRV and stress. Considering the previous, this study addressed these two research questions: What are the correlations between HRV, PA, and perceived eustress and distress in daily life among Finnish employees? Does PA moderate the relationships between HRV and eustress and distress? By investigating these questions, this thesis aimed to contribute to the existing knowledge, and offer practical insights for employees aiming to optimize well-being and performance in their respective work roles.

2 LITERATURE REVIEW

The interactive relationships between physiological responses and psychological well-being have been well explored within the realm of occupational environments. HRV, as a reflection of ANS function, stands out as a critical physiological marker, associated with the body´s adaptability to daily stressors (Thayer et al., 2011) Therefore, HRV is a relevant measure for the two categories of stress, which are eustress and distress. Eustress may enhance performance and well-being. Conversely, distress can impair health and occupational capability (Billman, 2011; Bienertova-Vasku et al., 2020). Furthermore, PA has been recognized as a lifestyle factor that holds the potential to modulate HRV and consequently, stress levels (Föhr et al., 2016a; Föhr et al., 2016b). By examining how these components influence one another, the following literature review will present existing knowledge and gaps that this study addresses (Kim et al., 2018; Jarvelin-Pasanen et al., 2018).

2.1 Heart rate variability

The human heart beats approximately 100,000 times a day (Shaffer et al., 2014). One prominent feature of the cardiovascular system is HRV which is the variation of time between consecutive heartbeats (Föhr et al., 2016b; Pinna & Edwards, 2020; Steffen et al., 2017). The human body´s operational complexities are a combination of different physiological and psychological systems that impact the heart performance (Ernst, 2017; Grippo, 2017; Shaffer et al., 2014; Steffen et al., 2017; Zahn et al., 2016). One key component of this multifaceted interplay is (ANS) (Grippo, 2017). The hypothalamus, an integral regulatory system in brains, collaborates with ANS to regulate a multitude of the body´s involuntary functions (Can et al., 2019). ANS has two divisions: sympathetic (SNS) and parasympathetic (PNS) nervous systems (Grippo, 2017). Activation of SNS elevates heart rate (HR), and as a result, alertness has been aroused, hence facilitating adaptive actions towards stressful situations. Conversely, a reduction in HR activates PNS for purpose of relaxation (Can et al., 2019; Pham et al., 2021). Vagus nerve is the longest cranial nerve, and it is the major nerve in PNS, which is responsible for rest and digestion in the body´s functions during stress (Lehrer et al., 2020; Pinna & Edwards, 2020). Alterations in the functioning of ANS are associated with changes in cardiovascular functions, particularly concerning HR dynamics (Pham et al., 2021).

Effective functioning of the ANS has been empirically linked to beneficial outcomes in behaviors, social interactions, and emotional regulation (McCraty & Shaffer, 2015). The SNS and PNS branches respond dynamically to real-life situations, a factor that significantly contributes to HR (Grippo, 2017; Peabody et al., 2023; Pham et al., 2021). In a typical 24-hour cycle among healthy individuals, average HR has been estimated to be approximately 75 beats per minute (McCraty & Shaffer, 2015; Shaffer et al., 2014). Variations in ANS functions have been proposed to explain diverse conditions, such as stress response, social behaviors, cognitive functions, and sleep (Grippo, 2017). These variations are regulated by the central autonomic network in brain, specifically in a region of brains called the prefrontal cortex. The prefrontal cortex enables the capability to adapt the situations flexibly (Zahn et al., 2016). In other words, HRV levels serve as biological markers to indicate one´s capability to adapt to environmental and psychological situations (Fatisson et al., 2016; Shaffer & Ginsberg, 2017). Importantly, variations in SNS and PNS branches can work in both linear and non-linear fashions (McCraty & Shaffer, 2015; Pinna & Edwards, 2020; Shaffer & Ginsberg, 2017). For instance, during and post running exercises SNS activation increases HR, concurrently with PNS, which is also activated so that high HR can be decreased for purpose of recovery (Shaffer & Ginsberg, 2017; Shaffer et al., 2014). The idea of enhancing the cardiovascular system with aerobic exercise, such as running, is known to be efficient according to empirical studies from decades (Joshi, 2012).

When HRV levels are high, they generally serve as indices of the heart´s capability to adapt to the physiological demands. To be more specific, in these circumstances, the heart is healthy (Steffen et al., 2017). Moreover, a healthy heart is also relevant to brain health, due to its role of ensuring sufficient circulation for the brain to function (Ernst, 2017). As a result of elevated HRV, emotional functions, stress management, and social behavior can be fostered (Georgiou et al., 2018; Pinna & Edwards, 2020). However, high HRV levels are not necessarily always a good thing. Particularly among older adults, elevated HRV can indicate cardiac conduction abnormalities, which can increase the risk of mortality (Shaffer & Ginsberg, 2017). In contrast, low HRV is associated with adverse health outcomes, such as chronic stress, depression, and anxiety (Georgiou et al., 2018; Kim et al., 2018; Steffen et al., 2017; Zhang, 2007). Reduced HRV is linked with the body´s incapability to efficiently activate PNS. This predicts that stress is likely to follow consequently (Kim et al., 2018). Moreover, when HR is high the HRV is then

low. This can be attributed to the fact that at elevated HR, the heartbeats are closer to each other, thereby reducing the potential for variability (McCraty & Shaffer, 2015; Steffen et al., 2017).

To summarize, HRV serves as a reliable noninvasive tool that can be used as a measurement to understand cardiac functionality and the activations in our ANS (Fatisson et al., 2016; Kim et al., 2018; Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996; The et al., 2020; Zhang, 2007). In addition, HRV provides insights into psychological functioning and mental health outcomes (Kim et al., 2018; Shaffer et al., 2014). Before undertaking HRV measurements, it is recommended to consider the individual´s medical history (Catai et al., 2020; Kim et al., 2018). To be more specific, it is important to identify possible diagnoses, medications, and currently existing stress levels (Catai et al., 2020).

2.1.1 Heart rate variability measurement

Heart rate variability biofeedback (HRVB) is an intervention designed to enhance the understanding of the body´s real-time physiological responses (Davila et al., 2017; Ernst, 2017; Kennedy & Henrickson-Parker, 2018; Steffen et al., 2017; Task Force of The European Society of Cardiology & The North American Society of Pacing and Electrophysiology, 1996). During HRVB physiological parameters such as HRV and HR, are measured with an electrocardiogram (ECG) signal from a device that has been attached to the chest with sensors of device (Davila et al., 2017; Ernst, 2017; Steffen et al., 2017; Zahn et al., 2016). These devices are rather user-friendly and should cause only minor or not at all discomfort during daily life (Can et al., 2019). It is advisable to conduct more than a 24-hour HRVB measurement period when the purpose is to assess the body´s ability to recover from different work and leisure time stressors during sleep and awake times (Föhr et al., 2016b; Pham et al., 2021; The et al., 2020).

Patterns of breathing influence on HRV (Jarvelin-Pasanen et al., 2018). In HRVB studies involving healthy participants, it has been demonstrated that breathing and HR have an association with each other (Lehrer et al., 2020). To be more specific, inhalation induces a decrease in arterial pressure, while in contrast arterial pressure increases during exhalation. This cycle is known as respiratory sinus arrhythmia (RSA) (Kemp & Quintana, 2013; Pham et al., 2021; Thayer et al., 2011). Resonance frequency (RF) refers to the number of breaths taken per

minute. This is an authentic feature among people, often in adults the RF ranges from 9 to 24 breaths per minute. When RF falls in the spectrum of 4,5 to 6 bpm, it can facilitate increases in HRV levels made in HRVB protocols (Lin et al., 2014; McCraty & Shaffer, 2015; Shaffer et al., 2014; Steffen et al., 2017). Breathing at specific RF values is a learnable skill, and practicing it is usually incorporated into HRVB training programs (Shaffer et al., 2014).

Several physiological mechanisms are extracted during HRV measurement, and those outputs are represented by various parameters in the HRV data set (Paso et al., 2013). The analytics from HRV measurements can be categorized into linear and non-linear algorithms. Linear algorithms in HRV measurement allow time or frequency domain analysis (Buccelletti et al., 2012; Forte et al., 2019; The et al., 2020). Time domain scores are calculations of consecutive successful heartbeats, which is a straightforward method to find out HRV (Buccelletti et al., 2012; Forte et al., 2019; Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996; The et al., 2020). Figure 1 below illustrates time-domain measurement.

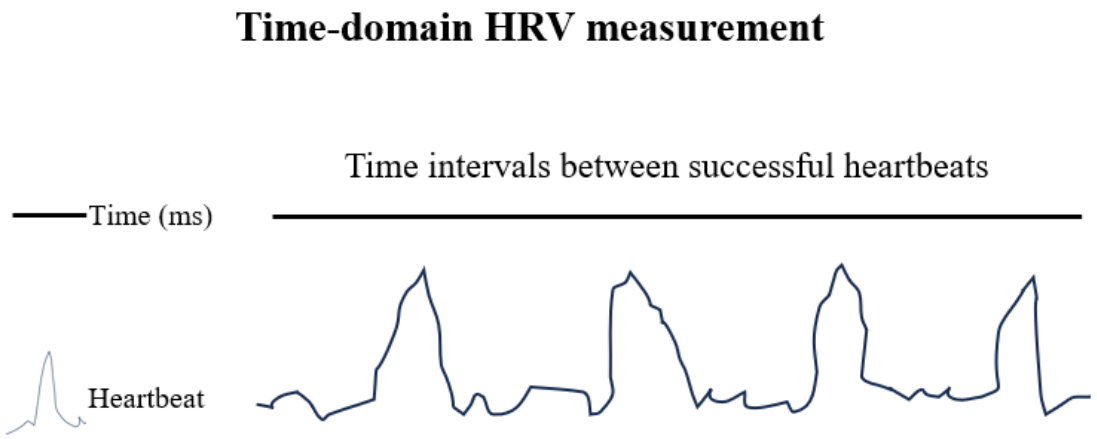


Figure 1. Time-domain HRV measurement.

Specific time-domain parameters, which are used in this study and introduced in the next chapter, can be identified from a lengthy HRV measurement, such as 24 hours (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). Frequency domain scores, on the other hand, are a more complex

form of calculations, which include a power spectral density analysis and non-linear analysis (Buccelletti et al., 2012; Forte et al., 2019; The et al., 2020).

Assessment of HRV is an instrument for serving understanding of the body´s biological and physiological effects on cardiac function, stress, and mental health outcomes. The HRV parameters elicit information on the time between every successful heartbeat, thereby providing specific information to identify alterations in both SNS and PNS. These fluctuations provide valuable data on an individual´s stress responses during everyday life. As stress is both a physiological and psychological phenomenon, HRVB has suited elements to study both factors and possibly make early identification of stress to prevent adverse health outcomes.

2.1.2 Heart rate variability parameters

Oscillations between consecutive instantaneous heart rates (RR)

HRV has been established as a reliable tool for evaluating the oscillations occurring between consecutive instantaneous heart rates (RR intervals). However, RR exhibits and irregular nature characterized by asymmetric trends in HR increases and decreases. This irregularity can have a notable influence on the time-domain methods employed in the HRV analysis (Sacha, 2014; Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). Studying RR intervals can enhance the understanding of rhythm dynamics. Consequently, RR intervals obtained from HRV measurements should be included, when disseminating information regarding HRV results (Draghici & Taylor, 2016; Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996).

Standard Deviation of Normal-to-Normal intervals (SDNN)

The SDNN intervals in heartbeats quantify the time variability between successful heartbeats, expressed in milliseconds (McCraty & Shaffer, 2015; Shaffer & Ginsberg, 2017). Essentially, SDNN calculates time domain scores in HRV measurements (Buccelletti et al., 2012; Fatisson et al., 2016). SDNN has gained widespread acceptance as a reliable metric of overall HRV measurement (Jarvelin-Pasanen et al, 2018; Shaffer & Ginsberg, 2017). In a systematic review,

SDNN was the most frequently utilized time domain parameter assessed. In addition, it has been argued that the reliability of SDNN scores increases when the measurement period is over 24 hours (The et al., 2020). From a medical perspective, based on SDNN measurements over 24 hours, SDNN values exceeding 100 milliseconds are indicative of optimal health. 50-100 milliseconds are suggested to be sub-optimal scores, and they indicate compromised health, while under 50 milliseconds is considered as unhealthy score (Shaffer & Ginsberg, 2017). Observational studies involving patients suggested, that scores of 0-50 milliseconds increased risk of mortality four-fold compared to scores of 50-100 milliseconds (McCraty & Shaffer, 2015; Shaffer et al., 2014). Differences in SDNN between females and males are not significant (Zhang, 2007). However, there is an inverse correlation between increasing age and SDNN (Fatisson et al., 2016; McCraty & Shaffer, 2015; Shaffer et al., 2014; Zhang, 2007). One clear reason for this decline is the reduction in the amount of PA, especially among people over 60 years of age (Zhang, 2007). Figure 2 below (Zhang, 2007) illustrates the relationship between HRV and overall health status. In the figure, a spike at the graph indicates a heartbeat.

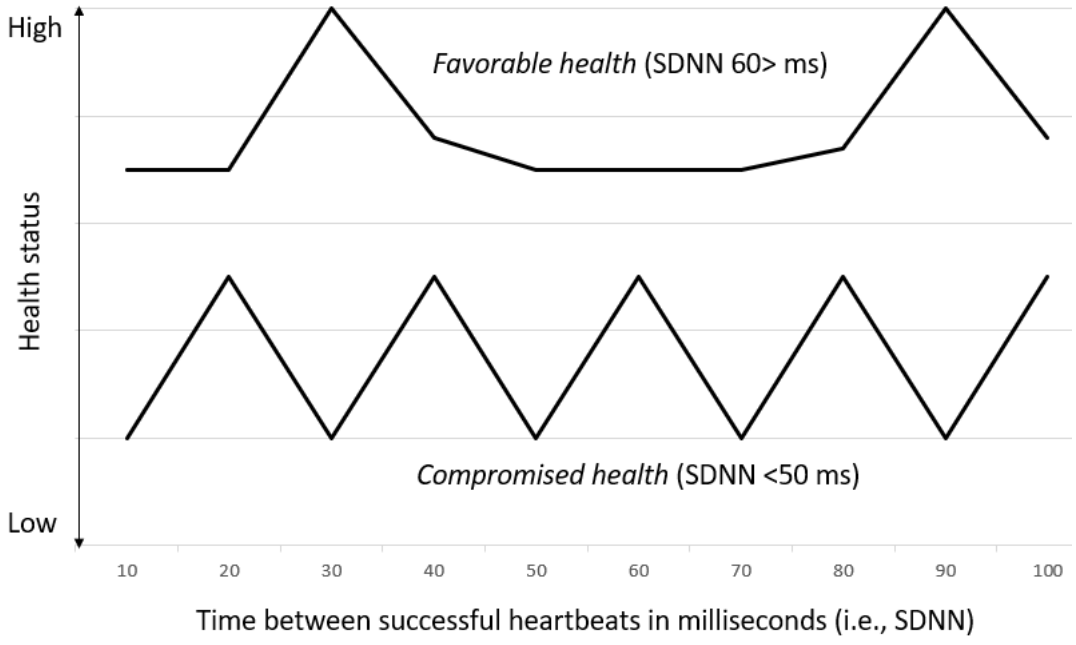


Figure 2. The relationship between HRV and health modified from Zhang (2007).

Root Mean Square of Successive Differences between normal heartbeats (RMSSD)

Within the context of HRV measurement, RMSSD stands for root mean square of successive differences between normal heartbeats (Shaffer & Ginsberg, 2017; Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). RMSSD provides an efficient means to evaluate RSA. It is noteworthy that a low RMSSD value demonstrates a negative correlation with overall health status (Shaffer & Ginsberg, 2017). Conversely, a high RMSSD value is associated with a notably enhanced subjective perception of health (Ernst, 2017). RMSSD, by its nature, encapsulates estimations of the short-term components of HRV and possesses favorable statistical properties. Hence, RMSSD is recommended to be included in the time-domain HRV analysis information (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996).

Time-domain and frequency-domain method

In the context of quantifying HRV, SDNN and RMSSD are both categorized under time-domain methods. When performing long 24-hour HRV measurements, the parameters provided by the time-domain method correlate robustly with those derived from the frequency-domain method. Consequently, reporting the results from time-domain measurement is deemed ideal in long-term HRV measurements. However, frequency-domain methods relevance emerges predominantly in such cases, where the HRV measurement is only short-term, such as one to five minutes. The frequency-domain method provides nuanced insights about autonomic modulations. Hence, therefore in short-term measurement frequency-domain method is likely a better option than the time-domain method (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). The current study employs a three-day measurement period, which can be classified as a long HRV measurement. Given this, only the results of the time-domain method are included in the result reporting. To be more specific, the results from the frequency-domain method are excluded entirely from the current study.

2.2 Physical activity

PA is a movement of the body, where the motion instigated by muscles leads to escalated energy expenditure (Rhodes et al., 2017; Thivel et al., 2018). The intensity and type of PA are usually

critical parameters assessed regarding PA. Intensity generally spans across a continuum from low intensity (LPA) (i.e., no shortness of breath) to moderate (MPA) (i.e., shortness of breath) and vigorous intensity (VPA) (i.e., heavy breathing). This spectrum increases energy expenditure progressively. Type, on the other hand, describes the PA aerobic (i.e., walking, jogging) or anaerobic (i.e., high-intensity interval training) activity. Additional assessment parameters generally are how often PA is done and what was the duration of the session (Rhodes et al., 2017).

Quite a familiar concept related to PA is exercise, which is a subcategory of PA (Mikkelsen et al., 2017; Thivel et al., 2018). To be more specific, the purpose of exercise is to systematically develop or maintain physical condition with repetitive exercise patterns. In contrast, another facet of PA is sports. Sports refers to a PA, which has sports-related specific rules and usually has organizations and teams involved around the sport-related events. Regarding public health, it is important to understand the distinction between exercise and sports. Sports as a term can be associated with athletes, who practice high amounts of exercise to achieve great skillsets and astonishing physical fitness. However, in the context of public health (i.e., non-athlete population), merely incorporating increased volumes of regular PA into their routine is enough to gain health benefits from PA (Thivel et al., 2018). Figure 3 below defines the weekly PA recommendations for adults.

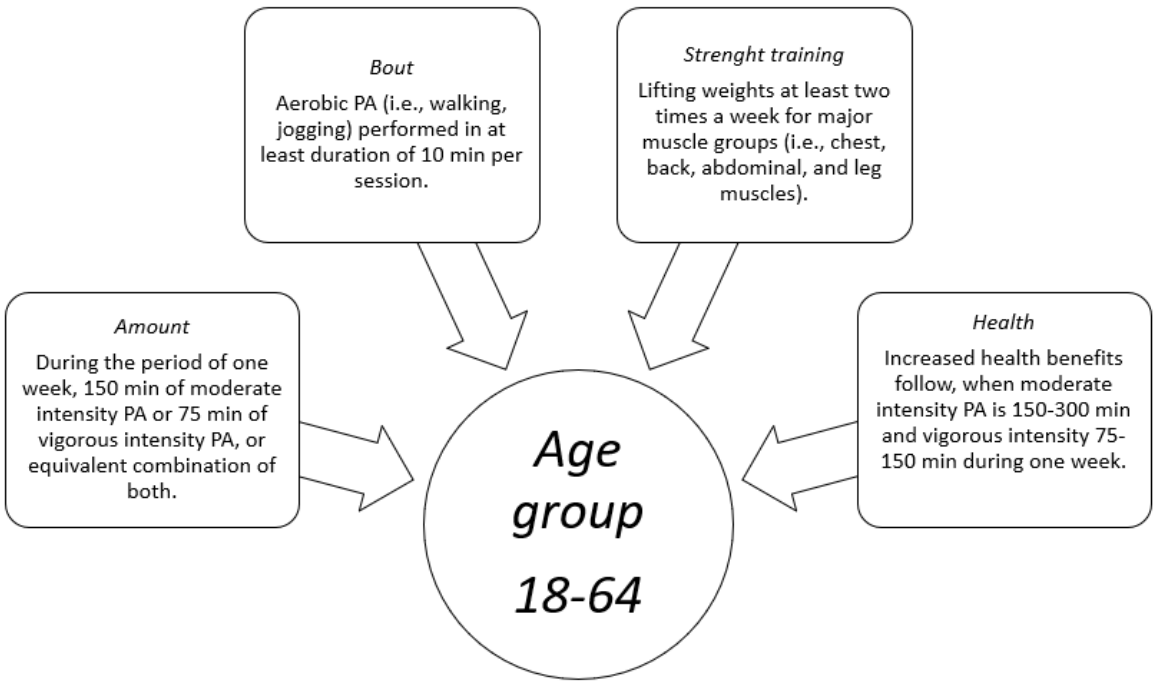


Figure 3. Weekly PA recommendations for adults aged 18-64 modified from Rhodes et al. (2017).

2.2.1 Effects of physical activity on physical health

Consistent engagement in PA has been demonstrated to mitigate the deleterious effects of more than 25 medical conditions. The effects of physical inactivity can be comparable to, or even exceed other significant health risk factors. According to substantial evidence, the recommendation of 150 minutes of MPA to VPA is a potent preventative measure against a multitude of diseases (Warburton & Bredin, 2016). Nevertheless, even lesser quantities and lower intensity of PA can still contribute significantly to health outcomes (McKeon et al, 2022; Warburton & Bredin, 2016). Even minor increases of PA, such as 15 minutes a day (i.e., 90 minutes per week), have been identified as an effective strategy to decrease the impacts of several diseases and reduce premature mortality. Effective forms of PA to gain these benefits are walking and running in minor and major distances, they both bolster aerobic fitness. Beyond aerobic fitness, the musculoskeletal system (i.e., muscles, bones, tendons etc.) plays an important role when executing PA throughout one´s lifespan. To enhance the performance of musculoskeletal system, acquiring a specific training program considering individual health and medical situations can be beneficial. This is pivotal because a robust musculoskeletal system increases the performance not only in PA, but also in an individual´s everyday routine movement tasks (Warburton & Bredin, 2016).

Given the recent developments in digitalization, sedentary behavior has increased across populations. Sedentary behavior refers to physical inactivity (i.e., office work, playing video games), where the energy expenditure is minimal (Warburton & Bredin, 2016). Prolonged periods of sitting have been correlated with an escalated risk of mortality and cardiovascular disease, a risk that persists even in instances where one simultaneously meets the PA recommendations (Panahi & Tremblay, 2018; Warburton & Bredin, 2016). Furthermore, sedentary behavior has been linked to a variety of metabolic dysfunctions, such as decreased glycemic control and negative effects on insulin action (Panahi & Tremblay, 2018).

Diminished levels of PA have been associated with alternations in appetite regulation. Sedentary behavior can disrupt the body´s capability to interact with body fat, which has been suggested to be the potential explanation for why sedentary people tend to consume too many calories related to their energy expenditure (Panahi & Tremblay, 2018). Decreasing the amount of daily PA has resulted in substantial weight gain, whereas an increase in the amount of PA can facilitate weight loss. In a longitudinal study involving approximately 5,000 adults, incorporating only 30 minutes of LPA (i.e., walking) into daily life yielded less weight gain over a several-year follow-up periods, in both females and males. Notably, this result was reached without any other major changes made in their lifestyles (Reiner et al., 2013).

Obesity and suboptimal physical fitness levels can predict type 2 diabetes. Based on the compelling evidence based on longitudinal studies, it can be stated that PA can reduce the possibility of getting type 2 diabetes. This effect is achieved when PA is executed at MPA or VPA at least once per week. Despite the previous, it is still unknown what are the exact physiological mechanisms in the body that cause the preventive effect of PA for risk of type 2 diabetes. Furthermore, PA is linked to a lower risk of developing dementia and Alzheimer´s disease in both sexes. In terms of preventing these both conditions, especially LPA (i.e., walking) appear to be effective in mitigating the risks of these conditions (Reiner et al., 2013).

While the PA recommendations for adults have specific amounts and durations, even lower levels of PA can derive health benefits. This notion can be especially useful for individuals with sedentary lifestyles and just starting to develop PA habits. Establishing PA habits can be a challenging endeavor and relapses might be involved. However, resiliency could be bolstered by the fact that the efforts they have made positively contributed to their health, despite not meeting the recommended guidelines. Consequently, they may find more encouragement to sustain PA habits and progressively approach the recommended guidelines, as a result potentially exceed them to achieve even more health benefits.

2.2.2 Effects of physical activity on mental health

Mikkelsen et al. (2017) have stated that the beneficial impact of PA on mental health is well documented in scientific literature. Numerous studies have drawn parallels that PA can have similar impacts on mental health than psychotherapy. Depression and anxiety are common

mental health conditions, respectively. Their symptoms can be decreased by regular PA, encompassing people from age groups of adolescents to the elderly (Mikkelsen et al., 2017). To be more specific, the reduction of symptoms can be achieved by doing aerobic (i.e., walking, jogging), non-aerobic (i.e., strength training, relaxation practices), or movement (i.e., yoga) activities. However, in the purpose of treatment for mental health conditions, PA does not override pharmacological intervention. PA should be ideally incorporated as a complementary treatment alongside medication and psychotherapy. Conversely, PA can also have adverse effects on mental health. In athletes, excessive training and exercise dependency can result in anti-inflammatory issues and injuries. In addition, sports environments can foster body image comparisons, potentially leading to a decrease in self-confidence. However, regarding these negative effects, it is vital to acknowledge that athlete lifestyle differs significantly from non-athlete lifestyle (McKeon et al., 2022; Mikkelsen et al., 2017).

Even amounts inferior to PA recommendations can potentially induce beneficial effects on mental health (McKeon et al., 2022; Mikkelsen et al., 2017). This knowledge is particularly relevant for especially patients with severe mental health disorders since they usually do not meet the PA recommendations (McKeon et al., 2022). Given this, at least some activity of PA must exist, in which the patient can take part in their leisure time (McKeon et al., 2022). A feasible aim is to find some form of PA where the difficulty of PA and personal skill level harmonize together, elicit a sense of pleasure, and have other people involved to facilitate social interaction (Felez-Nobrega et al., 2021; McKeon et al., 2022).

According to Felez-Nobrega et al. (2021), engagement in LPA (i.e., walking, daily chores, or any other everyday movement) corresponds with minimal energy expenditure. Based on multiple previous studies, LPA walking diminishes symptoms of depression. This could be an interesting option for people with mental health conditions since integrating and completing this kind of PA in daily life does not take that much effort. The implementation of this does not require substantial energy, skills, and financial investment to execute. Furthermore, a lack of motivation is common when experiencing mental health issues, as a result, the likelihood of taking part in MPA or VPA has been compromised. Notably, walking at LPA is an everyday PA, and if walking serves as a pleasant way to do PA, then the intensity of walking can be elevated to MPA. Up to this point, the evidence-based consensus posits that regarding the PA´s positive impacts on mental health, MPA has more significant effects compared to LPA.

For individuals dealing with mental health issues, it would be relevant to start some form of regular PA habit. As stated in the previous section, numerous types of PA are beneficial, and the benefits for mental health can be achieved even with modest amounts of PA. However, executing this can be a complex process. Initiating a PA regimen can be difficult for the individual when they have a mental health condition that adversely affects other crucial areas of their life (i.e., relationships and work performance). Furthermore, participation in conventional group-based PA class, which is a great idea, might be daunting if individuals perceive that their skills and fitness levels are inferior compared to other participants, potentially decreasing the likelihood of their future engagement.

A possibly effective solution for this could be for health care providers to offer tailored exercise groups targeted at those who have mental health issues. These groups could range from low threshold (i.e., walking groups) and more physically demanding ones (i.e., football). Participation in these groups could foster valuable peer support through discussions and shared experiences. Furthermore, this could stimulate their motivation towards PA, when they see that peers with similar challenges are successfully engaging in the activity.

2.2.3 Effects of physical activity on cognitive performance

Based on advanced brain scans (i.e., fMRI and ERP) sustained engagement to PA enables changes in brain structure, especially in the frontal cortex and hippocampus, thereby bolstering cognitive function. Such cognitive enhancements have been linked with improved learning outcomes in Western countries, where most adolescents take part in formal education. In adulthood, when young adults turn to older adults, it is natural to experience declines in cognitive performance (Erickson et al., 2015). Regarding the effects of PA, longitudinal studies have suggested that practicing PA consistently protects this decline by 40 %. Furthermore, when considering work performance, the high fitness level is associated with the increased capability to solve demanding cognitive tasks (Erickson et al., 2015; Erickson et al., 2019). Like PA effects on mental health, MPA is a way to improve cognitive performance as well (Erickson et al., 2015; Erickson et al., 2019; Pontifex et al., 2019). To be more specific, the long-term sustained MPA has been shown to have great developing effects on cognition (Erickson et al., 2015; Erickson et al., 2019). Impacts of PA on cognition can also have more indirect pathways.

For instance, PA can modulate physiological functions that improve sleep quality, therefore in this case, cognitive performance increases because of improved sleep (Erickson et al., 2019).

Pontifex et al. (2019) noted that, in addition to long-term adherence to PA, the effects of a single PA session on cognition have also aroused research attention. Following a PA session, enhanced concentration and sustained attention have been observed. Furthermore, most of the studies in this field has focused on cognitive control (i.e., solving problems, and avoiding distractions). After conducting multiple different tasks requiring these abilities post-PA session, the ability to control one´s actions increased. In previous studies, these kinds of results have been identified when the intensity of PA has been MPA or VPA, and the duration of a single PA session is between 16 to 35 minutes. However, the knowledge regarding PA´s effects on other cognitive functions (i.e., working memory, cognitive flexibility) is insufficient.

2.2.4 Effects of physical activity on stress

Accumulating empirical evidence suggests, that PA in any intensity (i.e., VPA, MPA or LPA) can serve as a tool to mitigate stress levels. This is based on the observation that PA has a direct correlation with psychosocial factors, which, in turn, influence the neuroendocrine system (Bischoff et al., 2019). Consistent engagement in PA enhances cardiovascular health, leading to the body´s increased capability to modulate physiological stress responses. To be more specific, these responses are associated with the hypothalamic-pituitary-adrenal (HPA) axis and activations in ANS (Bischoff et al., 2019; Mucke et al., 2018). Within the context of workplace interventions, various mind-body movement practices (i.e., yoga, tai chi) have been extensively used as forms of PA. They have been effective in lowering perceived stress levels. Yoga, for instance, improves focus, spirituality, and ability to engage in the present moment, making it a potentially appealing form of PA for sedentary people, given it is typically performed as a LPA. Additionally, a running intervention of several months has also elicited significant reductions in stress levels. Such outcomes were achieved by systematically elevating the intensity and duration of the exercise sessions (Bischoff et al., 2019).

Furthermore, the more nuanced model explaining the benefits of PA to stress is cross stressor adaptation (CSA) hypothesis. CSA has four different elements. First, it posits a decreased amount of perceived psychological stress. Second, it anticipates improvements in social support

and self-esteem. Third, it suggests an enhancement of the capability to maintain personal and social resources (Bischoff et al., 2019). Lastly, the stress-buffering effect, corresponds to the identification of efficient stress-coping strategies. If the latter produces efficient coping strategies, then it is more likely that psychological stress-related disorders do not arise (Bischoff et al., 2019; Mucke et al., 2018). Additionally, CSA proposes that PA itself is a stressor to the body. To arouse the four benefits of CSA, the intensity of exercise should be approximately half of one´s maximal oxygen consumption (i.e., VO2 max) (Mucke et al., 2018). Conversely, people failing to capitalize on these benefits of CSA on stress are more likely to be incapable of handling stress, which can lead to excessive amounts of negative stress (Bischoff et al., 2019; Mucke et al., 2018).

The practices and theories presented in this chapter might not be widely recognized in occupational communities. For instance. individuals lacking engagement in PA before might encounter mind-body movement practices and the CSA hypothesis for the first time. Therefore, it would be relevant to have an expert in the field to facilitate a workshop for the employees in the company, to ensure the understanding of the topics and adequate instructions for the application of practices. When the employees gain knowledge of why and how these practices and theories can enhance their work performance, that potentially arouses increased interest in implementing these practices.

2.3 Stress

In its original conception, the term “stress” is characterized as the body´s response to a variety of positive and negative factors, which can be physical, chemical, and biological (Anton et al., 2020; Bienertova-Vasku et al., 2020; Burman & Goswami, 2018; Can et al., 2019; Gandhe, 2014; Ganster & Rosen, 2013; Ratnawat & Jha, 2014). In other words, stress is an occurring situation, which causes strain for individuals (Burman & Goswami, 2018; Harshana, 2018; Ratnawat & Jha, 2014). The neural stress response in our brains is a result of what our eyes, nose, or ears detect in environmental situations. These situations are referred to as stressors (Can et al., 2019; Ganster & Rosen, 2013) Upon the occurrence of stressors, the HPA axis regulates the distribution of cortisol (i.e., the body´s stress hormone) throughout the body. This cortisol distribution process enables the possibility to react appropriately in the face of a stressor (Ganster & Rosen, 2013).

Stress can alternatively be conceptualized as a state in which the body cannot adjust to existing circumstances due to the overactivation of SNS (Burman & Goswami, 2018; Kim et al., 2018). The impact of stress on one´s performance is inherently subjective: it can vary daily, based on circumstances (Anton et al., 2020; Burman & Goswami; 2018; Can et al., 2019; Gandhe, 2014). Predominantly, stress hinges on the social situations or tasks required to be performed, or a combination of both (Anton et al., 2020; Gandhe, 2014). Notably, stress response can be both physical and psychosocial simultaneously. For instance, lower back pain might emerge because of too much sedentary behavior coupled with job dissatisfaction, wherein the interplay of these two culminates in stress (Ganster & Rosen 2013).

2.3.1 Eustress

The term eustress refers to stress where the stress response is positive (Anton et al., 2020; Gandhe, 2014; Ratnawat & Jha, 2014). In eustress, the amount of stress is elevated, which is aroused by the stimulation of SNS (Anton et al., 2020). This response, commonly referred to as the "fight or flight" response, prepares the body to react effectively to the situation at hand (Anton et al., 2020; Can et al., 2019; Thayer et al., 2011). This is a valuable reaction because one is then capable of mobilizing resources effectively to encounter challenges. Thereby, resiliency is bolstered, so the ability to handle similar situations successfully in the future is enhanced (Anton et al., 2020). Furthermore, eustress is typically accompanied by sense of competence and pleasure upon successful completion of tasks (Hargrove et al., 2015). Pleasure is defined as a feeling of satisfaction, where consciousness aligns with the body´s biological programming, meeting the need for social fulfillment (Csikszentmihalyi 2005, 77). When such factors are present in the context such as work, then happiness towards tasks at hand is likely (Csikszentmihalyi 2005, 210).

Cummings & Cooper (1998) argued that response to stress causes instability, thereby one is then willing to restore stability (Gandhe, 2014; Ganster & Rosen, 2013). This endeavor for the body´s mechanisms to maintain balance is defined as homeostasis by Hans Selye (Ganster & Rosen, 2013). In certain scenarios, this process can be executed by coming up with demanding tasks that need to be accomplished within a short timeframe (Heikkila et al., 2018). However, while doing this, it is essential to retain a sense of control over their environment and variables

impacting the assigned tasks (Gandhe, 2014). This can consequently foster commitment towards task completion and the utilization of resources, which eventually leads to improved self-efficacy (Heikkila et al., 2018).

Goal setting is a critical part of the process when the desire is to achieve eustress, with tasks related to goals expected to be challenging (Vartiovaara 2004, 11). Stress-related goal setting can be conceptualized as a cognitive process, aimed at fostering, an understanding of how to overcome stress factors rather than getting overwhelmed by them (Anton et al., 2020). To be more specific, the end goal serves as a motivational stimulus to get difficult tasks completed along the way. This process creates excitement, and scary feelings or thoughts are not of concern (Vartiovaara 2004, 11). However, too much eagerness and tense feelings can be evoked simultaneously during this process (Ratnawat & Jha, 2014; Vartiovaara 2004, 11). Such experiences open the world around in a new way that shapes thinking, and it is a toning experience. These reactions might be confusing to oneself and their social circles (Vartiovaara 2004, 11). In essence, eustress enhances competence to find solutions when facing obstacles, thereby reframing challenges as opportunities. The advantageous outcomes of eustress include an enhancement in well-being and constant commitment to tasks. Furthermore, the presence of eustress mitigates the likelihood of experiencing burnout (Fabio et al., 2018).

Based on the Conservation of Resources (COR) theory, eustress can also take place when one is in danger of losing resources (Gandhe, 2014). These resources can be physical (i.e., salary) and psychological (i.e., competence) (Jackson & Frame, 2018). In such a situation, eustress arises from the need to leverage available resources to combat the challenging situation. COR theory effectively triggers stress cycles with the intention that, at the end of these cycles one has gained additional resources. Conversely, distress or negative stress may ensue, if one fails to gain resources at the end of a stress cycle, despite their efforts (Gandhe, 2014). According to COR theory, distress, induced by the failure to secure resources, can potentially lead to burnout (Jackson & Frame, 2018).

Leveraging the process, wherein stress acts as a stimulatory factor, can prove advantageous when aiming toward fulfilling the optimal form of potential (Anton et al., 2020). This development process can potentially culminate to a “flow” state, which is referred to be the climax of eustress. Flow is a focused and effortless state, where the execution of peak

performance is possible. In contrast, if the amount of eustress is excessive, negative health consequences may ensue (Can et al., 2019; Heikkila et al., 2018). Even though eustress and flow are empowering states, performing at a high level is demanding, so sufficient recovery from periods of eustress is necessary (Heikkila et al., 2018; Kennedy & Henrickson-Parker, 2018). When resting HRV is high, recovery from stressful situations is effective and vice versa (Thayer et al., 2011).

Understanding the concept of eustress enables the opportunity to use stress as a resource to increase performance. As a result, employees gain insights of what are the specific components of their work roles that are vital for deriving enjoyment and effectiveness in their work tasks. This can be crucial since superior performance of employees impacts positively on the company´s success and elevates customer satisfaction.

2.3.2 Distress

Contrasting eustress is a form of negative stress, termed as distress. Distress is a common issue in occupational environments on a global scale (Can et al., 2019; Castaldo et al., 2015; Fordjour et al., 2020; Ratnawat & Jha, 2014). Outcomes of distress can be undesirable, encompassing feelings of negativity, anxiety, and fatigue (Bienertova-Vasku et al., 2020; Castaldo et al., 2015; Fordjour et al., 2020). Such outcomes take place due to the insufficient allocation of resources to effectively manage the stressors at hand (Anton et al., 2020; Facey et al., 2015; Heikkila et al., 2018; Ratnawat & Jha, 2014; Ruotsalainen et al., 2015). Notable psychological difficulties that emerge include disturbed sleep, memory challenges, and concentrating difficulties (Can et al., 2019; Fordjour et al., 2020). Severe distress can trigger neglecting of healthy habits (i.e., PA, healthy nutrition), and carrying out detrimental habits, such as substance abuse (i.e., alcohol) (Harshana, 2018; Ratnawat & Jha, 2014). Acute stress describes a situation, where stress is caused by some recent or imminent occurrences. In contrast, chronic stress refers to sustained exposure to stress combined with pressure, that can lead to disruption to key areas of life (i.e., personal relationships and career) (Can et al., 2019). Chronic stress can culminate in burnout. Burnout is usually incorporated with occupational context, where chronic stress and overload of work tasks lead to a drastic decline in performance (Anton et al., 2020; Ruotsalainen et al., 2015; The et al., 2020).

Distress functions are an umbrella term, it is influenced by multiple diverse factors (Facey et al., 2015; Fordjour et al., 2020; Ruotsalainen et al., 2015) These factors have been divided into five principal categories. First are lifestyle choices, including elements such as sleep, exercise, and nutrition habits. Second is physiological health, which accounts for present and previous medical conditions. Third is the attitude towards work, which can potentially be influenced by difficulties in time management, motivation, and resilience in the face of adversity. The fourth category is work parameters, such as quality of organization and amount of workload. The fifth is concerned with psychosocial dimensions, in terms of relationships and tolerance within the workplace context (Fordjour et al., 2020). In addition, individual personality traits, for instance, introversion and neuroticism are possible factors that can elevate psychological distress (Facey et al., 2015; Fatisson et al., 2016; Harshana, 2018). All in all, distress can cause serious damage to organizations in terms of suboptimal performance and possible absence from work among employees (Facey et al., 2015; Fordjour et al., 2020; Ratnawat & Jha, 2014).

Notably, the manifestations of distress symptoms lead to areduction of HRV before the alterations in HR being detected (McCraty & Shaffer, 2015; Shaffer et al., 2014). Established low HRV can predict decreased cognitive performance in occupational tasks (Forte et al., 2019). Previous research has identified intervention strategies, which have been implemented in the purpose of declining distress at the workplace among healthcare employees. Cognitive-behavioral training (CBT) is an established technique aimed at fostering coping strategies related to stress, such as time management and problem-solving (Ruotsalainen et al., 2015). Additionally, CBT may have a positive effect on the ability to control arising emotions and behaviors in various situations, which are aspects of emotional regulation (Pinna & Edwards, 2020). CBT has led to a reduction of the perceived amount of stress by 13 % among study participants. Relaxation methods, both mental (i.e., mindfulness) and physical (i.e., massage), have demonstrated a 23 % decrease in stress levels (Ruotsalainen et al., 2015). Modifications in the daily repetitive routines (i.e., schedules, monotonous work, communication styles, work environment) could enhance productivity. In addition, incorporation of leisure activities tailored to individual preferences during the work week, and scheduling regular vacations, especially after a sustained period of hard work, have demonstrated beneficial outcomes regarding distress reduction (Burman & Goswami, 2018). Consequently, future research efforts focusing on specific factors inducing stress in individuals could provide more valuable insights into these various distress factors (Ruotsalainen et al., 2015).

As stated previously, distress can have a significant adverse impact on health and performance. Therefore, early detection of distress is pivotal, so that preventing actions can be enabled. When the individual identifies the contents of those effective preventing actions, they can then allocate those actions again in the future, if they identify distress signals. Consequently, they have greater control of their health and performance outcomes. Thereby, this thesis is exploring one possible solution for early distress detection, in terms of HRV measurement.

2.3.3 Eustress-distress comparison

The existence of distress has been extensively validated in scientific research, while the studies related to eustress are so far limited (Bienertova-Vasku et al., 2020). Notably, eustress and distress are not directly associated with each other. The absence of distress does not automatically suggest the presence of eustress (Gandhe, 2014). Acknowledging distress is critical, due to its capacity to cause significant detriments in health and performance because of perceived negative threats (Hargrove et al., 2015; Heikkila et al., 2018). Nonetheless, in the pursuit of enhancing these factors, it is important to understand eustress. Within the scope of occupational context, eustress embodies positive challenges, serving as a great indicator of effectiveness and productivity among employees. Understanding the conditions when eustress or distress occurs could elevate the likelihood of an employee achieving and maintaining optimal performance, even in the face of high workloads. It is noteworthy, that high workloads should be assessed carefully, as having multiple tasks at the same time can arouse distress. Such multitasking might mitigate the ability to focus on a single task, potentially compromising the quality of work delivered (Heikkila et al., 2018). This kind of suboptimal performance among employees could predict significant productivity losses for companies (Can et al., 2019; Heikkila et al., 2018). Therefore, acquiring skills on how to sustain a state of eustress is valuable for employees who have a desire to constant high performance (Heikkila et al., 2018). Importantly, it is possible to experience positive and negative outcomes simultaneously. For example, an employee experiencing severe distress symptoms might still be willing to actively engage with the work community (Hargrove et al., 2015). Figure 4 below illustrates the differences between eustress and distress related to performance level.

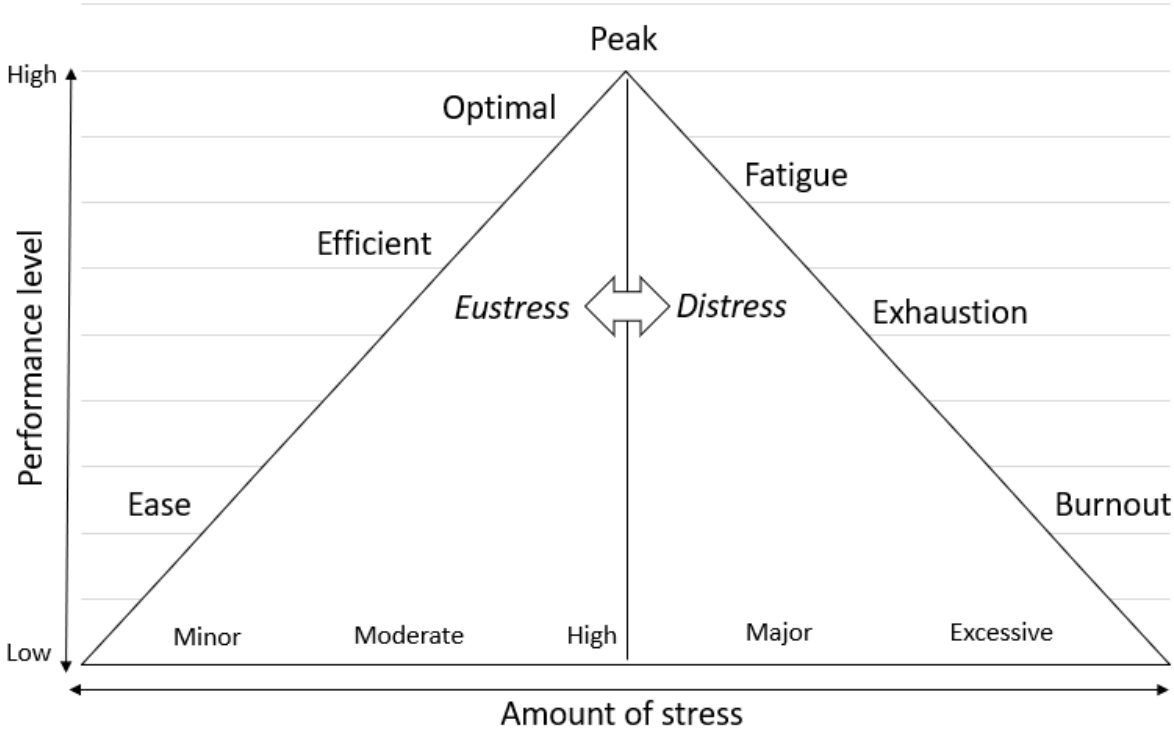


Figure 4. Relationship between eustress and distress to performance level, modified from Gandhe (2014).

Sharing knowledge about eustress could be enlightening for employees, as discussions related to stress usually focus on distress. Strategies to foster eustress among employees include promoting self-efficacy when facing adversity, providing tasks that are both challenging and meaningful, and incorporation of mindfulness practices (Heikkila et al., 2018). These actions support the presence of positive psychological capital components, such as hope and optimism (Hargrove et al, 2015; Heikkila et al., 2018). Ensuring that tasks are challenging prevents disengagement from work tasks because of too easy work. When in a lack of challenge, it is more likely that employees do not reach their highest potential (Heikkila et al., 2018). To be more specific, tasks lacking challenge may result in boredom, while challenging work is rather interesting and engaging (Heikkila et al., 2018; Ratnawat & Jha, 2014). Moreover, when work is challenging, the energy and motivation levels are elevated (Ratnawat & Jha, 2014). The association between tasks and self-efficacy is crucial. Contents of tasks determine whether an employee possesses enough competence to complete tasks or not. However, the implementation of these previous stress management tools has been proved to be difficult. A potential solution

for this could be taking advantage of technology solutions, which can be seamlessly integrated into daily routines (Heikkila et al., 2018).

As described, distress correlates to diminished performance compared to the performance relative to the individual´s baseline performance. In other words, if the employee were to have a good level of performance, distress would describe only a moderate level or potentially even lower performance. However, it is worth noting that not all people necessarily experience distress. Typically, people who have enough skills and resources can manage to maintain an ongoing good level of performance. This thesis presents information on how to elevate performance from good to great. One viable way to accomplish great performance is to understand the requisites for building eustress.

2.3.4 Occupational stress

When an employee does not have enough resources to cope with the pressure associated with work tasks, that is the definition of occupational stress (Burman & Goswami, 2014; Harshana, 2018). Workload has been identified to be the predominant factor inducing occupational stress (Harshana, 2018). The situation that triggers occupational stress can range from minor to major situations that employee encounters (Burman & Goswami, 2014). Additionally, if employees cannot have a say what are the contents of required work tasks necessary to do (i.e., absence of autonomy), that can diminish the motivation towards task execution (Harshana, 2018). It is instrumental to understand these factors as they potentially decrease the psychological and physical levels of performance among employees (Burman & Goswami, 2014; Harshana, 2018). To be more specific, these responses are described down below in Figure 5.

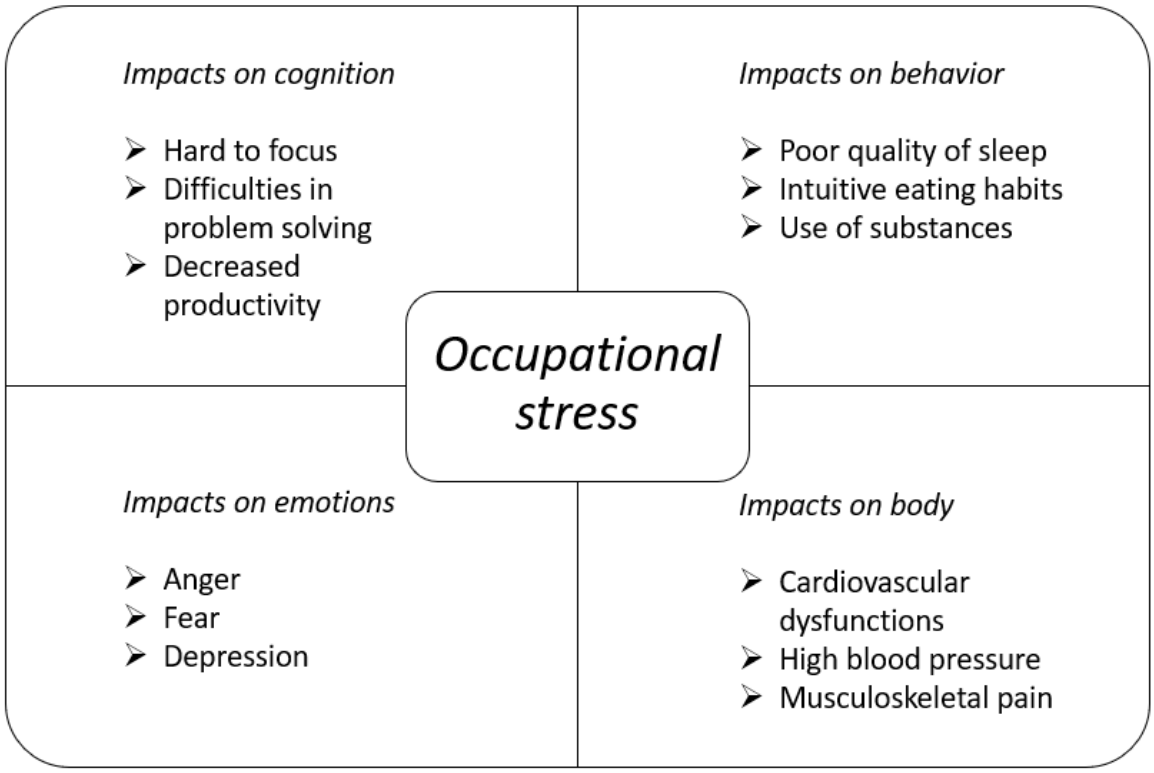


Figure 5. Consequences of occupational stress modified from Burman & Goswami (2014).

Regarding the relationship between work tasks and employees, a beneficial relationship between these two is established when employee possesses sufficient skills and appropriate coping mechanisms to manage work tasks effectively (Harshana, 2018). Finding solutions that align with the employees' preferences is worth investigating. According to employees, eustress has fostered them to be better at task completion, time management, and having a more optimistic approach towards work. Clear sign of these kind of experiences is feeling of excitement, coupled with simultaneous ability to focus on present moment during the task at hand. These beneficial qualities can be reinforced by creating opportunities to gain experience in certain tasks, and by providing feedback upon task completion (Hargrove et al., 2015). In addition, the provision of reward after task completion has been associated with elevated performance in the tasks (Ratnawat & Jha, 2014). Furthermore, these measures build trust in employees, and their resiliency towards adversity enhances. This culminates in employees realizing that with proactivity it is possible to have an impact. Consequently, this fosters commitment to lifelong learning enables employees to perform as active agents, who can create impact on outcomes (Hargrove et al., 2015). Organizations can promote this by offering continuous training for employees, empowering them to acquire new resources while their

career evolves (Burman & Goswami, 2018; Hargrove et al., 2015). Through these practices, organizations can become more successful, as their employees who gain resources along the way, are on a successful career path (Hargrove et al., 2015; Ratnawat & Jha, 2014).

The Transactional Model of Stress (TM) is a well-established framework of stress within work environments (Hargrove et al., 2015). TM states that stress is a combination of person, and the impact of the environment has on the person (Ganster & Rosen, 2013). This model is based on the idea, where one gives appraisal on how the stress stimuli effects on themselves (Ganster & Rosen, 2013; Hargrove et al., 2015). First, one evaluates whether the situation that could potentially cause stress is a matter of concern. According to TM, if the appraisal does not warrant concern, then that stimuli does not elicit a stress response. Conversely, if the appraisal deems the situation a concern, then secondary appraisal takes place. During secondary appraisal, one evaluates their competence to cope with the stressful situation. Here it is necessary to note that everyone´s appraisals are subjective. Typically, people who have great problem-solving skills and tolerance to spontaneous situations, are likely to experience fewer situations that trigger stress responses. These kinds of qualities in people predict eustress, underscoring the importance of eustress for cognitive capability, and eventually achieving mastery (Hargrove et al., 2015).

The methodologies introduced in this chapter are potentially powerful. Promoting them is likely to fall under the responsibility of leadership personnel within the organization. As an instrument, measuring HRV to identify eustress or distress could be an additional tool for individual employees. Importantly, this self-monitoring strategy would be a resource that would not take time away from the leaders and their responsibilities.

2.4 Relationship between heart rate variability, physical activity, and stress

The volume of studies exploring correlations between occupational stress and HRV remains relatively limited. A common limitation of most of the existing research has been the challenge to control the impact of all the other potential confounding factors in an individual´s life, such as PA, which can lead to a decrease in HRV (Jarvelin-Pasanen et al., 2018; Peabody et al., 2023). Valid theories and stress indicators could be beneficial to enhance the reliability of research (Facey et al., 2015; Fatisson et al., 2016; Jarvelin-Pasanen et al., 2018; Peabody et al.,

2023; Ratnawat & Jha, 2014). Despite these challenges, HRV has emerged as a relevant tool to assess occupational stress (Fatisson et al., 2016; Jarvelin-Pasanen et al., 2018; Peabody et al., 2023; The et al., 2020). In addition, given recent developments in technology, HRV measurements have evolved into a more specific tool to measure stress, compared to previous methods (Peabody et al., 2023). Given these developments, it is worth exploring HRVB as a means of identifying eustress and distress. It could serve as an indicator to signal when employees are nearing the threshold of eustress or distress overload, which may then turn into distress.

2.4.1 Impacts of heart rate variability measurements

Upon encountering stressful situations, the human body responds by generating stress hormones, which activate ANS and elicits a "fight or flight" response (Jarvelin-Pasanen et al., 2018; Kennedy & Henrickson-Parker, 2018). Alterations in ANS are a psychophysiological phenomenon, which HRV measurements can efficiently assess (Jarvelin-Pasanen et al., 2018; Peabody et al., 2023). Stressful experiences elevate activation in SNS, a reaction typically associated with low HRV. In contrast, when alterations in PNS elicit increases in HRV (Jarvelin-Pasanen et al., 2018). Increased HRV has been positively correlated with superior capabilities in social engagements and coping with distress (Kemp & Quintana, 2013; Shaffer et al., 2014) This finding is aligned with Porges´ polyvagal theory, which emphasizes the association between HRV and social behavior (Forte et al., 2019; Kemp & Quintana, 2013; Shaffer et al., 2014; Zahn et al., 2016). Work-life is a common environment where stressful situations might arise. Identifying possible stress-inducing factors can be beneficial so that it is possible to acknowledge and possibly modify these factors. As a result, chronic stress could be prevented (Jarvelin-Pasanen et al., 2018).

HRVB serves as an instrumental tool from which one can learn how to understand physiological responses in real-time, based on measurement derived from an ECG device attached to the upper body (Davila et al., 2017; Ernst, 2017; Kennedy & Henrickson-Parker, 2018; Steffen et al., 2017). The purpose of HRVB is that after using the device one has more awareness about their stress responses. By employing HRVB it becomes feasible to identify and manage stressful situations and take appropriate action to cope with stress (Kennedy & Henrickson-Parker, 2018). As a result, the previous level of cognitive ability and performance can be restored.

HRV monitoring operates as an efficient means of self-regulation (Kennedy & Henrickson-Parker, 2018; McCraty & Shaffer, 2015; Shaffer et al., 2014). This data is particularly useful information for especially those employees, who work in high-stress environments (Castaldo et al., 2015; Forte et al., 2019; Kennedy & Henrickson-Parker, 2018; Lehrer et al., 2020) There it is likely that the state of eustress turns to distress due to overload of substantial cumulative stress. Furthermore, as previous research indicates, interventions based on HRVB have consistently reported improved performance, even though cohort populations have been switched (Forte et al., 2019; Kennedy & Henrickson-Parker, 2018; Lehrer et al., 2020). This enhanced performance has been evidenced via elevated resting HRV in the successful execution of cognitive ability assessments (McCraty & Shaffer, 2015; Pham et al., 2021; Shaffer et al., 2014). Nevertheless, it should be noted that if people already present low levels of existing stress prior to the HRVB measurement, then HRVB intervention might not yield relevant results (Kennedy & Henrickson-Parker, 2018).

In conclusion, HRVB can serve as an important tool within situations, where people work under high amounts of stress. Under such circumstances, HRVB can provide essential information that aids in attaining optimal performance in the tasks at hand. This information is significant, as it evaluates both physiological and cognitive attributes (Kennedy & Henrickson-Parker, 2018). HRVB has reached a reputation as an accurate and specific tool to make reliable assessment of stress responses (Castaldo et al., 2015; Fatisson et al., 2016; Georgiou et al., 2018; Kennedy & Henrickson-Parker, 2018).

2.4.2 Engagement in physical activity

Physiologically, during stress reaction SNS is activated, which can result in a decrease in HRV. On the other hand, from the psychological perspective, an elevated amount of PA correlates with decreased subjective stress and consequently an improvement in psychological well-being. This same beneficial result was also identified among employees in the context of occupational stress. In other words, individuals can benefit from PA in terms of a stress management tool (Föhr et al., 2016b). Notably, stress can act as a barrier to engaging in PA, potentially leading employees to forego such activities due to energy depletion (i.e., after a stressful workday). However, as the results of PA interventions state, PA has either a positive effect or at least a

non-detrimental effect on work performance, thus making engaging in PA a worthy endeavor for employees (Jackson & Frame, 2018).

According to a cross-sectional study by Föhr et al. (2016a) with 16 275 Finnish employees, positive health outcomes of PA can be achieved with even minimal duration and LPA, with the positive outcomes growing when the duration and intensity of PA are increased. A worthy consideration for people with low levels of physical fitness is that for them, recovery time after VPA is longer compared to those with higher levels of physical fitness. This delayed recovery is particularly relevant for people with older age. Nevertheless, consistent long-term PA has shown enhanced daily quality of recovery based on HRV measurements. To summarize, a high amount of PA (i.e., MPA, or VPA) has been associated with lower levels of stress.

As underscored previously, this thesis aims to appraise the utility of HRV as an instrument to detect eustress and distress. However, PA has already been proven to be an effective tool to modify stress levels. The prevalent issue of neglecting PA sessions post-workday could potentially be mitigated in terms of creating a routine of PA sessions pre-workday. However, this idea has its challenges, as adults usually rate workday responsibilities before PA in order of importance. Engaging in PA activity pre-workday, where the intensity is too high related to their fitness level, can cause delayed recovery, thereby impairing their work performance. Moreover, a new PA habit, where the intensity is too high, might overwhelm the individual, leading to declined motivation to take part in PA in the future. Conversely, starting with LPA, which is enjoyable, enhances the likelihood that a pre-workday PA habit can be formed, as it does not compromise performance in the work tasks. Furthermore, as fitness level increases, they can then progressively increase the intensity and still be able to recover post-PA session, thereby the work performance during the following day is not compromised.

2.4.3 Stress detection

In previous studies with healthcare employees, it has been established that there are clear patterns of alterations in HRV that correlate to stressful situations. These situations can be such as situations where crucial decision-making is needed rapidly (Peabody et al., 2023). Such situations typically elicit physiological stress responses, in terms of elevated HR (Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). To be more specific, in these situations, the

participants have reported decreases in HRV, signifying an elevation of activation in SNS (Fatisson et al., 2016; Föhr et al., 2016b; Peabody et al., 2023).

Stress response is classified as a psychophysiological phenomenon (Föhr et al., 2016b; Jarvelin-Pasanen et al., 2018; Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). Critical cognitive abilities, such as memorizing and the ability to make decisions play a pivotal role in performance output (Forte et al., 2019; Peabody et al., 2023; The et al., 2020). Competence to perform effectively under cognitive stress is essential to master, especially in high-risk occupations, where suboptimal decision-making can have astronomical consequences. Effective stress management is important in pursuit of enhanced cognitive performance (Castaldo et al., 2015; Peabody et al., 2023; The et al., 2020). Monitoring and gaining insights about daily stressors could be important, as with that data individuals could start taking preventive actions, such as PA, in the purpose of preventing distress (Föhr et al., 2016b).

Regarding stressful situations overall within the context of work tasks, gained experience in the work role has been connected to lower SNS activation during stressful experiences. In other words, experience in a work role decreases stress responses (Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). For individuals in relatively new roles with minimal experience, the cultivation of repetitive habits is beneficial. Habits can prevent the possibility of acute stress turning into chronic stress, as these habits foster a sense of control within demanding situations (Ganster & Rosen, 2013; Peabody et al., 2023). Chronic stress is characterized as a prolonged period of acute stress, where the experienced amount of stress is consistently high (Kennedy & Henrickson-Parker, 2018).

While HRV stands as an appropriate tool for measuring stress, it should not be the only measure (Peabody et al., 2023; The et al., 2020). Stressful situations are a subjective experience, so the subjective appraisal needs to be taken into consideration (Burman & Goswami, 2018; Föhr et al., 2016b; Grippo, 2017; Peabody et al., 2023). In previous studies, measuring subjective experience with a questionnaire combined with HRV analysis has shown results, that these two variables are connected (Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023).

3 RESEARCH OBJECTIVES

Stress has both physiological and psychological dimensions (Föhr et al., 2016b; Jarvelin-Pasanen et al., 2018; Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). Measuring HRV has been identified as a robust tool to assess alterations of ANS (Jarvelin-Pasanen et al., 2018; Peabody et al., 2023). To find out what are the daily stressors and then identify appropriate coping strategies for them, the benefits of HRVB are well documented in scientific research (Kennedy & Henrickson-Parker, 2018). The other stress management tool, also well documented, is PA. PA is an efficient intervention to enhance psychological well-being (Föhr et al., 2016b). Evidence suggests that engagement in PA has not decreased work performance. Rather, it tends to enhance the work performance (Jackson & Frame, 2018). However, all the other external factors beyond the work life in individuals' lives (i.e., outside work life) modify the levels of stress. This makes stress detection complex, and more theories to detect stress are needed (Facey et al., 2015; Fatisson et al., 2016; Jarvelin-Pasanen et al., 2018; Peabody et al., 2023; Ratnawat & Jha, 2014). In previous studies, there has been a correlation between HRV analysis and subjective stress assessment (Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). Consequently, in addition to HRV and PA, it is necessary to use variables to assess subjective psychological experiences. In the context of this study, that variable will be a modified version of the Valencia Eustress-Distress Appraisal Scale (VEDAS), developed by Rodriguez et al. (2013).

Therefore, the purpose of this study is to investigate possible influencing variables (i.e., HRV and PA) that may significantly affect perceived stress levels. This study explores both eustress and distress, thus the possible correlation between variables and stress levels could consequently predict work performance levels.

The aim is to address the following research questions:

1. What are the correlations between HRV, PA and perceived eustress and distress in daily life among Finnish employees?
2. Does PA moderate the relationships between HRV and eustress and distress?

Hereby, given the literature review of this thesis, the hypothesis for this study is that there exists a correlation between HRV and perceived stress levels and that PA can potentially moderate these variables.

4 METHODS

4.1 Participants

Participants (n = 50) were recruited from Finnish companies. Inclusion criteria necessitated that individuals were:

1. Currently employed by the respective company.
2. At least 18 years old.
3. Operating during working hours of 06:00 AM to 10:00 PM.

Conversely, the exclusion criteria were as follows:

1. Working during night hours.
2. Wearing a pacemaker or other electronic or metallic devices.
3. A diagnosed cardiac arrhythmia.
4. Consumption of any of these medications: beta blockers, calcium channel blockers, tricyclic antidepressants, or anesthetics.

4.2 Instruments

HRV data was acquired using a wearable technology device, the Bittium Faros. The device was attached to the upper body with electrodes, for a duration of a total of three days in this study, to ensure continuous data collection. The collected HRV parameters in this study were RR and time-domain measurements SDNN and RMSSD. The purpose was to use the device 24 hours a day, excluding the situations where the device may be subjected to water exposure. The procedure of attaching the device requires approximately a couple minutes, and detachment requires merely a few seconds. Participants received specific instructions on how to use the device prior to starting the measurement period.

Current PA levels were explored at the beginning of the study using the Godin Leisure-Time Physical Activity Questionnaire. The original questionnaire has 3 items that assess the number of times a person engages in VPA, MPA, and LPA activities in a typical week (Godin, 2011). Subsequently, throughout the three-day measurement period, PA was gauged daily via a modified version of the same questionnaire. In contrast, the modified questionnaire assessed

the precise number of minutes expended by the individual on a given day in VPA, MPA and LPA activities. The amount of PA (i.e., how many times) weekly prior to measurement was collected once. During the measurement, the amounts of PA daily in minutes were collected by filling a questionnaire once each day.

This present study employs a modified version of the VEDAS instrument (Rodriguez, 2013). Within this modified variant, the statements of the appraisal scale went through a linguistic translation into Finnish made by the primary researcher. Concurrently, even though these statements were modified, their core remained aligned with the original ones. A modified version was facilitated in the Webropol platform.

In the context of evaluating stress with foundational VEDAS: eustress, and distress both have their own 6-point Likert scales. These scales were retained also in the modified version employed in this study. The modified questionnaire encompasses a total of 20 statements, 10 corresponding for eustress and the remaining 10 for distress. From the foundational VEDAS scale, the statements selected to evaluate distress are as follows: 15, 16, 27, 21, 24, 17, 2, 28, 6, 10. Conversely, the statements enlisted to assess eustress included: 15, 16, 21, 24, 2, 27, 14, 17, 10, and 31.

4.3 Procedures

In the context of participant recruitment through collaboration with organizations, the company's representatives were initially presented with official study documents. They then granted permission to recruit among their company´s employees. Subsequently, a representative from the company emailed an advertisement about the study to designated departments inside the company. Simultaneously, recruitment was also undertaken via the primary researcher´s personal Instagram account. In both recruitment methods, the participant was directed to view the research notification, privacy notice and informed consent form. These documents encompassed contact information details for members of the research team, ensuring that the potential participant had an opportunity to ask for any clarifications. After making the decision to participate in the study, the participant affirmed their inclusion by filling out the informed consent form.

Initially, enrolled participants received a research package dispatched either to a designated location or via postal mail. The package contained the necessary equipment for performing HRV measurements. To secure confidentiality, the kit was anonymous and did not possess any personal information of the participant. However, the kid did hold participants´ personal STUDY ID, the number solely associated with the participant in the current study and instructions on how to initiate the HRV measurement period.

Furthermore, participants received digital material dispatched to their e-mail addresses, in which they were briefed on the research protocol. The material included instructions on how to attach and use the Bittium Faros device, which was designed for HRV quantification. In addition, the e-mail had Webropol links to the personal information and baseline Godin-Shephard Leisure-Time Physical Activity Questionnaire, modified Godin-Shephard Questionnaire, and modified VEDAS scale. Furthermore, participants were instructed to commence data with the Bittium Faros device over three consecutive working days. At the end of each of these days, participants were instructed to complete the modified Godin-Shephard questionnaire and VEDAS scale regarding that day before going to bed. Post the three-day measurement period, participants returned the Bittium device to the pre-specified drop-off point or via postal mail. With the return of the device, the participants' active engagement in this study was completed.

4.4 Data analysis

Initially, post the HRV data acquisition phase and the return of the Bittium Faros device, the HRV data was unloaded from the device. This procedure was facilitated by using the Kubios software platform. Kubios generated detailed data reports, enabling an in-depth review of the HRV parameters. Each of the focal HRV parameters in this study (RR, SDNN, and RMSSD) had its own variable name in SPSS software, and the numerical values from Kubios were inputted under those variable names. Subsequently, the findings from the PA questionnaire were viewed. The varying activity intensities, in this case, VPA, MPA and LPA were allocated under their variable name in the SPSS. The quantified durations in each category were logged under their variable names. Finally, the results from the VEDAS scale were addressed. The mean values for each participant from the three-day measurement eustress and distress were counted. Mean values were submitted under their respective variable name in SPSS. During

and after this entire process, the data was saved as an SPSS Statistics Data Document (i.e., .sav file).

In SPSS, descriptive statistics of the variables were viewed to provide insights into central tendencies, variations, and distributions (Zulfiqar & Bhaskar, 2016). Next, the statistical method for exploring the relationships between variables HRV, PA and perceived eustress and distress was defined. Pearson´s correlation is a statistical measurement that quantifies the linear relationship between two continuous, random variables (Schober et al., 2018). As a result, Pearson enabled the opportunity to address the first research question of this study.

Furthermore, the nature of the present data was nested. To elaborate, daily measures were nested within individual participants, who, in turn, were nested within different companies. To investigate this nested data structure, this study employed the multilevel modeling (MLM) method for data analysis. MLM is particularly advantageous as it facilitates a dual-level investigation, allowing the exploration of variations within individuals and across different individuals. These participant-specific variations may differ between participants since they likely start with different baselines of well-being. In MLM, random intercepts enable the opportunity to examine these differences. As a result, a nuanced understanding of the dynamics between variables is enabled. Furthermore, the inclusion of random slopes in the data analysis is critical. This addition allows the assessment for the relationship of the strength and direction of HRV and PA. Specifically, it aids in understanding how individual responses vary concerning changes in these metrics (Gordon, 2019). To elaborate, MLM was used in this study to address the second research question. The MLM included days that had partially missing observations. The total possible observations for each variable (HRV, PA and eustress and distress) was 123. HRV had 17 missing observations, PA six and eustress and distress four each. As a result, 461 out of 492 observations were included in the dataset of the MLM. Below in Table 1, is a comprehensive explanation of how the MLM was built. In the table, the HRV parameters are independent variables (i.e., predictors), PA intensities are moderating variables, and eustress and distress are dependent variables (i.e., outcomes).

Table 1

Building the multilevel model.

Multilevel model	*Actions in Model*
Model 1	Add in time (days for measurements).
Model 2	Add in random time and intercepts.
Model 3	Add in control variables (Gender, Age, Height, Weight)
Model 4	Add in HRV variables (RMSSD, SDNN, and RR) as independent variables (each in separate model)
Model 5	Add in PA variables (VMPA, VPA, MPA, LPA) as moderating variables and interaction terms of HRV*PA (each in separate model) to test moderating effects of PA on the relationship between HRV and eustress and distress.

4.5 Ethical considerations

The protocol for this longitudinal study received a favorable ethical statement from the University of Jyväskylä Human Sciences Ethics Committee. Participating in this study carried minimal potential risks. One anticipated risk linked to participation was itching on the skin caused by the electrodes of the Bittium Faros device. This itching is rare, carries no serious or long-term consequences, and dissipates soon after removing the electrodes. Participants were however forewarned about this potential risk. The time taken for participation: using the device and answering the questionnaire and scale was minimal but did take some time from the participant's day. Participants were free to withdraw from the study at any time without giving a reason. In addition, participants were be informed that their decision to participate or not

would have no impact whatsoever on their employment relationship with their respective company. In this study, age was collected in 5-year intervals. In addition, the participants were from different companies, so it is not possible to identify participants from the final report, which is published for open view for everyone in the Master´s thesis archives at the University of Jyvaskyla. The data collected from the participants was only accessible to the designated research team. Personally identifiable data was used only in for communication purposes and was discarded after the research data had been collected.

5 RESULTS

5.1 Descriptive statistics

Descriptive statistical analysis serves as a preliminary examination for basic statistical summaries of central tendencies, dispersion, and distributional characteristics of the principal variables under investigation. Within the scope of the current study, those variables are HRV, PA, and eustress and distress. The following chapter presents graphical representations, including histograms, a line chart, and bar graphs - to present the frequency distribution and descriptive profiles of the variables. To be more specific, introducing descriptive statistics lays the groundwork for the more complex analyses that follow, which are Pearson´s correlation and MLM.

Before the application of statistical tests, assumptions were checked, it was essential to validate the underlying assumptions to ensure the applicability of the inferential procedures. The normality of residuals was confirmed by using the Shapiro-Wilk test, understood as suitable for analyses involving minor cohorts (n = <50). This test assesses the structure of the data to a normal distribution, where a significant result ($p < 0.05$) indicates a deviation from normality. In the present study, the results were not significant, thereby affirming the assumption of normality (Vetter, 2017). Moreover, homoscedasticity, which stands for the equality of variances across observations, is another critical assumption. It posits that the variance within groups of data points should remain constant (Rand & Guillaume, 2018). In the dataset, there were no distinct patterns or funnel shapes, indicating that homoscedasticity was maintained. Multicollinearity was evaluated following the guidelines presented by Sureiman & Mangera (2020), which state that if the presence of multicollinearity is indicated then independent variables have a high correlation between them. The Variance Inflation Factor (VIF) serves as one metric of multicollinearity criteria: in a VIF value exceeding 5, multicollinearity may be identified, whereas a score over 10 indicates strong multicollinearity. In the study, the authors stated that variables with high VIF scores should be excluded from study (Sureiman & Mangera, 2020). In the present study, the highest VIF values, which were for variables SDNN (6,537) and RMSSD (6,295), did not posit strong multicollinearity. Given that the scores were not high, the variables were retained for the analyses.

5.1.1 Participant demographics

Participants of this study (n = 41) had a gender distribution of 37 females and four males, and they all were Finnish employees. Initially, a total of 50 participants were recruited to participate. However, nine of them were excluded from the study for various reasons. As presented in Appendix 1, age was collected in five different intervals: 1) 18-24 years, 2) 25-34 years, 3) 35-44 years 4) 45-54 and 5) +55 years old. The mean of the participants for age intervals was 3,05, indicating that the average age for the participants in this study was between 35-44 years old. Amounts of weekly PA were also extracted in Appendix 1. The participants self-reported their frequency of engagement in VPA, MPA, or LPA. On average, VPA was engaged 1,48 times per week, MPA 2,81 times per week, and LPA 2,59 times per week.

5.1.2 Heart rate variability

In this study, HRV was assessed through parameters including SDNN, RMSSD and RR. Below are the descriptive statistics for each of these parameters.

Standard Deviation of Normal-to-Normal intervals (SDNN)

In the cohort of this study, the SDNN values ranged from a minimum of 7,4 milliseconds (ms) to a maximum of 113,3 ms. The average SDNN was 45,7 ms, with a standard deviation of approximately 25,8 ms. This standard deviation refers to considerable variation in HRV among the participants.

The histogram below (Figure 6) delineates the frequency distribution of SDNN values. Distribution is slightly skewed towards the lower end, which indicates that a larger proportion of this cohort had lower SDNN values.

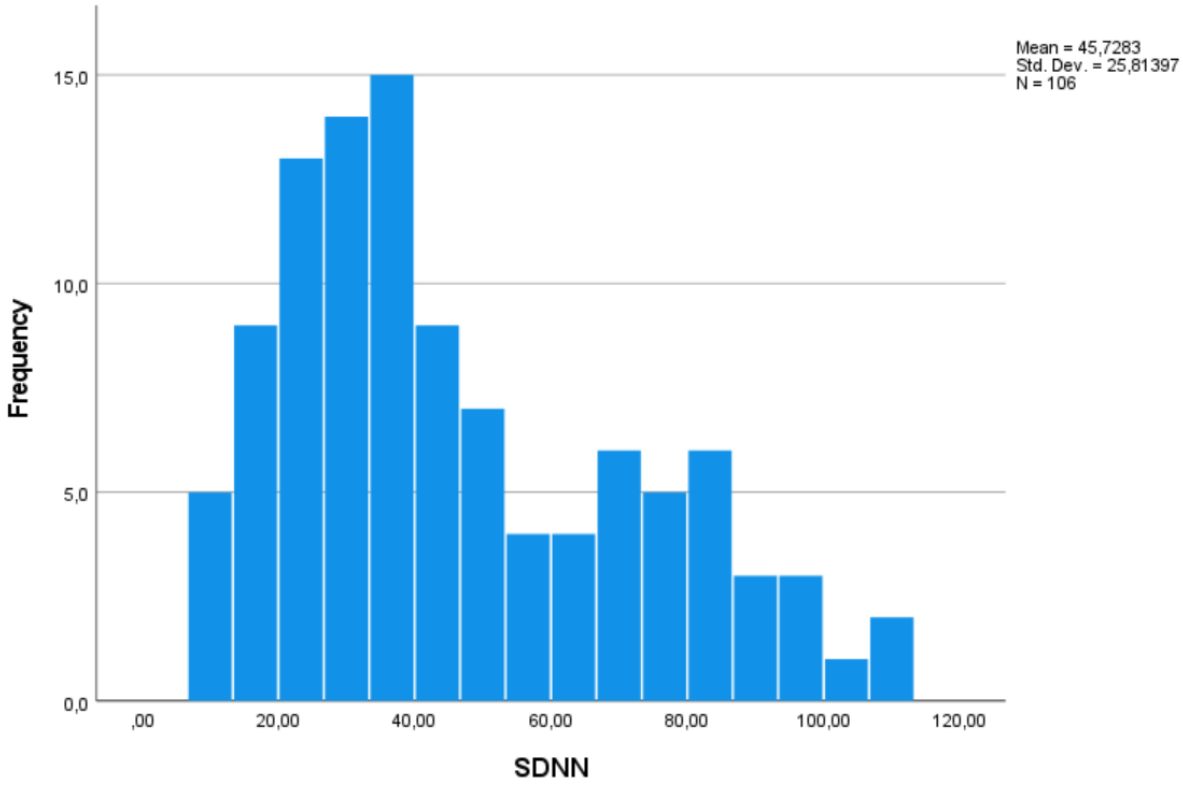


Figure 6. Histogram of SDNN frequencies.

Root Mean Square of Successive Differences between normal heartbeats (RMSSD)

The analysis yielded an RMSSD range from 3,5 ms to 127 ms. The mean RMSSD was 37,1 ms with a substantial standard deviation of 31,02 ms, indicating considerable variability within the cohort.

The histogram below (Figure 7) presents a wide dispersion of RMSSD scores across participants, with a concentration of values in the lower range.

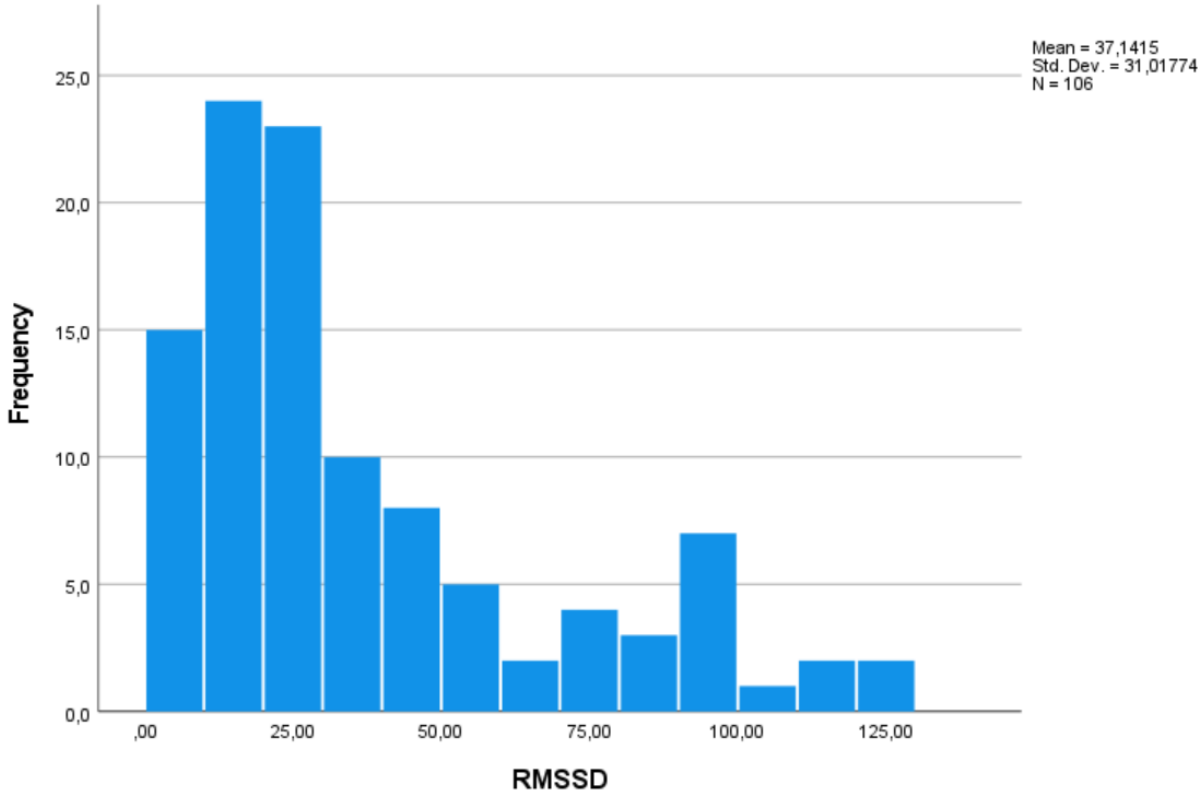


Figure 7. Histogram of RMSSD frequencies.

Oscillations between consecutive instantaneous heart rates (RR)

Descriptive analysis revealed RR intervals ranging from 304 ms to 1230 ms. The average RR interval was calculated as 730,5 ms, coupled with a high standard deviation of 176,4 ms.

The histogram below (Figure 9) illustrates a broad spread of values. In the histogram, there are several peaks, each reflecting groups of participants with distinct HR patterns.

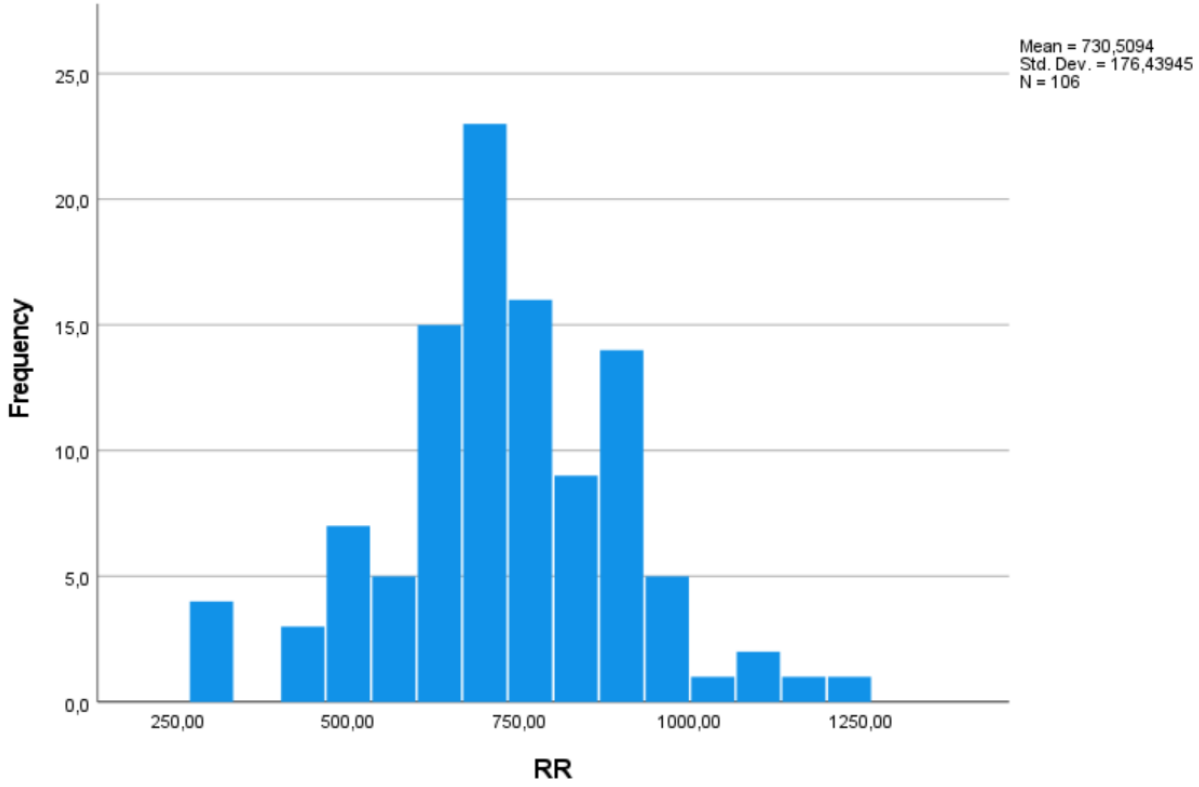
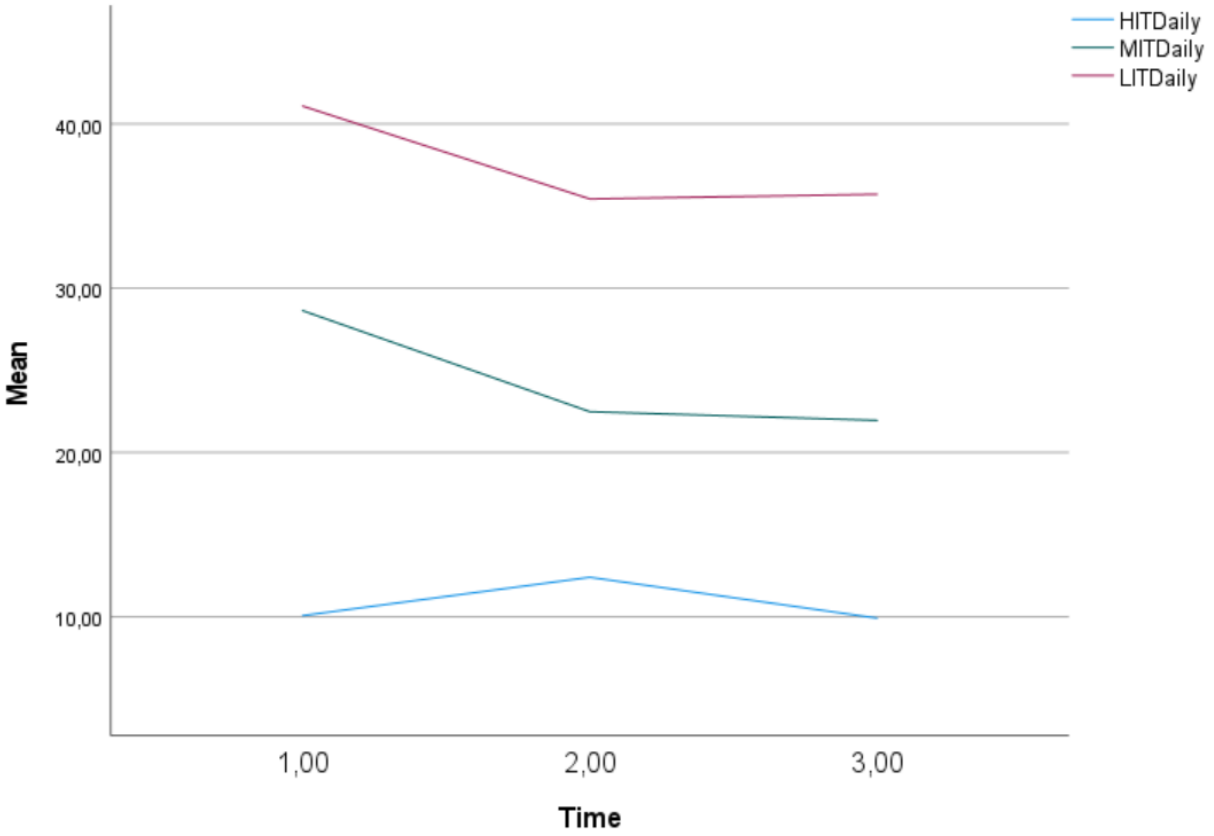


Figure 9. Histogram of RR frequencies.

5.1.3 Physical activity

Daily PA durations in minutes were categorized into three intensity levels: VPA, MPA, and LPA, which revealed varying levels of engagement. The average minutes spent on VPA was 10,8 minutes, with a widespread, as indicated by the standard deviation of 24,4 minutes. MPA had a higher average of 24,4 minutes, and an even wider standard deviation of 28,9 minutes, suggesting a larger variance. LPA was the most engaged intensity, with an average of 37,4 minutes and the highest variability of 33,7 minutes.

A line graph (Figure 10) below, encapsulates the average daily PA intensity over the observed three-day measurement period. Within this graph, Time refers to the first, second and third measurement days.



Note. HITDaily = VPA; MITDaily = MPA; LITDaily = LPA.

Figure 10. Daily PA average durations over three-day measurement period.

Histograms for VPA, MPA and LPA (Figures 11, 12, and 13 respectively) below provide a visual summary of the distribution of daily minutes engaged on each intensity.

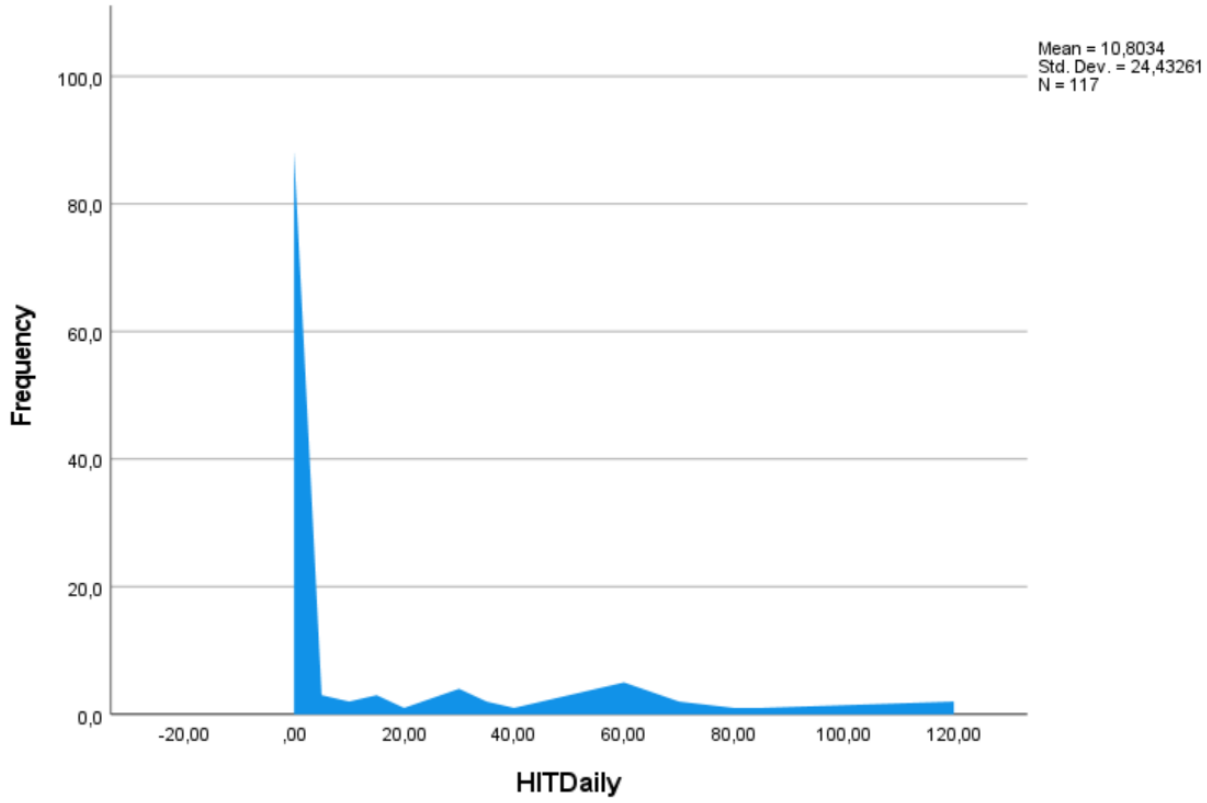


Figure 11. VPA daily in minutes.

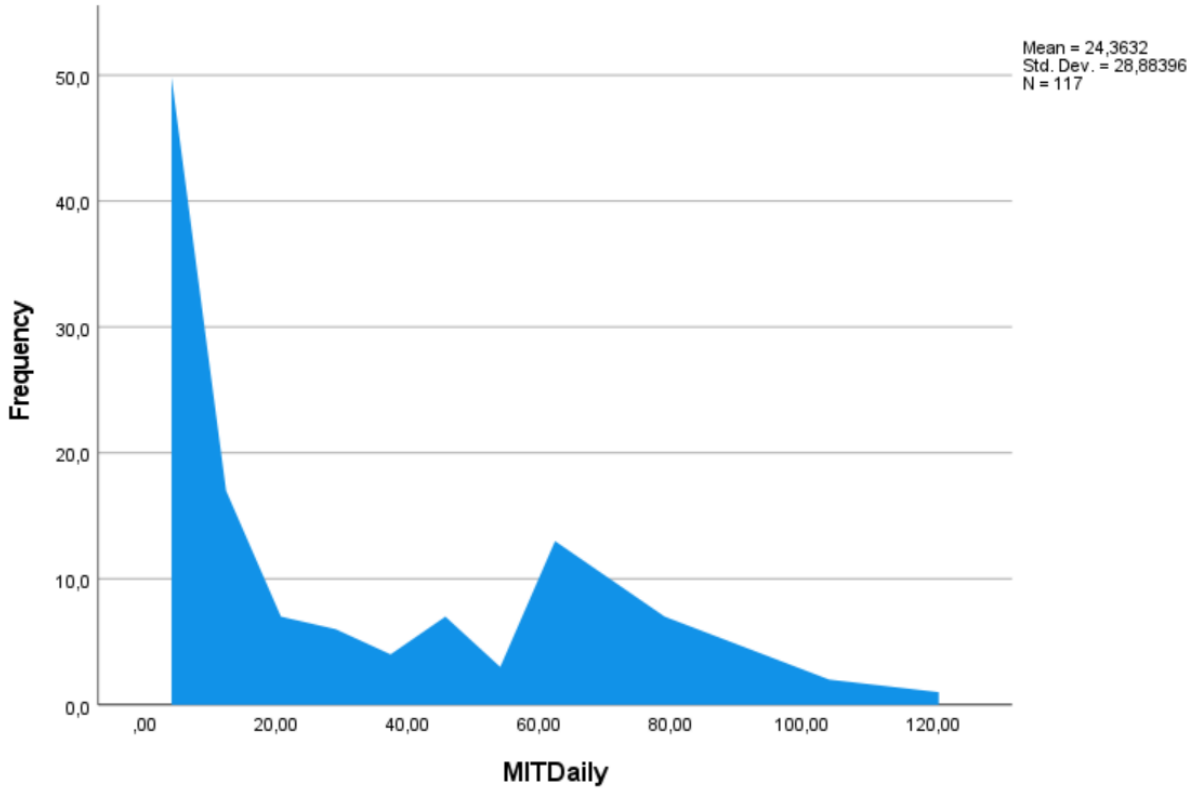


Figure 12. MPA daily in minutes.

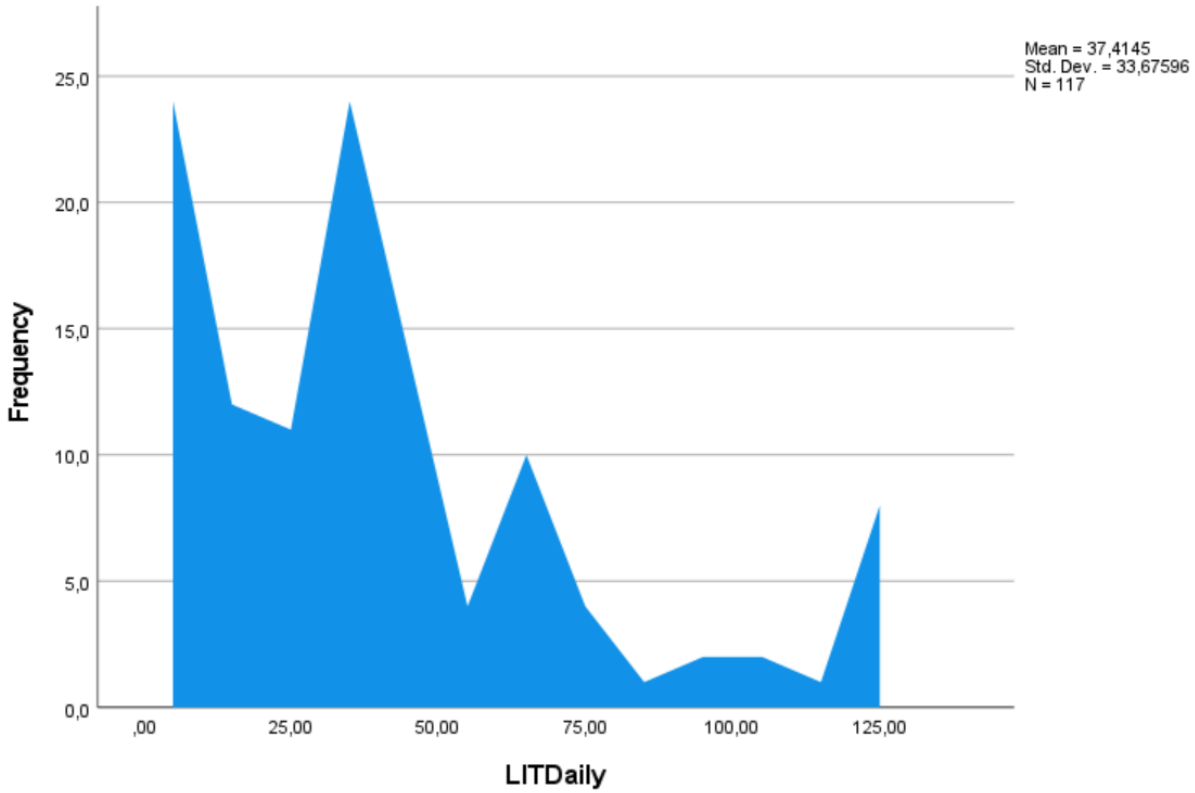


Figure 13. LPA daily in minutes.

5.1.4 Eustress and distress

In the present study, the perceived stress was assessed in two different categories: eustress and distress. The subjective evaluation of stress for both categories was extracted using a 6-point Likert scale (Appendix 3). Below are the descriptive statistics for each of these categories.

Eustress

With the cohort of this study, the eustress levels varied from 1 to 5,8. The average eustress score was 2,83, accompanied by a standard deviation of 1,18, indicating moderate variability in the perception of eustress.

The bar below (Figure 14), illustrates that most of the participants reported their eustress levels close to the average score. In addition, very high eustress levels were rarely reported.

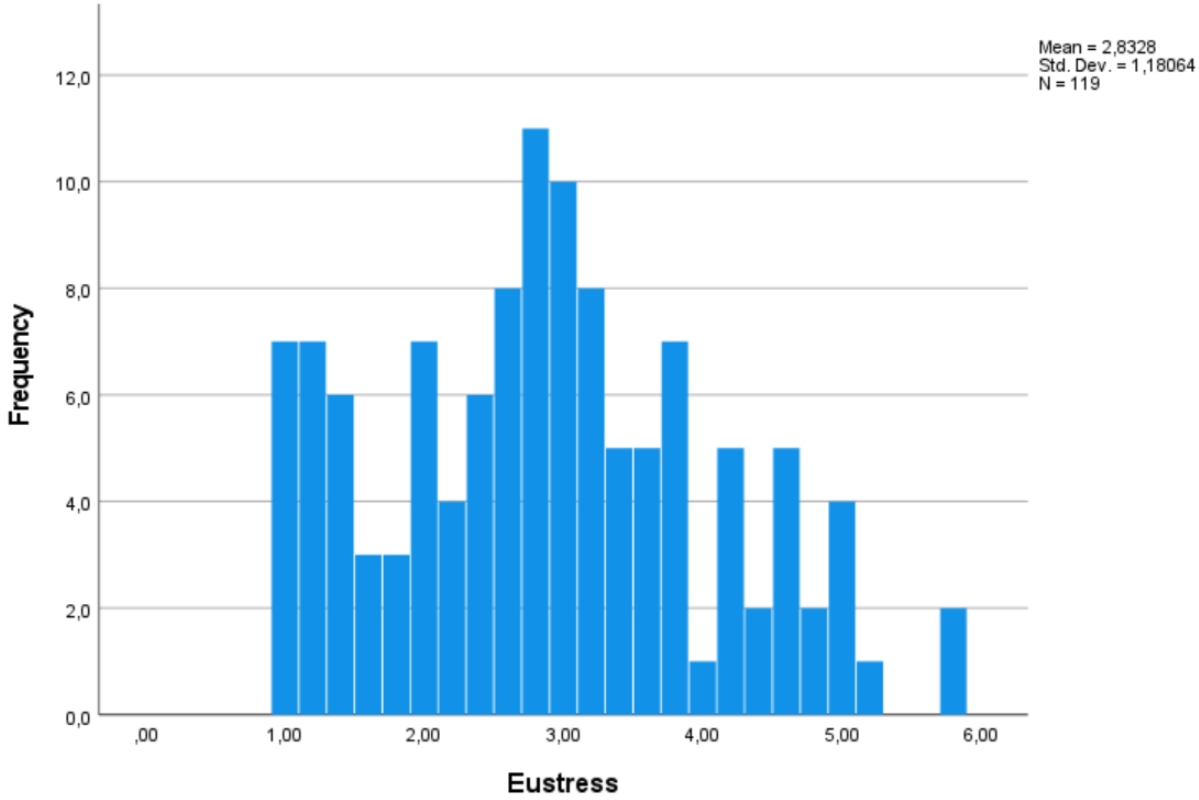


Figure 14. Bar of Eustress frequencies.

Distress

With the cohort of this study, the distress levels varied from 1 to 5,2. The average distress score was 2,48, accompanied by a standard deviation of 1,07, indicating moderate average levels of distress with a relatively narrow spread of responses.

The bar below (Figure 15) illustrates that most of the participants reported their distress levels close to the average score. Similarly, to eustress, the frequency of higher distress scores appears to be less common, indicating that extreme levels of distress were not widely reported in the cohort of this study.

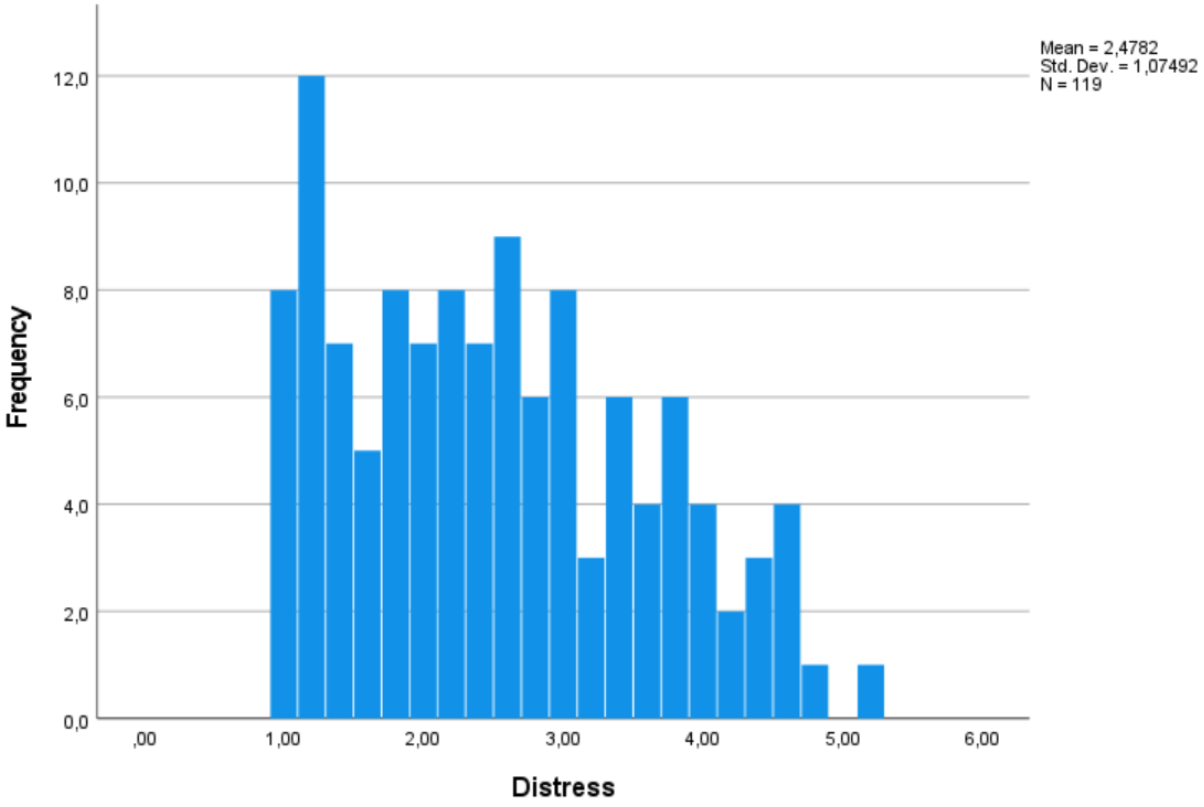


Figure 16. Bar of distress frequencies.

5.2 Correlation analysis

This chapter examines the relationships between HRV parameters, PA intensities, and perceived eustress and distress among the cohort of this study. As outlined in Figure 3 (chapter 2.2) of this thesis, the established weekly PA recommendations for adults emphasize VPA and MPA. Therefore, an additional variable, designated as VMPA was formulated in the SPSS dataset. This variable plays a role in the correlation analysis as well as in the following (chapter 5.3) MLM analysis. The primary research questions of this study focused on the correlation patterns that emerge from the variables examined in daily life, therefore this chapter seeks to address that research question. Notably, Table 2 presented below in this chapter, revealed significant correlations between different HRV parameters. However, that information is irrelevant regarding the research questions of this present study. Consequently, these results were not discussed when presenting the following results of correlations.

Results

MPA and SDNN demonstrated a significant positive correlation (r = 0,206, p = 0,040), which suggested that as daily engagement in MPA minutes increased that also increased the SDNN values.

A significant negative relationship between MPA and eustress (r = -0,188, p = 0,043) alongside LPA and eustress (r = -0,185, p = 0,046) was identified. These findings suggest that as engagement in MPA and LPA minutes daily increased, the levels of eustress decreased among the participants of this study.

Furthermore, a significant positive correlation between LPA and distress (r = 0,310, p = <0,001) was discovered. This suggests that participants who engaged more in LPA minutes daily reported higher levels of distress.

Finally, a negative correlation between SDNN and distress (r = -0,217, p = 0,028) and RMSSD and distress (r = -0,266, p = 0,007) was also extracted from Table 2. This result suggests that higher SDNN and RMSSD scores are associated with lower distress levels. Below in Table 2 are all the significant results (p <0,005) of the correlation analysis.

Table 2

Correlations in all three days combined between HRV, PA, and eustress and distress.

	Pearson Correlation (r) P-value (p)	RR	SDNN	RMSSD	Eustress	Distress
VMPA	r p	0,033 0,743	0,169 0,093	0,138 0,170	-0,0139 0,136	-0,071 0,447
VPA	r p	0,071 0,483	0,018 0,862	0,028 0,786	0,014 0,882	0,105 0,264
MPA	r p	-0,009 0,931	0,206* 0,040*	0,159 0,114	-0,188* 0,043*	-0,172 0,065
LPA	r p	0,158 0,116	0,025 0,806	-0,036 0,725	-0,185* 0,046*	0,310* <0,001*
RR	r p	1	0,376 <0,001	0,359 <0,001	-0,078 0,434	-0,181 0,067
SDNN	r p	0,376 <0,001	1	0,915 <0,001	-0,038 0,706	-0,217* 0,028*
RMSSD	r p	0,359 <0,001	0,915 <0,001	1	0,007 0,940	-0,266* 0,007*
Eustress	r p	-0,078 0,434	-0,038 0,706	0,007 0,940	1	0,121 0,189
Distress	r p	-0,181 0,067	-0,217* 0,028*	-0,266* 0,007*	0,121 0,189	1

Note. * = significant correlation. To be more specific, the correlation between different HRV variables (RR, SDNN, and RMMSD) for each other was not the focus in this present study. Therefore, even though few correlations between them were statistically significant in the table statistics, they are not marked as statistically significant (i.e., *) in the table.

5.3 Multilevel modeling

This chapter introduces the interplay of the key variables (HRV, PA and eustress and distress) of this study. With the MLM, the aim is to address whether PA moderates the relationships between HRV and eustress and distress. To clarify, the MLM aims to answer the second research question of this study. According to Robson (2015), to identify whether the MLM was a reliable statistical model for this study, the -2 Restricted Log Likelihood score was collected after every model of the MLM building (Robson 2015, 58).

In MLM concerning eustress, as demonstrated below in Table 3, the introduction of models four and five led to a decrease in -2LL scores across all HRV variables, except RR, which exhibited minimal increases in scores following the incorporation of model five. The observed decreases in -2LL scores indicated that the inclusion of these models enhanced the MLM´s fit for this study, an essential development given that the key variables of this study (HRV and PA) were added in the MLM at these stages. Conversely, the incorporation of model three did not elicit a comparable decline in –2LL score, and rather the result was minor increase in the scores. This suggests that addition of model three did not improve the MLM in a statistically significant way, which is deemed acceptable considering that the control variables introduced in model three (gender, age, height, and weight) were not the focus of the statistical analysis.

Table 3

Eustress multilevel model.

Model	*Modeled Parameters (df)*	*-2LL Model Deviance*			*Chi-squared Test*			*BIC*		
1	Eustress and Time (2)	379,1			N/A			393,4		
2	Model 1 + random time and intercepts (2)	379,1			0 (no difference in model fit)			402,9		
3	Model 2 + control variables (6)	393,1			x^2 (4) = 14,0, p = .007			416,8		
4	Model 3 + HRV variables (7)	RMSSD 355,2	SDNN 354,5	RR 357,6	RMSSD x^2 (1) = 37,9, p = <.001	SDNN x^2 (1) = 38,6, p = <.001	RR x^2 (1) = 35,5, p = <.001	RMSSD 378,1	SDNN 377,3	RR 380,4
5	Model 4 + PA variables and HRV*PA interaction terms (9)	RMSSD	SDNN	RR	RMSSD x^2 (2) in all:	SDNN x^2 (2) in all:	RR x^2 (2) in all:	RMSSD	SDNN	RR
	VMPA->	352,7	349,6	358,8	=2,5, p = .287	=4,9, p = .086	=-1,2, p = 1.000	375,2	372,2	381,4
	VPA->	351,8	348,4	360,5	=3,4, p = .183	=6,1, p = .047	=-2,9, p = 1.000	374,3	371,0	383,1
	MPA->	353,2	350,6	357,5	=2,0, p = .368	=3,9, p = .142	=0,1, p = .951	375,8	373,2	380,0
	LPA->	355,0	352,4	361,8	=0,2, p = .905	=2,1, p = .350	=-4,2, p = 1.000	377,6	375,0	384,3

Note. df = degrees of freedom; 2-LL = 2- Log Likelihood; Chi-Squared test = statistic and df derived from differences between model N and model N-1 in deviance and df, respectively; BIC = Bayesian Information Criterion.

Eustress multilevel model results

Subsequently, as presented below in Table 4, the evaluation regarding eustress on HRV variables revealed no statistically significant interaction with the various daily PA intensities. However, the relationship between SDNN and VMPA (p = 0,058) as well as SDNN and VPA (p = 0,060) suggested that increases in VMPA and VPA exert a moderate impact on SDNN and eustress levels. While these values do not meet the conventional threshold for statistical significance, they approach the boundary delineated by Concato & Hartigan (2016), who presented that statistical significance is acknowledged when the p-value is less than 0,05.

Table 4
Eustress interaction term scores.

Parameter	*Estimate*	*Std.Error*	*df*	*t*	*p*	*95% CI Lower*	*95% CI Upper*
RMSSD*VMPA	0,000	0,000	83,585	-1,626	0.108	0,000	3,649E-5
RMSSD*VPA	0,000	0,000	84,898	-1,544	0.126	-0,001	9,355E-5
RMSSD*MPA	-9,662E-5	0,000	79,636	-0,784	0,435	0,000	0,000
RMSSD*LPA	-1,756E-5	0,000	83,727	-0,166	0,869	0,000	0,000
SDNN*VMPA	0,000	0,000	86,401	-1,919	0,058	0,000	7,899E-6
SDNN*VPA	0,000	0,000	88,358	-1,904	0,060	-0,001	1,866E-5
SDNN*MPA	0,000	0,000	78,746	-1,039	0,302	0,000	0,000
SDNN*LPA	8,955E-5	0,000	88,792	0,698	0,487	0,000	0,000
RR*VMPA	-2,633E-5	1,642E-5	80,463	-1,604	0,113	-5,900E-5	6,336E-6

RR*VPA	-9,355E-6	3,153E-5	67,713	-0,297	0,768	-7,228E-5	5,357E-5
RR*MPA	-2,801E-5	1,819E-5	73,752	-1,540	0,128	-6,425E-5	8,236E-6
RR*LPA	6,045E-6	1,692E-5	80,138	0,357	0,722	-2,763E-5	3,972E-5

In the distress MLM, which is presented below in Table 5, the integration of models two, three, and four all decreased the -2LL scores across entire model, indicating that the MLM was improving with the addition of each of those models. In contrast to eustress MLM, adding the model five to the distress MLM elevated the –2LL scores in all three HRV parameters. This indicated that adding in model five did not improve the distress MLM. This outcome represents a finding that PA affects eustress differently than distress. An alternative MLM for distress was not formulated, given that the utilization of MLM in this study was to address the same research question (2) across two different dimensions of stress (eustress and distress), thereby maintaining a consistent analytical approach across both stress dimensions.

Table 5

Distress multilevel model.

Model	*Modeled Parameters (df)*	*-2LL Model Deviance*			*Chi-squared Test*			*BIC*		
1	Distress and Time (2)	358,6			N/A			372,9		
2	Model 1 + random time and intercepts (2)	358,6			0 (no difference in model fit)			382,4		
3	Model 2 + control variables (6)	352,6			x^2 (4) = 6,0, p = .199			376,3		
4	Model 3 + HRV variables (7)	RMSSD 309,1	SDNN 309,1	RR 315,7	RMSSD x^2 (1) = 43,5, p = <.001	SDNN x^2 (1) = 43,5, p = <.001	RR x^2 (1) = 36,9, p = <.001	RMSSD 331,9	SDNN 332,0	RR 338,5

5	Model 4 + PA variables and HRV*PA interaction terms (9)	RMSSD	SDNN	RR	RMSSD x^2 (2) in all:	SDNN x^2 (2) in all:	RR x^2 (2) in all:	RMSSD	SDNN	RR
	VMPA->	323,6	322,1	333,9	=-14,5, p = <.001	=-13,0, p = .001	=-18,2, p = <.001	346,1	344,7	356,4
	VPA->	323,8	323,5	332,6	=-14,7, p = <.001	=-14,4, p = <.001	=-16,9, p = <.001	346,4	346,1	355,2
	MPA->	320,6	318,9	331,2	=-11,5, p = .003	=-9,8, p = .007	=-15,5, p = <.001	343,2	341,5	353,7
	LPA->	316,5	315,5	324,3	=-7,4, p = .024	=-7,4, p = .040	=-8,6, p = .013	339,0	338,1	346,8

Note. df = degrees of freedom; 2-LL = 2- Log Likelihood; Chi-Squared test = statistic and df derived from differences between model N and model N-1 in deviance and df, respectively; BIC = Bayesian Information Criterion.

Distress multilevel model results

Table 6 below presents similar results to eustress (Table 4), whereas the evaluation regarding distress on HRV variables showed no statistically significant interaction across the various daily PA intensities. However, the association between SDNN and MPA (p = 0,060) indicated that as MPA quantity increases that has moderate impact on SDNN and distress levels. As stated in the prior chapter, this result as well is not statistically significant.

Table 6

Distress interaction term scores.

Parameter	*Estimate*	*Std.Error*	*df*	*t*	*p*	*95% CI Lower*	*95% CI Upper*
RMSSD*VMPA	0,000	8,363E-5	85,370	-1,345	0,182	0,000	5,554E-5
RMSSD*VPA	2,401E-5	0,000	89,260	0,131	0,896	0,000	0,000
RMSSD*MPA	0,000	0,000	81,652	-1,478	0,143	0,000	5,349E-5
RMSSD*LPA	2,902E-5	8,689E-5	83,605	0,334	0,739	0,000	0,000
SDNN*VMPA	0,000	9,755E-5	84,186	-1,753	0,083	0,000	3,302E-5
SDNN*VPA	-9,919E-5	0,000	90,703	-0,506	0,614	0,000	0,000
SDNN*MPA	0,000	0,000	80.020	-1,908	0,060	-0,001	1,086E-5
SDNN*LPA	4,721E-5	0,000	90,757	0,446	0,657	0,000	0,000
RR*VMPA	6,323E-6	1,451E-5	79,913	0,436	0,664	-2,255E-5	3,520E-5
RR*VPA	2,342E-5	2,790E-5	67,978	0,839	0,404	-3,225E-5	7,908E-5
RR*MPA	1,675E-6	1,634E-5	74,760	0,103	0,919	-3,087E-5	3,422E-5
RR*LPA	-3,979E-6	1,424E-5	85,959	-0,279	0,781	-3,228E-5	2,432E-5

6 DISCUSSION

The present study investigated the relationships between HRV, PA, and perceived eustress and distress in the daily lives of Finnish employees. As stated in the research questions, the study sought to determine correlations between HRV and PA with eustress and distress and evaluate the moderating role of PA in the relationships between HRV and these stress dimensions.

6.1 Findings and implications

In the correlation analysis, MPA and SDNN had a statistically significant positive correlation. This result indicated that an increase in daily minutes of MPA correlated with elevated SDNN values. This result aligned with the literature presented in this study. Specifically, Rhodes et al. (2017) demonstrated weekly PA recommendations for adults in Figure 3, suggesting MPA for 150 to 300 minutes done weekly, which provides health benefits (Rhodes et al., 2017). In addition, Shaffer & Ginsberg (2017) elucidated that elevation in SDNN values indicated improved individual health outcomes, thus aligning with the results of the current analysis.

Moreover, a significant negative correlation between MPA and eustress and LPA and eustress came across. These findings suggest that as engagement in MPA and LPA minutes daily increased, the levels of eustress decreased among the participants of this study. Such a finding contrasts with the assertions by Jackson & Frame (2018), who posited that PA has either a positive effect or at least no adverse effect on work performance. Gandhe (2014) emphasized the importance of managing various variables and environmental factors that could impact task completion under eustress. Typically, eustress arises when the desire is to allocate resources towards addressing the encountered stressors. Furthermore, as presented in Figure 4, the amount of perceived stress is between moderate to high in the state of eustress (Gandhe, 2014). The observed decrease in eustress with increased MPA and LPA could be attributed to the diminished capacity of participants of this study to perform demanding cognitive tasks during periods of eustress. This factor may also be explained by the participants` PA habits, as reported in the present study. Data from Figures 12 and 13 indicate inactivity among the cohort, suggesting possible lower health status overall. Thus, engaging in increased levels of MPA and LPA might compromise participants` recovery from PA, leading to reduced well-being and, consequently, lowered eustress levels.

A statistically significant positive correlation occurred between LPA and distress. This association suggests that participants who engaged more frequently in LPA reported higher levels of distress. As explained by Fordjour et al (2020), distress decreases health status due to various reasons (Fordjour et al., 2020). The distress levels, illustrated in Figure 16, revealed that the average distress score with this cohort was 2,48 on a 6-point scale. This suggests a moderate level of fatigue and exhaustion among participants, as illustrated in Figure 4, potentially influencing their reluctance to engage more vigorous forms of PA, such as VPA and MPA, presented in Figures 11 and 12, respectively. LPA, as shown in Figure 13, emerged as the most engaged PA intensity within the cohort. Furthermore, as Föhr et al. (2016a) have reported, participating in LPA, even in minimal durations, can confer positive health outcomes (Föhr et al., 2016a). Consequently, the prevalent engagement in LPA among the cohort can be considered beneficial. This engagement should be continued with long-term commitment, and then progressively incorporate MPA and VPA into the PA routines, to gain more health benefits.

Regarding the relationships between HRV variables and stress dimensions, a statistically significant negative correlation raised between SDNN and distress and RMSSD and distress. These results suggest an inverse relationship whereby higher SDNN and RMSSD values are indicative of reduced levels of distress. The correlation regarding SDNN is well aligned with the literature of this study, as demonstrated in Figure 2. Similarly, the findings for RMSSD also aligned with the existing literature. Ernst (2017) articulated that higher RMSSD values associate with enhanced subjective health status, thereby supporting the results obtained in the current analysis (Ernst, 2017). In contrast, the relationship between HRV parameters and eustress did not reach statistical significance. This suggests that the relationships between HRV and eustress is more nuanced. This may also reflect the varied individual responses to stressors, which not necessarily directly correlate to HRV parameters.

In the context of MLM, no statistically significant findings presented themselves regarding the moderating effects of PA on HRV or stress outcomes. Nonetheless, certain results were approaching statistical significance, suggesting potential trends worth noting. Specifically, within the eustress MLM framework, the interaction between SDNN and VMPA as well as SDNN and VPA hinted a moderate impact of increased VMPA and VPA levels on SDNN values and subsequently on eustress levels. These findings may be linked to the findings from

correlation analysis, where an increase in MPA and LPA correlated with a decrease in eustress levels. Moreover, in the case of distress MLM, the results of interaction between SDNN and MPA indicated that as MPA levels increase, that has a moderate impact on SDNN and distress. This could be related to the correlation analysis, which suggested that participants who engaged more in LPA reported elevated levels of distress. It is critical to interpret these results with caution, given that the p-values exceeded the conventional threshold of statistical significance and, as presented in Tables 5 and 6, the null estimates (i.e., direction of relationships) in all three instances, rendered these findings speculative.

In summary, the increased levels of SDNN caused by MPA validate the already well-established scientific consensus that MPA provides physiological health enhancements. Interestingly, an inverse relationship was noted between LPA and MPA engagement and eustress levels, indicating that executing PA in these intensities may act as a distraction in work tasks that require a high level of cognitive performance (i.e., eustress). This suggests that the quantity of PA undertaken should be carefully considered when the aim is to induce eustress towards task completion. Instead, when the desire is to create state of eustress, emphasis should focus on strategies presented in existing literature, such as finding tasks that bring joy, ensuring that level of competence is enough, and setting goals towards execution. Furthermore, in scenarios of distress, an elevation in distress levels correlated with increased engagement in LPA. LPA emerged as the most engaged PA intensity in this study, with an average daily engagement of 37,4 minutes, as illustrated in Figure 13. Comparative analysis with MPA (Figure 12) and VPA (Figure 11) revealed that, for most of the measurement days, activity levels significantly trailed the average values (VPA = 10,8 minutes; MPA = 24,4 minutes) of both intensities. Consequently, the health benefits of VPA and MPA, presented in Figure 3, are not realized. Participant who primarily engage in LPA, but lack VPA and MPA, stand to benefit from PA interventions targeted to enhance their aerobic conditioning through the inclusion of MPA and VPA into their PA regimes. As a result, they would have a vital resource (PA) for health enhancement and potentially distress mitigation. This resource could be combined with another tool for measuring distress, which is HRV measurement. In this study, elevated scores in HRV parameters SDNN and RMSSD showed a reduction in distress levels. Therefore, aligned with the literature, HRV monitoring is a reliable tool for assessing employee well-being.

6.2 Strenghts and limitations

This present study analyzed stress in a comprehensive manner. Both physiological (HRV) and psychological (perceived stress) participated to the study. This dual approach allowed more nuanced understanding of stress, compared to the studies that focus on only either physiological or psychological dimensions. HRV measurements with Bittium Faros device offered real-time objective physiological data for consistent three-day (72 hours) measurement period. To be more specific, utilizing this measurement allowed the opportunity to capture the dynamic nature of stress responses. Moreover, after completed measurements, the data was analyzed with Kubios HRV software (i.e., gold standard HRV analysis software). Considering the entire dataset, as presented in chapter 4.4, a total of 461 out of 492 possible observations took place. In other words, a total of 6,3 % of observations lacked from the dataset. This high completion rate contributed to the study´s reliability and the validity of its findings.

In contrast, the present study had several limitations. Notably, among the cohort, occupations and their specific work roles remained anonymous. Research by Kennedy & Henrickson-Parker (2018) and Peabody et al. (2023) suggested that an individual´s work role and experience in that role (i.e., novice or veteran) correlate to the perceived stress levels (Kennedy & Henrickson-Parker, 2018; Peabody et al., 2023). Additionally, this current study did not account for the variety of occupational environments in which the employee operated. For instance, the cohort included healthcare employees, some of whom were employed in hospital settings (i.e., hectic, and spontaneous environment) while others worked in office environments (i.e., calm, and controlled environment). These different environments, combined with individual characteristics, may impact perceived stress levels.

Regarding the implementation of VEDAS instrument, it turned out that a few of the participants did not encounter certain scenarios posited by the VEDAS instrument within their measurement period. Despite this, participants had to answer those claims regardless, as the instrument mandated the completion of every item. This situation resolved through guidance provided by the primary researcher, advising participants to answer the option that most closely aligned with their situation. This potentially led to inaccurate data collection. In future studies that implement VEDAS instrument, a longer measurement period than three days, or collecting detailed information about participants work role and leisure-time activities pre-study could solve the

issue. As a result, researcher could have a better understanding what items of VEDAS to include or exclude to the instrument used in the study. Furthermore, the potential bias existed in the completion of the VEDAS instrument and PA questionnaire, given their reliance on self-reported, subjective experiences.

6.3 Suggestions for future research

Presented by Jackson & Frame (2018), PA has either positive effect ort at least no adverse effect on work performance (Jackson & Frame, 2018). In contrast, the results of this present study indicate that PA could potentially compromise work performance, as executing intensities MPA and LPA correlated with decreases in eustress levels. These outcomes could be further studied with more extensive cohort, to enhance the robustness of these findings. Another further research could examine what is the correlation between cognitive task performance and PA. To elaborate, this present study identified that intensities of MPA and LPA correlate with diminished eustress levels, and as outlined in the literature (Anton et al., 2020; Fabio et al., 2018; Vartiovaara, 2004, 11), cognitive processes relate to eustress.

Another finding in this present study was the positive correlation between LPA and elevated levels of distress. LPA itself unlikely causes an escalation in distress levels. Therefore, a longitudinal investigation into the causal factors underlying this relationship might explain these findings. Moreover, such a study could also aim to examine the effects of persistent engagement in LPA on distress levels over time. According to Felez-Nobrega et al. (2021), LPA has a positive effect on mental health. However, LPA is absent from the weekly PA recommendations for adults, as shown in Figure 2.

The results derived from MLM did not reach statistical significance. However, results that approached statistical significance indicated that VMPA and VPA could have a moderating influence on eustress and SDNN, while MPA appears to have similar moderating effects on distress and SDNN. These findings suggest further explorations. For instance, future studies could aim to identify the specific thresholds of VMPA, VPA, and MPA that yield a significant impact on SDNN, eustress, and distress levels. In addition, considering within-person factors, investigating how individuals baseline physical fitness level impacts the effectiveness of PA

interventions on HRV and perceived stress, could provide valuable insights. Through such investigation, more precise PA recommendations could be created for stress management.

7 CONCLUSION

In the current study, MPA exhibited a positive correlation with SDNN, indicating its potential health benefits and stress mitigation capabilities. Interestingly, the relationship between PA and perceived stress had more complexity. Elevated levels of MPA and LPA correlated with a reduction in eustress, indicating the nuanced impact of these PA intensities on cognitive and emotional performance (i.e., eustress). In addition, this study identified that an increased quantity of LPA correlated to elevated levels of distress. Given the unlikelihood of LPA directly causing elevated distress, this relationship potentially has other influencing factors that future studies could explore. Considering the relationship between HRV and distress, this study affirmed the already established literature, that higher SDNN and RMSSD levels associate with lower levels of distress.

Furthermore, this study did not yield statistically significant effects regarding the moderating role of PA within the relationships between HRV and perceived eustress and distress levels. Nonetheless, trends approaching statistical significance raised, suggesting a potential avenue for future study aimed at determining the thresholds at which various PA intensities begin to exert a significant moderating effect on stress levels. Identifying these thresholds could provide valuable insights into the optimal PA intensities that employees could adopt to effectively manage and mitigate their stress levels.

REFERENCES

Anton, N., Lebares, C., Karipidis, T. & Stefanidis, D. (2020). Mastering stress: mental skills and emotional regulation for surgical performance and life. *Journal of Surgical Research*, 263, A1-A12. https://doi.org/10.1016/j.jss.2021.01.009

Bienertova-Vasku, J., Lenart, P. & Scheringer, M. (2020). Eustress and distress: neither good nor bad, but rather the same*? BioEssays*, 42(7), 1900238. https://doi.org/10.1002/bies.201900238

Billman, G. (2011). Heart rate variability – a historical perspective*. Frontiers in Physiology*, 2, 86. https://doi.org/10.3389/fphys.2011.00086

Bischoff, L., Otto, A-K., Hold, C. & Wollesen, B. (2019). The effect of physical activity interventions on occupational stress for health personnel: A systematic review. *International Journal of Nursing Studies*, 97, 94-104. https://doi.org/10.1016/j.ijnurstu.2019.06.002

Buccelletti, F., Bocci, G., Gilardi, E., Fiore, V., Calcinaro, S., Fragnoli, C., Maviglia, R. & Franceschi, F. (2012). Linear and nonlinear heart rate variability indexes in clinical practice. *Computational and Mathematical Methods in Medicine*, 2012, (219080). https://doi.org/10.1155/2012/219080

Burman, R. & Goswami, T. (2018). A systematic literature review of work stress. International *Journal of Management Studies*, 3(9), 112. doi:10.18843/ijms/v5i3(9)/15

Can, Y., Arnrich, B. & Ersoy, C. (2019). Stress detection in daily life scenarios using smart phones and wearable sensors: a survey. Journal of Biomedical Informatics, 92, 103139. https://doi.org/10.1016/j.jbi.2019.103139

Castaldo, R., Melillo, P., Bracale, U., Caserta, M., Triassi, M. & Pecchia L. (2015). Acute mental stress assessment via short term HRV analysis in healthy adults: a systematic review with meta-analysis. *Biomedical Signal Processing and Control*, 18(2015), 370-377. doi:10.1016/j.bspc.2015.02.012

Catai, A., Pastre, C., Godoy, M., Silva, E., Takahashi, A. & Vanderlei, L. (2020). Heart rate variability: are you using it properly? standardization checklist of procedures. *Brazilian Journal of Physical Therapy*, 24(2), 91-102. doi:10.1016/j.bjpt.2019.02.006

Concato, J. & Hartigan, J. (2016). P values: From suggestion to superstition. *Journal of Investigative Medicine*, 64(7), 1166-1171. https://doi.org/10.1136/jim-2016-000206

Csikszentmihalyi, M. (2005). *Flow*. Rasalas Publishing

Davila, M., Lewis, G. & Porges, S. (2017). The physiocam: a novel non-contact sensor to measure heart rate variability in clinical and field applications. *Frontiers in Public Health*, 5, 300. https://doi.org/10.3389/fpubh.2017.00300

Draghici, A-E. & Taylor, J-A. (2016). The physiological basis and measurement of heart rate variability in humans. Journal of Physiological Anthropology, 35, 22. https://doi.org/10.1186/s40101-016-0113-7

Erickson, K., Hillman, C. & Kramer, A. (2015). Physical activity, brain, and cognition. *Current Opinion in Behavioral Sciences*, 4, 27-32. https://doi.org/10.1016/j.cobeha.2015.01.005

Erickson, K., Hillman, C., Stillman, C., Ballard, R., Bloodgood, B., Conroy, D., Macko, R., Marquez, D., Petruzzello, S. & Powell, K. (2019). Physical activity, cognition, and brain outcomes: A review of the 2018 physical activity guidelines. *Medicine & Science in Sports & Exercise*, 51(6), 1242-1251. doi: 10.1249/MSS.0000000000001936

Ernst, G. (2017). Heart-Rate variability – more than heart beats? *Frontiers in Public Health*, 5, 240. https://doi.org/10.3389/fpubh.2017.00240

Fabio, A., Peiro, J., Rodriguez, I. & Kozusznik, M. (2018). The valencia eustress-distress appraisal scale (VEDAS): validation of the Italian version. *Sustainability*, 10(11), 3903. https://doi.org/10.3390/su10113903

Facey, A., Tallentire, V., Selzer, R. & Rotstein, L. (2015). Understanding and reducing work-related psychological distress in interns: a systematic review. *Internal Medicine Journal*, 45(10), 995-1004. https://doi.org/10.1111/imj.12785

Fatisson, J., Oswald, V. & Lalonde, F. (2016). Influence diagram of physiological and environmental factors affecting heart rate variability: an extended literature overview. *Heart International*, 11(1), e32-e40. doi:10.5301/heartint.5000232

Forte, G., Favieri, F. & Casagrande, M. (2019). Heart rate variability and cognitive function: a systematic review. *Frontiers Neuroscience*, 9(13), 710. doi: 10.3389/fnins.2019.00710

Fordjour, G., Chan, A. & Fordjour, A. (2020). Exploring potential predictors of psychological distress among employees: a systematic review. *International Journal of Psychiatry Research*, 2(7), 1-11. doi:10.33425/2641-4317.1047

Föhr, T., Pietilä, J., Helander, E., Myllymäki, T., Lindholm, H., Rusko, H. & Kujala, U. (2016a). Physical activity, body mass index and heart rate variability-based stress and recovery in 16 275 Finnish employees: A cross-sectional study. BMC Public Health, 16, 701. doi: 10.1186/s12889-016-3391-4

Föhr, T., Tolvanen, A., Myllymaki, T., Järvelä-Reijonen, E., Peuhkuri, K., Rantala, S., Kolehmainen, M., Korpela, R., Lappalainen, R., Ermes, M., Puttonen, S., Rusko, H. & Kujala, U-M. (2016b). Physical activity, heart rate variability-based stress and recovery, and subjective stress during a 9-month study period. *Scandinavian Journal of Medicine & Science in Sports*, 27(6), 612-621. https://doi.org/10.1111/sms.12683

Gandhe, R. (2014). Positive stress: review of relevant theories and an alternative conceptualization. *Indian Journal of Positive Psychology*, 5(3), 260-266. https://www.proquest.com/scholarly-journals/positive-stress-review-relevant-theories/docview/1629407837/se-2

Ganster, D. & Rosen, C. (2013). Stress and employee health: a multidisciplinary review. *Journal of Management*, 39(5), 1085-1122. doi: 10.1177/0149206313475815

Georgiou, K., Larentzakis, A., Khamis, N., Alsuhaibani, I., Alaska, Y. & Giallafos, E. (2018). Can wearable devices accurately measure heart rate variability? a systematic review. *Folia Medica (Plovdiv),* 60(1), 7-20. doi: 10.2478/folmed-2018-0012

Godin, G. (2011). The Godin-Shephard leisure-time physical activity questionnaire. *Health & Fitness Journal of Canada*, 4(1), 18-22. https://doi.org/10.14288/hfjc.v4i1.82

Gordon, A. (2019). A practical guide to multilevel modeling. *University of Toronto.* https://sites.lsa.umich.edu/whirl/wp-content/uploads/sites/792/2020/11/MLMWorkshopSlides_UofT_Fall2019.pdf

Grippo, A. (2017). Opinion: "heart rate variability, health, and well-being: a systems perspective" research topic. *Frontiers in Public Health*, 5, 246. https://doi.org/10.3389/fpubh.2017.00246

Hargrove, B., Becker, W. & Hargrove, D. (2015). The HRD eustress model: generating positive stress with challenging work. *Academy of Human Resource Development*, 14(3), 231-233. https://doi.org/10.1177/1534484315598086

Harshana, PVS. (2018). Work related stress: a literature review. *Annals of Social Sciences Management studies,* 2(3), 555586. doi:10.19080/ASM.2018.02.555586

Heikkila, P., Mattila, E. & Ainasoja, M. (2018). Designing a eustress toolbox: from entrepreneur experiences to an online service. *Human Technology*, 14(2), 233-257. doi:10.17011/ht/urn.201808103818

Jackson, A. & Frame, M. (2018). Stress, health, and job performance: What do we know? *Journal of Applied Biobehavioral Research*, 23(4), e12147. https://doi.org/10.1111/jabr.12147

Jarvelin-Pasanen, S., Sinikallio, S. & Tarvainen, M. (2018). Heart rate variability and occupational stress - systematic review. *Industrial Health*, 56(6), 500-511. doi:10.2486/indhealth.2017-0190

Joshi, P. (2012). Heart rate variability (HRV): an overview. *Department of Physiology*, 6, 15-24. http://icyer.com/documents/HRV%20workshop%20souvenir%202012.pdf#page=15

Kemp, A. & Quintana, D. (2013). The relationship between mental and physical health: insights from the study of heart rate variability. *International Journal of Psychophysiology*, 89(2013), 288-296. doi: 10.1016/j.ijpsycho.2013.06.018

Kennedy, L. & Henrickson-Parker, S. (2018). Biofeedback as a stress management tool: a systematic review. *Cognition, Technology & Work*, 21, 161-190. doi:10.1007/s10111-018-0487-x

Kim, H-G., Cheon, E-J., Bai, D-G., Lee, Y. & Koo, B-H. (2018). Stress and heart rate variability: a meta-analysis and review of the literature. *Psychiatry Investigation*, 15(3), 235-245. doi:10.30773/pi.2017.08.17

Lehrer, P., Kaur, K., Sharma, A., Shah, K., Huseby, R., Bhavsar, J. & Zhang, Y. (2020) Heart rate variability biofeedback improves emotional and physical health and performance: a systematic review and meta-analysis. *Applied Psychophysiology and Biofeedback*, 45(3), 109-129. doi:10.1007/s10484-020-09466-z

Lin, I.M., Tai, L.Y. & Fan, S.Y. (2014). Breathing at a rate of 5.5 breaths per minute with equal inhalation-to-exhalation ratio increases heart rate variability. *International Journal of Psychophysiology*, 91(3), 2016-11. https://doi.org/10.1016/j.ijpsycho.2013.12.006

McCraty, R. & Shaffer, F. (2015). Heart rate variability: new perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. *Global Advances in Integrative Medicine and Health*, 4(1), 46-61. doi:10.7453/gahmj.2014.073

McKeon, G., Curtis, J. & Rosenbaum, S. (2022). Promoting physical activity for mental health: An updated evidence review and practical guide. Current Opinion in Psychiatry, 35(4), 270-276. doi: 10.1097/YCO.0000000000000796

Mikkelsen, K., Stojanovska, L., Polenakovic, M., Bosevski, M. & Apostolopoulos. (2017). Exercise and mental health. *Maturitas,* 106, 48-56. https://doi.org/10.1016/j.maturitas.2017.09.003

Mucke, M., Ludyga, S., Colledge, F. & Gerber, M. (2018). Influence of regular physical activity and fitness on stress reactivity as measured with the trier social stress test protocol: A systematic review. Sports Medicine, 48, 2607-2622. https://doi.org/10.1007/s40279-018-0979-0

Felez-Nobrega, M., Bort-Roig, J., Ma, R., Romano, E., Faires, M., Stubbs, B., Stamatakis, E., Olaya, B., Haro, J., Smith, L., Shin, J., Kim, M. & Koyanagi, A. (2021). Light-intensity physical activity and mental ill health: A systematic review of observational studies in the general population. *International Journal of Behavioral Nutrition and Physical Activity*, 18, 123. https://doi.org/10.1186/s12966-021-01196-7

Panahi, S. & Tremblay, A. (2018). Sedentariness and health: Is sedentary behavior more than just physical inactivity? *Frontiers of Public Health*, 6, 258. https://doi.org/10.3389/fpubh.2018.00258

Pandey, S. (2020). Principles of correlation and regression analysis. *Journal of the Practice of Cardiovascular Sciences*, 6(1), 7-11. doi: 10.4103/jpcs.jpcs_2_20

Paso, G., Langewitz, W., Mulder, L., Roon, A. & Duschek, S. (2013). The utility of low frequency heart rate variability as an index of sympathetic cardiac tone: A review with emphasis on a reanalysis of previous studies. *Psychophysiology*, 50(5), 477-487. https://doi.org/10.1111/psyp.12027

Peabody, J., Ryznar, R., Ziesmann, M. & Gillman, L. (2023). A systematic review of heart rate variability as a measure of stress in medical professionals. *Cureus*, 15(1), e34345. doi:10.7759/cureus.34345

Pham, T., Lau, Z., Chen., S.H. & Makowski, D. (2021). Heart rate variability in psychology: a review of hrv indices and an analysis tutorial. *Sensors 2021*, 21(12), 3998. https://doi.org/10.3390/s21123998

Pinna, T. & Edwards, D. (2020). A systematic review of associations between interoception, vagal tone, and emotional regulation: potential applications for mental health, wellbeing, psychological flexibility, and chronic conditions. *Frontiers Psychology*, 11, 1792. doi: 10.3389/fpsyg.2020.01792

Pontifex, M., McGowan, A., Chandler, M., Gwizdala, K., Parks, A., Fenn, K. & Kamijo, K. (2019). A primer on investigating the after effects of acute bouts of physical activity on cognition. *Psychology of Sport and Exercise*, 40, 1-22. https://doi.org/10.1016/j.psychsport.2018.08.015

Rand, W. & Guillaume, R. (2018). A guide to robust statistical methods in neuroscience. *Current Protocols in Neuroscience*, 82, 8.42.1-8.42.30. doi:10.1002/cpns.41

Ratnawat, R.G. & Jha, P.C. (2014). Impact of job relates stress on employee performance: a review and research agenda. *Journal of Business and Management*, 16(11), 01-06. doi:10.9790/487X-161150106

Reiner, M., Niermann, C., Jekauc, D. & Woll, A. (2013). Long-term health benefits of physical activity – a systematic review of longitudinal studies. *BMC Public Health*, 13, 813. https://doi.org/10.1186/1471-2458-13-813

Rhodes, R., Janssen, I., Bredin, S., Warburton, D. & Bauman, A. (2017). Physical activity: health impact, prevalence, correlates, and interventions. *Psychology & Health*, 32(8), 942-974. doi:10.1080/08870446.2017.1325486

Robson, K. (2015). *Multilevel Modeling in Plain Language.* SAGE Publications.

Rodriguez, I., Kozusznik, M.W. & Peiro, J.M. (2013). Development and validation of the Valencia eustress-distress appraisal scale. *International Journal of Stress Management*, 20(4), 279. doi:10.1037/a0034330

Ruotsalainen, J., Verbeek, J., Mariné, A. & Serra, C. (2015). Preventing occupational stress in healthcare workers. *Cochrane Database of Systematic Reviews*, 4, CD002892. doi: 10.1002/14651858.CD002892.pub5

Sacha, J. (2014). Interaction between heart rate and heart rate variability. *Annals of Noninvasive Electrocardiology*, 19(3), 207-126. https://doi.org/10.1111/anec.12148

Schober, P., Boer, C. & Schwarte, L. (2018). Correlation coefficients: Appropriate use and interpretation. *Anestesia & Analgesia*, 126 (5), 1763-1768. doi: 10.1213/ANE.0000000000002864.

Shaffer, F. & Ginsberg, J.P. (2017). An overview of heart rate variability metrics and norms. *Frontiers in Public Health*, 5, 258. https://doi.org/10.3389/fpubh.2017.00258

Shaffer, F., McCraty, R. & Zerr, C. (2014). A healthy heart is not a metronome: an integrative review of the heart´s anatomy and heart rate variability. *Frontiers in Psychology*, 2014(5), 1040. doi:10.3389/fpsyg.2014.01040

Steffen, P., Austin, T., Debarros, A. & Brown, T. (2017). The impact of resonance frequency breathing on measures of heart rate variability, blood pressure, and mood. *Frontiers in Public Health*, 5, 222. https://doi.org/10.3389/fpubh.2017.00222

Sureiman, O. & Mangera, C-M. (2020). F-test of overall significance in regression analysis simplified. *Journal of the Practice of Cardiovascular Sciences*, 6 (2), 116-122. doi: 10.4103/jpcs.jpcs_18_20

Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology. (1996). Heart rate variability – Standards of measurement, physiological interpretation, and clinical use. *European Heart Journal*, 17, 354-381. https://www.escardio.org/static-file/Escardio/Guidelines/Scientific-Statements/guidelines-Heart-Rate-Variability-FT-1996.pdf

Thayer, J., Åhs, F., Fredrikson, M., Sollers, J. & Wager, Tor. (2011). A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. *Neuroscience and Biobehavioral Reviews,* 36(2012), 747-756. https://doi.org/10.1016/j.neubiorev.2011.11.009

The, A-F., Reijmerink, I., Laan, M. & Cnossen, F. (2020). Heart rate variability as a measure of mental stress in surgery: a systematic review. *International Archives of Occupational and Environmental Health*, 93, 805-821. https://doi.org/10.1007/s00420-020-01525-6

Thivel, D., Tremblay A., Genin, P., Panahi, S., Riviére, D. & Duclos, M. (2018). Physical activity, inactivity, and sedentary behaviors: definitions and implications in occupational health. *Frontiers in Public Health*, 6, 288. doi: 10.3389/fpubh.2018.00288

Vartiovaara, I. (2004). *Voimaa eustressista*. Duodecim Oy Publishing

Vetter. T. (2017). Fundamentals of research data and variables: The devil is in the details. *Anesthesia and analgesia*, 125 (4), 1375-1380. doi: 10.1213/ANE.0000000000002370.

Warburton, D. & Bredin, S. (2016). Reflections on physical activity and health: What should we recommend? Canadian Journal of Cardiology, 32, 495-504. https://doi.org/10.1016/j.cjca.2016.01.024

Zahn, D., Adams, J., Krohn, J., Wenzel, M., Mann, C., Gomille, L., Jacobi-Scherbening, V. & Kubiak, T. (2016). Heart rate variability and self-control – a meta-analysis. *Biological Psychology*, 115(2016), 9-26. https://doi.org/10.1016/j.biopsycho.2015.12.007

Zhang, J. (2007). Effect of age and sex on heart rate variability in healthy subjects. *Journal of Manipulative and Physiological Therapeutics*, 30(5), 374-379. doi: 10.1016/j.jmpt.2007.04.001.

Zulfiqar, A. & Bhaskar, S-B. (2016). Basic statistical tools in research and data analysis. *Indian Journal of Anaesthesia*, 60(9), 662-669. doi: 10.4103/0019-5049.190623

APPENDICES

APPENDIX 1. Personal Information & Physical Activity Baseline Questionnaire.

Participants filled out the questionnaire before the beginning of the measurement period.

Henkilötiedot

1. STUDY ID
2. Etu- ja sukunimi
3. Sähköpostiosoite
4. Sukupuoli
5. Ikäjakauma (18-24 & 25-34 & 35-44 & 45-54 tai +55)
6. Pituus cm
7. Paino kg

Fyysisen aktiivisuuden perustaso

8. Kuinka monta kertaa viikossa tällä hetkellä teet kuormittavaa liikuntaa (voimakas hengästyminen) esim. juoksu, jääkiekko, koripallo, uinti yms.
9. Kuinka monta kertaa viikossa tällä hetkellä teet kohtuullisen kuormittavaa liikuntaa (hengästyminen) esim. ripeä kävely, hölkkäily, tennis, pyöräily yms.
10. Kuinka monta kertaa viikossa tällä hetkellä teet kevyttä liikuntaa (ei hengästymistä) esim. pyöräily, kävely, golf, jooga, yms.

APPENDIX 2. Physical Activity Assessment Questionnaire.

Participants filled out the questionnaire at the of each measurement day prior going to bed.

Fyysisen aktiivisuuden arviointi

Tässä kyselyssä arvioidaan fyysisen aktiivisuuden määrää minuuteissa tutkimuksen kolmen päivän mittausjakson aikana. Pyydämme täyttämään arvioinnin jokaisen mittauspäivän päätteeksi eli yhteensä kolme kertaa mittausjakson aikana.

1. STUDY ID
2. Kuinka monta minuuttia tämän päivän aikana teit kuormittavaa liikuntaa (voimakas hengästyminen) esim. juoksu, jääkiekko, koripallo, uinti yms.
3. Kuinka monta minuuttia tämän päivän aikana teit kohtuullisen kuormittavaa liikuntaa (hengästyminen) esim. ripeä kävely, hölkkäily, tennis, pyöräily yms.
4. Kuinka monta minuuttia tämän päivän aikana teit kevyttä liikuntaa (ei hengästymistä) esim. pyöräily, kävely, golf, jooga, yms.

APPENDIX 3. Eustress and Distress Appraisal Scale.

Participants filled out the questionnaire at the end of each measurement day prior going to bed.

Eustressi-Distressi Arviointiasteikko

Tätä Eustressi-Distressi Arviointiasteikkoa käytetään sinä kolmen päivän mittausjaksona, kun käytössä on Bittium Faros teknologialaite. Pyydämme täyttämään Arviointiasteikon jokaisen mittauspäivän päätteeksi ennen nukkumaanmenoa. On mahdollista, että osa väittämistä aiheuttaa ahdistusta.

Arviointiasteikko sisältää 20 väittämää, jotka arvioidaan asteikolla 1–6. Jokaiseen väittämään tarvitaan yksi vastaus.

1. STUDY ID

Väittämät 2–11 arvioivat eustressiä eli positiivista stressiä. Arvioissa pienin koettu eustressi vastaa vastausvaihtoehtoa 1 ja suurin koettu eustressi vastausvaihtoehtoa 6.

2. Koin olevani eristäytynyt
    1. Ehdottomasti ei ole hyödyllinen kokemus
    2. Todennäköisesti ei ole hyödyllinen kokemus
    3. Luultavasti ei ole hyödyllinen kokemus
    4. Luultavasti on hyödyllinen kokemus tehtävien toteuttamiseksi
    5. Todennäköisesti on hyödyllinen kokemus tehtävien toteuttamiseksi
    6. Ehdottomasti on hyödyllinen kokemus tehtävien toteuttamiseksi

3. Tunsin itseni aliarvostetuksi
    1. Ehdottomasti ei ole hyödyllinen kokemus
    2. Todennäköisesti ei ole hyödyllinen kokemus
    3. Luultavasti ei ole hyödyllinen kokemus
    4. Luultavasti on hyödyllinen kokemus kehittymiseni kannalta
    5. Todennäköisesti on hyödyllinen kokemus kehittymiseni kannalta

6. Ehdottomasti on hyödyllinen kokemus kehittymiseni kannalta

4. Emotionaalinen tuki oli puutteellista ihmisiltä työn ulkopuolella

1. Ehdottomasti ei ole hyödyllinen kokemus
2. Todennäköisesti ei ole hyödyllinen kokemus
3. Luultavasti ei ole hyödyllinen kokemus
4. Luultavasti ei heikennä suorituskykyäni
5. Todennäköisesti ei heikennä suorituskykyäni
6. Ehdottomasti ei heikennä suorituskykyäni

5. En saanut tukea päivittäisissä askareissa ihmisiltä työn ulkopuolella (esim. lastenhoito, kotityöt)

1. Ehdottomasti ei ole hyödyllinen kokemus
2. Todennäköisesti ei ole hyödyllinen kokemus
3. Luultavasti ei ole hyödyllinen kokemus
4. Luultavasti ei heikennä suorituskykyäni
5. Todennäköisesti ei heikennä suorituskykyäni
6. Ehdottomasti ei heikennä suorituskykyäni

6. Tein töitä työajan ulkopuolella

1. Ehdottomasti ei ole hyödyllinen kokemus
2. Todennäköisesti ei ole hyödyllinen kokemus
3. Luultavasti ei ole hyödyllinen kokemus
4. Luultavasti on hyödyllinen kokemus tehtävien toteuttamiseksi
5. Todennäköisesti on hyödyllinen kokemus tehtävien toteuttamiseksi
6. Ehdottomasti on hyödyllinen kokemus tehtävien toteuttamiseksi

7. Olin osallisena herkissä tai kiistanalaisissa tilanteissa

1. Ehdottomasti ei ole hyödyllinen kokemus
2. Todennäköisesti ei ole hyödyllinen kokemus
3. Luultavasti ei ole hyödyllinen kokemus
4. Luultavasti on hyödyllinen kokemus kehittymiseni kannalta
5. Todennäköisesti on hyödyllinen kokemus kehittymiseni kannalta

6. Ehdottomasti on hyödyllinen kokemus kehittymiseni kannalta

8. Koin syrjintää tai suosimista
    1. Ehdottomasti ei ole hyödyllinen kokemus
    2. Todennäköisesti ei ole hyödyllinen kokemus
    3. Luultavasti ei ole hyödyllinen kokemus
    4. Luultavasti on hyödyllinen kokemus kehittymiseni kannalta
    5. Todennäköisesti on hyödyllinen kokemus kehittymiseni kannalta
    6. Ehdottomasti on hyödyllinen kokemus kehittymiseni kannalta

9. Minun täytyi ottaa riskejä
    1. Ehdottomasti ei ole hyödyllinen kokemus
    2. Todennäköisesti ei ole hyödyllinen kokemus
    3. Luultavasti ei ole hyödyllinen kokemus
    4. Luultavasti on hyödyllinen kokemus tehtävien toteuttamiseksi
    5. Todennäköisesti on hyödyllinen kokemus tehtävien toteuttamiseksi
    6. Ehdottomasti on hyödyllinen kokemus tehtävien toteuttamiseksi

10. Sosiaalinen tuki oli vähäistä työpaikalla
    1. Ehdottomasti ei ole hyödyllinen kokemus
    2. Todennäköisesti ei ole hyödyllinen kokemus
    3. Luultavasti ei ole hyödyllinen kokemus
    4. Luultavasti ei heikennä suorituskykyäni
    5. Todennäköisesti ei heikennä suorituskykyäni
    6. Ehdottomasti ei heikennä suorituskykyäni

11. Seuraukset, joita tekemilläni virheillä oli
    1. Ehdottomasti ei ole hyödyllinen kokemus
    2. Todennäköisesti ei ole hyödyllinen kokemus
    3. Luultavasti ei ole hyödyllinen kokemus
    4. Luultavasti on hyödyllinen kokemus kehittymiseni kannalta
    5. Todennäköisesti on hyödyllinen kokemus kehittymiseni kannalta

6. Ehdottomasti on hyödyllinen kokemus kehittymiseni kannalta

Väittämät 12–21 arvioivat distressiä eli negatiivista stressiä. Arvioissa pienin koettu distressi vastaa vastausvaihtoehtoa 1 ja suurin koettu distressi vastausvaihtoehtoa 6.

12. Koin olevani eristäytynyt
    1. Ehdottomasti ei ole paineiden lähde
    2. Todennäköisesti ei ole paineiden lähde
    3. Luultavasti ei ole paineiden lähde
    4. Luultavasti on paineiden lähde
    5. Todennäköisesti on paineiden lähde
    6. Ehdottomasti on paineiden lähde

13. Tunsin itseni aliarvostetuksi
    1. Ehdottomasti ei ole paineiden lähde
    2. Todennäköisesti ei ole paineiden lähde
    3. Luultavasti ei ole paineiden lähde
    4. Luultavasti on paineiden lähde
    5. Todennäköisesti on paineiden lähde
    6. Ehdottomasti on paineiden lähde

14. Olin osallisena herkissä tai kiistanalaisissa tilanteissa
    1. Ehdottomasti ei ole paineiden lähde
    2. Todennäköisesti ei ole paineiden lähde
    3. Luultavasti ei ole paineiden lähde
    4. Luultavasti on paineiden lähde
    5. Todennäköisesti on paineiden lähde
    6. Ehdottomasti on paineiden lähde

15. Emotionaalinen tuki oli puutteellista ihmisiltä työn ulkopuolella
    1. Ehdottomasti ei ole paineiden lähde
    2. Todennäköisesti ei ole paineiden lähde

3. Luultavasti ei ole paineiden lähde
4. Luultavasti on paineiden lähde
5. Todennäköisesti on paineiden lähde
6. Ehdottomasti on paineiden lähde

16. En saanut tukea päivittäisissä askareissa ihmisiltä työn ulkopuolella (esim. lastenhoito, kotityöt)

1. Ehdottomasti ei ole paineiden lähde
2. Todennäköisesti ei ole paineiden lähde
3. Luultavasti ei ole paineiden lähde
4. Luultavasti on paineiden lähde
5. Todennäköisesti on paineiden lähde
6. Ehdottomasti on paineiden lähde

17. Minun täytyi ottaa riskejä

1. Ehdottomasti ei ole paineiden lähde
2. Todennäköisesti ei ole paineiden lähde
3. Luultavasti ei ole paineiden lähde
4. Luultavasti on paineiden lähde
5. Todennäköisesti on paineiden lähde
6. Ehdottomasti on paineiden lähde

18. Tein töitä työajan ulkopuolella

1. Ehdottomasti ei ole paineiden lähde
2. Todennäköisesti ei ole paineiden lähde
3. Luultavasti ei ole paineiden lähde
4. Luultavasti on paineiden lähde
5. Todennäköisesti on paineiden lähde
6. Ehdottomasti on paineiden lähde

19. Minun täytyi toimia haastavassa roolissa (esim. antaa rakentava palaute kollegalle)

1. Ehdottomasti ei ole paineiden lähde
2. Todennäköisesti ei ole paineiden lähde

3. Luultavasti ei ole paineiden lähde
4. Luultavasti on paineiden lähde
5. Todennäköisesti on paineiden lähde
6. Ehdottomasti on paineiden lähde

20. Työasiat olivat mielessäni myös vapaa-ajalla
    1. Ehdottomasti ei ole paineiden lähde
    2. Todennäköisesti ei ole paineiden lähde
    3. Luultavasti ei ole paineiden lähde
    4. Luultavasti on paineiden lähde
    5. Todennäköisesti on paineiden lähde
    6. Ehdottomasti on paineiden lähde

21. Sosiaalinen tuki oli vähäistä työpaikalla
    1. Ehdottomasti ei ole paineiden lähde
    2. Todennäköisesti ei ole paineiden lähde
    3. Luultavasti ei ole paineiden lähde
    4. Luultavasti on paineiden lähde
    5. Todennäköisesti on paineiden lähde
    6. Ehdottomasti on paineiden lähde