Sedentary Work Style and Heart Rate Variability: A Short Term Analysis

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Abstract. Emerging studies suggest that sedentary work style is often associated with deleterious physiological implications, including diabetes, high blood pressure and obesity. However, only few studies linked prolonged periods of sitting with psychological responses thus the implications of sedentary behavior on mental health still remain highly unexplored.
In this study, we investigated the relation between sedentary time and Heart Rate Variability (HRV) parameters, which are considered important biological markers of psychological processes including cognitive and emotional aspects. In this manner, we aim to explore factors that may indicate that sedentary behavior causes responses at psychological level. Recent progress in the sophistication and usability of wearable sensors offers the opportunity to continuously record ECG parameters and accelerometer data in daily-life settings, such as at workplace.

1 Introduction

Physical inactivity leads to a number of health complications and various media campaigns are designed to encourage increase in physical activity levels and promote healthy lifestyle. However, a general increase in physical activities is not sufficient to improve health. An important component of physical activity is the work style. In developed economies, knowledge workers typically have a work style that requires sitting for prolonged periods of time. As a number of studies have shown [1]; [10]; [13] sedentary work style leads to an array of health complications, including diabetes, high blood pressure and obesity. The negative effects on health due to sedentary work style occur even if people follow the guidelines on physical activity and lead a healthy lifestyle outside of the workplace [1]; [10]. However, the impact of prolonged periods of sitting on mental health remains a largely unexplored area of research [18].

In this study, we explore how sedentary behavior affects a biological marker that is indicative for processes at physiological (and maybe emotional and cognitive) levels, namely Heart Rate Variability (HRV). Being suitable for a short term analysis of cognitive and emotional responses, HRV might provide cues for the potential

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psychological impacts of sedentary behavior thus motivating further investigations in this area.

Wearable devices to measure ECG are readily available and are unobtrusive to use, finding applications beyond health monitoring (for instance sport performance monitoring), therefore becoming a powerful tool for both research and clinical studies [4]. The clinical relevance of HRV was first noted in 1965 [9] and continues to be used today to examine neuropathy in diabetic patients, risk of cardiovascular mortality and a number of other physiological and pathological conditions [4]. On the other hand, recent studies have found strong correlation between HRV and mental stress [7], visual stimulations [3] and mood states [5]; [6]. In addition, the influence of physical activities on HRV has been widely studied, including the effects of habitual physical activity and also HRV analysis during pre-scheduled activities. However, less emphasis has been placed on the physical inactivity, especially in workplace.

2 Background

Heart rate variability represents variations in inter-beat intervals (IBI) and provides a significant measure of physiological and pathological conditions [4], furthermore psychological responses. It mirrors the relationship between sympathetic and parasympathetic branches of autonomic nervous system; the former stimulates organs' functioning and causes increase in heart rate (HR), while the later inhibits functioning of organs and causes a decrease in heart rate [3]; [15]; [16]. The balance between sympathetic and parasympathetic systems constantly changes when the body attempts to achieve an optimum state corresponding to all internal and external stimuli [2]; [17]. Therefore, HRV is considered a measure of changes in system balance and consequently as a measure of body responses to internal and external provocations [2]; [17].

These studies have demonstrated that lower HRV values often suggest sympathetic dominance, higher stress and negative emotions, according to experiments where subjects were asked to watch horror movies [3] or perform mental tasks [7], [15]. Higher HRV values, to the contrary, indicate domination of parasympathetic system and positive emotions that were typically evoked by watching delightful movies, such as love stories [5] or landscape scenes [3].

3 Materials and Methods

3.1 Classification of Sedentary Time

Accelerometers are widely available in newer generations of smart phones, typically used for their role in user interfaces [14]. They provide an important research tool able to reliably measure and classify a number of physical activities, including walking, jogging, sitting, standing [11], and more complex activities such as estimation of metabolic energy expenditure, sit-to stand transfers, and assessment of balance and intensity of physical activity [12].

For our study, it was important to distinguish only sitting periods from all other physical activities and to provide precise duration and timestamp of each segment. We analyzed acceleration data and calculated standard deviation of resultant accelerations over each one-minute interval [12] - the square roots of the sum of the values of each axis (*x, y* and *z*) squared [11]. In most cases it was easy to distinguish periods characterized by very low intensity movements that were considered sedentary periods.

All the activities related to usage of the phone itself, such as making phone calls or sending texts, were also recorded; the accelerometer data for these periods was discarded to avoid confusion with physical activities.

3.2 HRV Measures

In order to acquire HRV, we used Shimmer Wireless ECG sensor [8]; [17], connected with the mobile phone via Bluetooth. Due to limited performance of the mobile device, the maximum ECG sampling rate that it could process (along with the data from other sensors, including accelerometer and location) did not allow us to use frequency domain analysis [4]; [15]; [16]. Therefore, our focus was on time domain analysis of HRV. In order to prevent the sensor battery from running out during subjects' working time, we recorded ECG data for 1 minute during a time frame of 5 minutes. Before the calculation of time domain measures of HRV took place, all abnormal heart beats and artefacts were removed from consideration; the signal suffered high noise usually when the subject was moving intensively.

In the ECG recordings, each interval between neighboring beats, called NN interval was detected. We analyzed the following measures [4]; [15]; [16]:

SDNN[ms] – Standard deviation of the NN interval, i.e. the square root of variance.

RMSSD[ms]- The square root of the mean squared differences of successive NN intervals.

pNN50[%] – The proportion derived by dividing NN50 by the total number of NN intervals, where NN50 represents the number of interval differences of successive NN intervals greater than 50ms.

4 Experiments and Results

We recruited 6 participants from our research centre (4 males and 2 females), with ages between 26 and 35, with an average age of 29. They were all knowledge workers with no major differences either in the type of job regarding sedentary routines or in the number of working hours. None of the subjects was a cigarette smoker, nor had a chronic disease.

A total of 47 recordings have been collected among the six subjects. Descriptive statistics have been reported in Table 1.

For each one of these recording we calculated three HRV indexes, namely SDNN, RMSSD and pNN50, as before described, and an activity index (NonSedTime) to measure non-sedentary time, that is the percent of time spent in non sedentary activities. Since sedentary and non-sedentary time indexes are counter-proportional, selecting one of the two is sufficient to investigate the correlation between sedentary behavior and HRV parameters.

Table 1. Descriptive statistics of activity and HRV indexes, used in our study.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
NonSedTime	47	0.00	46.85	13.38	10.49
SDNN Mean	47	0.05	0.18	0.09	0.04
RMSSD Mean	47	0.63	0.87	0.76	0.06
pNN50 Mean	47	0.25	0.49	0.37	0.06

The analysis (Table 2) showed a positive correlation between non-sedentary time and HRV indexes – SDNN and pNN50 indexes increase as NonSedTime increases and vice versa, i.e. the lower amount of time spent in non-sedentary activities the lower the values of SDNN and pNN50. A lower levels of SDNN and pNN50 is known to be associated with higher stress levels [4]; [15]; [16] and negative emotions [3-7]. Therefore, the results indicate that sedentary workstyle lead the subjects to be more prone to negative emotions and stress, measuring the stress level according to the Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology [4]. However, due to the small sample size of this pilot study, the results should be considered only as an indication for the association between sedentary behavior and psychological processes.

Table 2. Correlation analysis between non-sedentary time and HRV indexes.

Correlations

	SDNN Mean	RMSSD Mean	pNN50 Mean
NonSedTime	.442**	0.046	0.262+
SDNN Mean	1	.305*	.740**
RMSSD Mean	.305*	1	.576**
pNN50 Mean	.740**	.576**	1

+. Correlation is significant at the 0.10 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2 also shows a strong internal coherence for HRV indexes, in fact the correlations between these indexes are always highly statistically significant. This means that the relationship between SDNN, RMSSD, and pNN50 is typically strong, and the phenomena revealed with one of the indexes should also apply for the others, even though it is indirect.

Furthermore, since the recording entries are hierarchical within participants, we estimated, with hierarchical linear regression, the relationship between the non-sedentary time and HRV, using SDNN as a dependent variable. Results are showed in Table 3.

Table 3. Hierarchical linear regression.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.072	.0085	.056	.089	71.594	1	.000
NonsedTime	.002	.0003	.001	.002	25.827	1	.000
(Scale)	.001						

5 Conclusions

Emerging studies suggest that sedentary work style is often associated with deleterious health complications, including diabetes, high blood pressure and obesity [1]; [3]; [5]; [9]; [10]; [11]; [19]. In this study, we aimed to explore the correlation between sedentary time and HRV parameters, which are considered biological markers of both physical and mental health. In particular, recent studies demonstrated that lower HRV values often suggest sympathetic dominance, higher stress and negative emotions [3-7]. Recent progress in the sophistication and usability of wearable biosensors offers the opportunity to continuously record ECG parameters and accelerometer data in daily-life settings, such us at work place. In this experiment we used a Shimmer Wireless ECG sensor, connected with the mobile phone via Bluetooth, to investigate the correlation between sedentary time and HRV parameters at workplace, thus exploring possible cues for the association between sedentary behavior and psychological processes. Results showed a strong relationship with HRV parameters, in particular with SDNN and pNN50, suitable for a short term analysis. Such evidences suggest the use of wearable devices to measure ECG indexes in naturalistic environment to explore new possibilities to encourage a healthy work style. However, due to the small sample size, these results provide only cues about the examined correlations and we believe that they might motivate for future investigation on the correlation between sedentary time and HRV but also on the impacts of sedentary behavior on psychological response including emotions, stress and the mood.

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