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An Analysis of Work-Related Stress Using Smart Devices: A Preliminary Study †

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Abstract: Nowadays, many people are forced to accelerate their rhythms because of frenetic life and work. Both private and professional lives intertwine, and finding the time for other activities is challenging. Time is one of the goods that has been lost or is difficult to obtain anyway. This experimental and prospective study aims to evaluate the heart rate cycle of medical doctors during their life/work routine. Thanks to technology, it is possible to monitor these parameters constantly. The results of this study are derived from a literature analysis and a trial carried out on three professionals regarding their work-related heart rate (Apple Watch®). The main limitation is represented by the sample; it is certainly small and does not provide significant results. This study represents the first step for a trial that can be carried out on a large scale; this preliminary study provides information about the heart rate cycle.

Keywords: heart rate; heart rate determination; emotional stress; job-related stress; job satisfaction; job performance

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1. Introduction

1.1. Background

The work and private life balance can be seriously compromised if demand increases. The result, seen as a source of material gain, is often placed above all else. Being overburdened affects the time and energy that could be devoted to leisure activities, leading to critical situations within the family and the relationships of the couple or friends. To maintain a healthy balance, it is essential to take the time to take care of your social relationships, make movements, eat properly, and devote yourself to recreational activities, as reported in the literature. Priority can be given to work in the short term but not in the medium to long term [1]. There is a risk that our "batteries" will not be recharged [1,2].

Stress that is related to work activities is manifested when the demands of the working environment exceed the worker's ability to face them (or control them). Stress is not a disease but can cause mental and physical health problems if it manifests intensely for prolonged periods [3]. Working under pressure can improve performance and give satisfaction when challenging goals are achieved. In reverse, when demands and pressure become excessive, they cause stress. Stress can be caused by problems at work or in other areas. Studies highlighted the negative effect of work stress on both the number of accidents in the course of work and the physical and mental health of the worker, as well as the risk of

cardiovascular disease. The study shows a double chance of cardiovascular disease deaths in stressed workers who presented no other risk factors for these diseases [3,4]. By now, everyone agrees that, based on work stress, there is an interaction between organizational factors and personal factors. An excessive workload and a lack of control over the tasks would mainly cause work stress. So, even with a heavy workload, a worker might feel relaxed if he perceives he can handle the load most appropriately. The effort–reward imbalance model hypothesizes that work stress is found in the presence of a high commitment associated with a poor reward [1–4].

The term reward means economic gain, social approval, job stability, and career opportunities. Stress cardiomyopathy, a form of heart failure induced by stressful events, appears to have far more extensive clinical features than reported and involves young and adult subjects without an identifiable triggering factor [5–7]. Stress cardiomyopathy (SC) primarily affects postmenopausal women and is characterized by acute, profound, but reversible left ventricle dysfunction in the absence of significant coronary disease. By bringing these results and future results to light, it will be possible to predict the cardiovascular risk of workers and, above all, modulate their work based on health risks. This study was conducted given the large amount of work in the psychological field on work-related stress and the literature on psychological stress-related heart disease.

1.2. Objective

This study aims to conduct a preliminary survey and assess heart rates at different stages of the day. Heart rate is evaluated at intervals, knowing the subjects' working time and, therefore, being associated with it. The study aims to present these innovative data and promote research.

2. Material and Methods

2.1. Information Sources

A literature search about this topic was conducted in major scientific databases such as PubMed, Embase, and Elsevier.

2.2. Search

A search was carried out for similar works in the literature to carry out the research and expand the case reported in the work. Although the articles are still few, they were included for supporting data. The keywords used in the search are as follows: "heart rate" AND "work" AND "stress". The choice of keywords aims to obtain as many results as possible and limits the risk of interference with non-pertinent works; in any case, a manual evaluation of the individual works was carried out.

2.3. Eligibility

The inclusion criteria are as follows:

- Studies about heart rate monitoring and stress;
- Studies about heart rate monitoring and work;
- Studies about medical doctors and stress;
- Last ten years of study, full text, on humans.

The exclusion criteria are as follows:

- Studies about a specific disease or primary heart disease;
- Cardiopathy-induced studies with psychological conditions;
- Animal studies.

2.4. Additional Analyses

In this study, a sample of three people, three medical doctors, were considered to compare their cardio-frequency responses during work and stress management (two males and one female). The doctors are considered to have more than five years of experience [8],

are in a familiar work environment, and are in contact with known patients. The medical-surgical treatments proposed and carried out during the cardio-frequency analysis are treatments that doctors can perform safely, as they have already gone through the learning curve. The work environment is a known environment, a private work environment.

Heart Rate Monitor

This study used common, non-professional devices as heart rate monitors that showed good reliability [9]. The study involved two Apple® devices: two Apple Watch® 2nd Series and an Apple Watch® 4th Series. The heart rate monitor function was active 24 h a day and monitored individuals' private lives, sports, and working lives (medical doctors with different specializations). Data were extracted, and one month of data was analyzed away from holidays or private events. The included people did not take drugs and met ASA1 criteria.

3. Results

From the literature search, a total of 1288 works were obtained; after the first screening, works older than ten years and texts that were not available were eliminated. Only human RCTs were included; finally, all the results related to the selected topics were evaluated manually, and only six works were isolated (Table 1).

Table 1. Risk of bias and results (HR = heart rate).

Author and Year	Risk of Bias	Main Results
Enoki et al. (2017) [10]	High	Stress-related and HR
Kanthak et al. (2017) [11]	Unclear	Burnout depression and stress-related HR
Föhr et al. (2016) [12]	Moderate	Employes and external activity on stress and HR
Semmer et al. (2015) [13]	Unclear	Illegitimate work and stress-related HR
Chema et al. (2013) [14]	Low	Yoga and work stress-related HR
Chema et al. (2011) [15]	Low	Yoga and work stress-related HR

3.1. Risk of Bias

Risk of bias results were performed and are shown in Table 1.

3.2. Trial Results

The data were exported from the Apple Health® application of individual smartwatches with a heart rate monitor function and were subsequently analyzed. In the following images, data concerning the single operators during the days of work and the free days, or family time, have been proposed. Three people wore heart rate monitors (Apple Watch®) to evaluate their heart rate; Table 2 (WT = working time, RT = not working time, N = night/sleep) and Figure 1 are some examples of the results obtained.

Table 2. Heart rate (max and min) between Medical Doctor 1, Medical Doctor 2, and Psychologist, 4 days. WT = working time, RT = not working time, and N = night/sleep.

	MD1	MD2	Psy
WT	65–104	69–92	67–88
RT	70–101	62–79	62–78
N	51–89	51–78	44–79
RT	68–85	60–78	62–72
WT	72–93	65–82	71–85
N	45–78	52–69	48–75
WT	71–95	73–91	70–92
RT	70–99	63–79	62–78
N	51–89	50–75	/
RT	69–85	60–78	60–75
WT	72–93	65–82	71–85
N	45–78	52–69	48–75

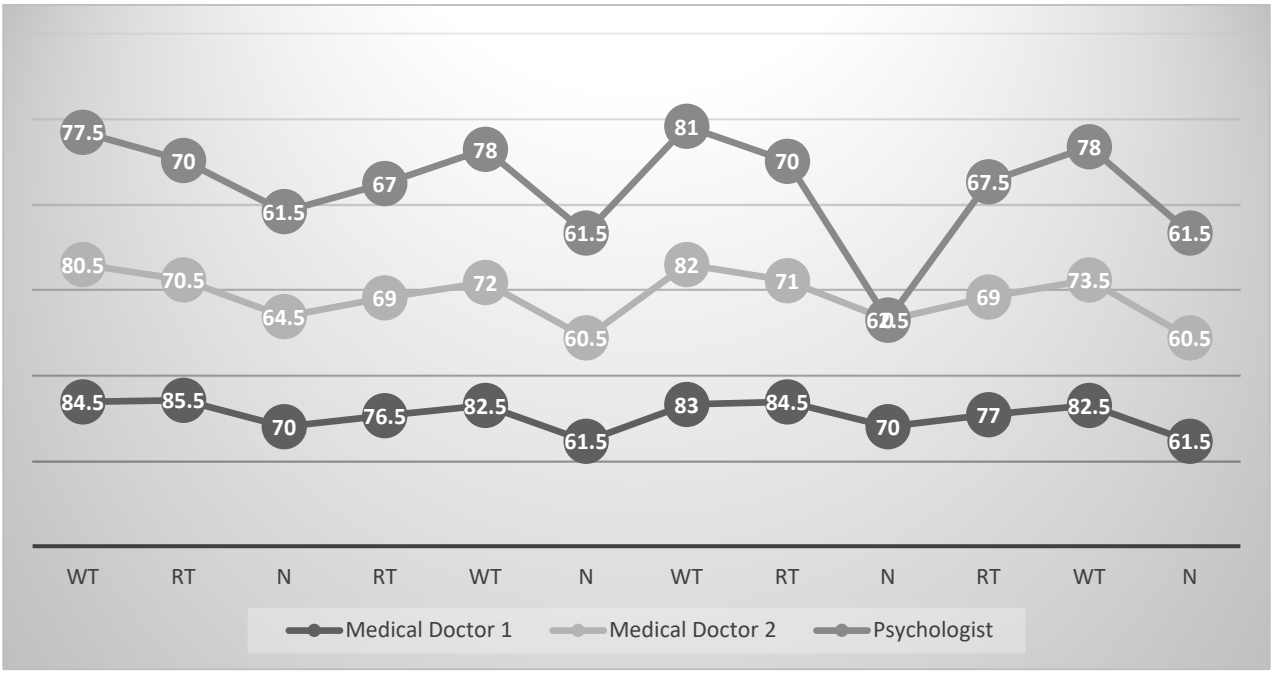

Figure 1. Axis indicates the heart rate (medium rate) over four days—a legend is shown in Table 1.

Different statistical results were obtained using the Fisher test; several days were taken to sample, evaluating the WT concerning the RT. Despite being slightly higher than the heart rate in the WT, all results give non-significant statistical data, with an average mark of $p = 0.6532$ and average data of 76.58, 69.75, and 70.31 for MD1, MD2, and Psy, respectively. Indeed, the sample needs to be more significant to draw interesting results. The model was not chosen through a blinded method, and the subjects can wear a heart rate monitor. We need more information on the performance of the Apple Watch heart rate monitor. However, the work of the perspectival type can undoubtedly be a good start.

4. Discussion

Eitel and colleagues [16] conducted a study to exhaustively define the clinical spectrum of SC to investigate the usefulness of a set of criteria based on functional magnetic resonance imaging that could help in diagnostic decisions in cases of suspected SC. The study was conducted in seven tertiary care centers in Europe and North America between 2005 and 2010 among 256 patients with SC assessed at the time of presentation in the centers and, subsequently, one to six months after the acute event. The patients had a mean age of 69; the sample constituted 89 percent of women and 81 percent in the postmenopausal period. In 71 percent of the cases, a stressful event was identified less than 48 h after presentation to the center, 30 percent of cases were emotional, and 41 percent had physical stress. Coronary angiography showed coronary arteries healthy in 193 patients (75 percent of the sample). Magnetic resonance imaging reduced severe left ventricular function in all patients. There is, therefore, a close correlation between work, stress, and the onset of heart disease [17,18]. Among the articles considered in this study is one that assessed the stress related to work for people working at call centers. Electrocardiograms were performed on this sample of patients, but no anomalies were found in these examinations associated with working or private life. One of the areas for improvement in this study is that the analysis was performed once a year on a routine basis and not during working hours. In addition, autonomic nervous function in male employees appears to be more vulnerable to work-related stress than in female ones [10]. According to Kanthak et al., there is evidence between exhaustion and reduced vagal function, both in burnout and depression. There is autonomic dysregulation in these pathologies [11].

Furthermore, high physical activity, lower stress on workdays, and a lower body mass index are associated with better recovery during sleep. However, according to the authors, several factors could affect heart-rate-variability-based stress [12]. Low job control and job strain, but not job demands, were associated with an elevated resting heart rate [13]. Therefore, there may be an alteration of the stress-related heart rate at the end of a job or the tension caused by not having one shortly. There are habits or lifestyles, as some previous authors have proposed, that can positively influence the heart rate [12]. According to a study, yoga that is also performed at the workplace can help eliminate or decrease workers' stress, improve general health, and limit the possibility of cardiovascular disease [14,15]. Indeed, at work, especially if there are no good relationships with colleagues, it is possible to experience exposure to an increase in heart rate and stress. For example, the growth of tasks by others or otherwise carrying out work on behalf of other colleagues can lead to this [19–21]. Stressful working conditions can expose them to other systemic diseases, as already mentioned in the study. For example, an increased risk of early dementia is one of these [6,22,23]. Stress can also lead to alterations at the molecular level of our body, making it possible to create modifications in the immune system; these can also lead to a series of chronic or acute diseases closely related to biomarkers or pro-inflammatory cytokines [24–28], seeing their profile altered in cases of stress. Important, and at the base of this study, are the alterations and possible cardiovascular pathologies related to stress and, therefore, to work-related stress [3,29]. The use of heart rate monitors in employees has gained significant attention in recent years as a potential tool to improve the quality of life and the quality of work. Heart rate monitors, typically worn as wearable devices, provide real-time feedback on an individual's heart rate, allowing them to monitor and manage their physiological responses to various stressors. By leveraging this technology, organizations can support their employees in achieving optimal well-being, enhancing job performance, and promoting a healthier work environment. One of the primary benefits of using heart rate monitors is the ability to monitor and manage employee stress levels. Stress is a common issue in the workplace and can have detrimental effects on both physical and mental health. Employees can gain insights into their stress patterns by continuously tracking heart rates and identifying triggers contributing to elevated heart rates. This awareness empowers individuals to take proactive steps to manage stress, such as practicing relaxation techniques, engaging in physical activity, or seeking social support. Over time, this can lead to a reduction in stress-related symptoms and an improved quality of life.

Furthermore, heart rate monitors can also enhance the quality of work by enabling individuals to optimize their performance. Research has shown an optimal level of arousal for cognitive functioning and task performance, commonly known as the "Yerkes-Dodson Law." Heart rate monitors can help individuals identify their optimal arousal levels by tracking their heart rate during work-related activities. With this information, employees can tailor their work strategies and adjust to maintain their heart rate within the optimal range, thereby maximizing their productivity and overall quality of work. Moreover, heart rate monitors can effectively promote physical activity and maintain a healthy lifestyle among employees. Sedentary behavior is a prevalent concern in many workplaces, contributing to various health issues such as obesity, cardiovascular diseases, and musculoskeletal disorders. Employees can track their activity levels using heart rate monitors and set goals for increasing physical movement throughout the workday. Employers can also implement workplace wellness programs utilizing heart rate monitors to encourage employees to engage in regular physical activity and adopt healthier habits. This not only improves the quality of life for employees but also leads to increased energy levels, reduced absenteeism, and improved job satisfaction. It is important to note that successfully implementing heart rate monitors in the workplace requires a supportive organizational culture and adequate privacy protections. Employees should be educated about the purpose and benefits of using heart rate monitors, ensuring that the technology is seen as a tool for empowerment rather than surveillance.

Additionally, clear guidelines must be established regarding the use and storage of heart rate data to maintain employee privacy and comply with relevant data protection regulations. While the potential benefits of heart rate monitors in the workplace are promising, further research is needed to explore their long-term effectiveness and impact on employee outcomes. Additionally, studies investigating the cost-effectiveness and return on investment associated with implementing heart rate monitoring programs would provide valuable insights for organizations considering their adoption. By integrating heart rate monitors with an AI system that can analyze and interpret the collected data, it is hypothesized that the AI system can identify employees' optimal performance states and effectively modulate their work schedules accordingly. The hypothesis suggests that when employees are at their optimal arousal levels, as determined via heart rate monitoring, their productivity and overall quality of work will increase.

The AI system can detect signs of fatigue, stress, or decreased employee engagement using real-time heart rate data. Based on these insights, the AI system can dynamically adjust work schedules by incorporating short breaks, providing rest intervals, or assigning tasks that align with employees' physiological states. This time modulation optimizes employees' performance and enhances their well-being by ensuring they work when they are most alert, focused, and motivated. The hypothesis assumes that aligning work schedules with employees' physiological states will result in several positive outcomes. Firstly, it is expected to increase productivity, as employees will work during their optimal performance states, which may result in improved concentration, cognitive abilities, and task execution. The hypothesis predicts that modulating work schedules based on heart rate data will reduce the risk of burnout and work-related stress by preventing prolonged fatigue or excessive strain. This, in turn, is anticipated to enhance employees' well-being and job satisfaction.

It should be noted that the hypothesis assumes that the AI system is well-designed, considering individual differences and preferences, and respects employees' autonomy and work–life balance. Additionally, appropriate safeguards and privacy measures should be implemented to ensure the responsible use of heart rate data and protect employees' personal information. A comprehensive study could test this hypothesis by involving employees utilizing heart rate monitors during work activities. The employees would be randomly assigned to either an experimental group, where their work schedules are modulated based on the AI system's heart rate data, or a control group, where no such modulation occurs. Objective measures of productivity, task performance, and well-being indicators (e.g., stress levels and job satisfaction) would be collected and compared between the two groups over a specified period. Suppose the study results demonstrate a significant improvement in productivity and well-being outcomes in the experimental group compared to the control group. In that case, it will support the hypothesis that integrating heart rate monitors with an AI system capable of modulating workers' time can positively affect employees' performance and overall quality of work. Further research and experimentation are needed to fully explore the potential benefits and challenges of implementing such a system in real-world work environments (Figure 2) [30].

In conclusion, using heart rate monitors among employees can improve the quality of life and work. By providing real-time feedback on physiological responses, heart rate monitors enable individuals to manage stress levels, optimize performance, and promote physical activity. However, careful consideration must be given to privacy concerns and organizational support to ensure this technology's successful implementation and acceptance in the workplace.

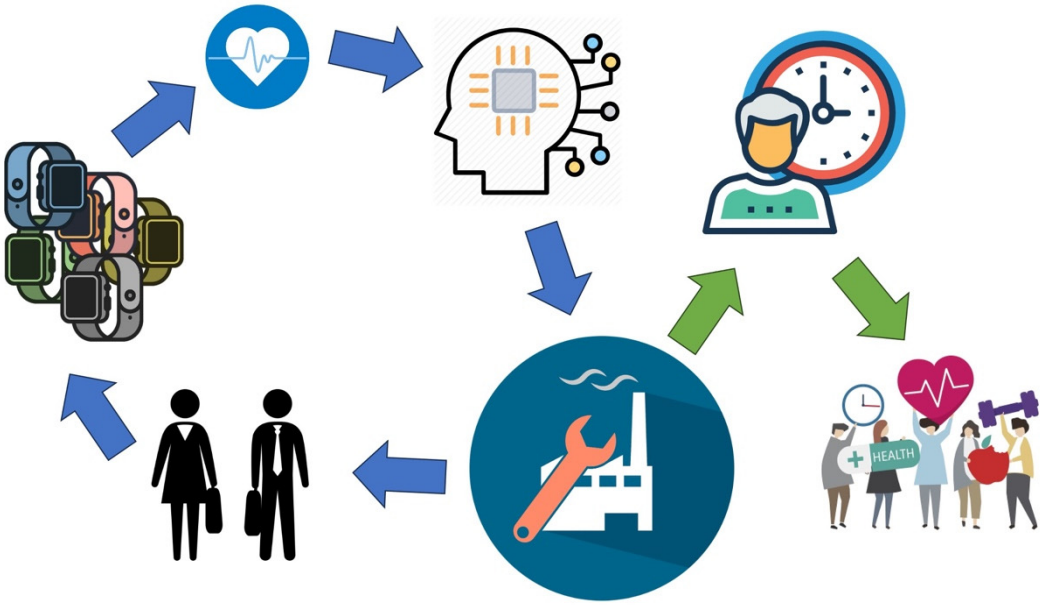

Figure 2. AI managed employees' heart rate monitors to improve wellbeing.

4.1. Limitation

The limits of this study are related to the size of the sample examined; given the simplicity of finding heart rate monitors, it would be possible to carry out mass studies and evaluate factors such as these in entire working structures. An acceleration in heart rate may be logical because of activity. Additionally, blood pressure should be included for a more complete result. Information about Apple Watch heart rate monitor performances is not available.

4.2. Bias and Fi-Index Tool

This manuscript has been checked with the Fi-index tool and obtained a score of 0.19 for all authors on 12 April 2023, according to SCOPUS® [31,32]. The fi-index tool aims to ensure the quality of the reference list and limit any auto-citations.

5. Conclusions

It was, therefore, possible in this study to analyze some works and draw up a report on work-related cardiovascular risk. In addition to these data, our experimental study has provided support for indicating a correlation between heart rate and work. Stressful jobs can have a different influence on the heart rate. In the study, some conditions, such as sporting activity, good rest, or, in any case, a healthy work environment, have shown how they can help reduce stress and regulate heart rate. In addition, some habits, like yoga in the workplace, can lower the heart rate and work-induced pressure. This work can stimulate much more extensive studies of whole populations. Smart devices are now standard, and companies that process these data could directly invest in analyzing these data, certainly bringing out exciting results. All data on heart rates, calories burned, or other lifestyle-related or stress-related factors are constantly being handled by the servers of these multinationals. Furthermore, being able to profile and select the population would allow for precise and reliable studies. It would be possible to evaluate occupational diseases related to age more accurately, the ethnic group of origin, or conduct social conscience investigations.

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