Working in the Office and Smart Working Differently Impact on the Cardiac Autonomic Control

Francesca Perego[1], Beatrice De Maria[1], Giuseppina Cassetti[1], Monica Parati[1,2], Vlasta Bari[4], Beatrice Cairo[3], Francesca Gelpi[4], Alberto Porta[3,4], Laura Adelaide Dalla Vecchia[1]

[1]IRCCS Istituti Clinici Scientifici Maugeri, Milano, Italy
[2]Neuroengineering and Medical Robotics Laboratory, Department of Electronics, Information and Bioengineering, Politecnico di Milano, Milan, Italy
[3]Department of Biomedical Sciences for Health, University of Milan, Milan, Italy
[4]Department of Cardiothoracic, Vascular Anesthesia and Intensive Care, IRCCS Policlinico San Donato, San Donato Milanese, Milan, Italy

Abstract

The COVID-19 pandemic significantly changed the working settings of millions of office employees. Recently, the study of the cardiac autonomic control profile (CACP) has been suggested as an early screening tool in occupational medicine. In this study we describe the CACP in relation to different working conditions. Seventeen healthy office active employees (age: 38±7 yrs, 9/8 males/females) were studied, by means of electrocardiogram 24-hour Holter monitoring, while alternating working at home (SMART) and in the office (OFFICE), respectively. The beat-to-beat series of the time distance between two consecutive R-wave peaks was extracted during the 24 hours. Parametric power spectral analysis was iterated over the RR series during daytime (DAY) and nighttime (NIGHT). The degree of perceived stress, as measured via the visual analogue scale, was higher in OFFICE. During NIGHT the variance of the RR series was higher in SMART than in OFFICE situation. A similar tendency was observed for the absolute power of RR series in high frequency band. We conclude that the expected circadian rhythm of the vagal control is more evident in the SMART situation than in the OFFICE condition and the perceived stress is lower, with beneficial effects for the cardiovascular system and for the overall status of the entire organism.

1. Introduction

The COVID-19 pandemic has profoundly marked a turning point in the working habits of many office employees. The shift from working in the office (OFFICE) to smart working (SMART) at home has blurred boundaries between working and domestic demands, giving rise to several concerns including changes in physical activity, eating habits, familial relationships, as well as the perceived work-related stress and motivation [1, 2]. Until now, the evaluation of the impact of SMART versus OFFICE has been mostly limited to the administration of questionnaires [3].

A full understanding of how working habits may change everyone's life could provide important insights into the organization and management of office and remote work activities in the years to come, with the ultimate goal of improving employee well-being [3]. In addition, it could aid cardiovascular disease prevention, as it is known that work-related stress is associated to an increased risk for the development of cardiovascular and cardio-metabolic dysfunctions [5-7]. Such a risk is mirrored by an altered cardiac neural regulation, characterized by a reduced vagal and/or an augmented sympathetic modulation to the heart [5]. In this perspective, the study of cardiac autonomic control profile (CACP) by means of HRV analysis might provide insights about environmental and psychosocial perturbations, as work habit changes. Indeed, the measurement of heart rate variability) (HRV), via the assessment of the magnitude of the variations of the time interval between two consecutive R-wave peaks (RR) from a continuous electrocardiogram (ECG) recording, has been suggested [4] as an early, non-specific screening tool for primary prevention in occupational medicine.

Accordingly, the aim of this study is to determine the extent to which CACP is modified in relation to different working conditions. Thus, we compared the CACP of healthy office employees during two different working conditions, namely SMART and OFFICE, by means of HRV analysis derived by a continuous 24-hour Holter ECG monitoring.

2. Population and experimental protocol

Seventeen healthy office employees (age: 38±7 yrs, 9 males and 8 females) were enrolled in the study. Characterization of the population is reported in Table 1. Inclusion criteria were: i) healthy subjects; ii) active

Table 1. Characterization of the enrolled population.

Index	Population (n = 17)
Gender [% of males]	53
Age [yrs]	38±7
BMI [$kg \cdot m^{-2}$]	23.7±2.3
Smoking [%]	29
Social drinkers [%]	59
Nulliparous [%]	70
With one child [%]	18
With two children [%]	6
With three children [%]	6
No cohabitant [%]	29
One cohabitant [%]	47
≥2 cohabitants [%]	24
House [m^2]	83.6 ± 27.2

BMI: body mass index. Interval variables are expressed as mean ± standard deviation. Categorical variables are expressed as percentage.

workers; iii) alternation between working at home and in the office in the same week. Exclusion criteria were: i) presence of any disease known to influence the state of the CACP; ii) regular use of medication; iii) heavy smokers; iv) heavy alcohol drinkers. At enrollment, each subject completed a questionnaire about demographic and clinical information, working and free-time habits.

Each subject self-positioned a 3-lead 24-hour Holter ECG (360° eMotion FAROS, MegaElectronics, Finland; Sylco srl, Monza, Italy), at a sampling rate of 500 Hz, during both a SMART and an OFFICE day, in a randomized order. The study protocol was completed in the period July-September 2020.

Participants were asked to rate the perceived degree of stress at the end of SMART and OFFICE day utilizing a visual analogue scale (VAS), consisting of an unmarked ruler with endpoints labelled as “no perceived stress” (0) and “very high perceived stress” (10). The protocol adhered to the principles of the Declaration of Helsinki and was approved by the local Ethics Committee (2467CE). Each subject signed a written informed consent.

3. Methods of analysis

3.1. Beat-to-beat time series extraction and selection of the periods for analysis

From the ECG (lead II), RR interval time series were derived by means of an automatic algorithm. Detections of r-wave peaks were manually checked. Correction of ectopic beats was performed by cubic spline interpolation, never exceeding 5% of total beats. Segments of 5000 consecutive RR intervals were selected during daytime (DAY, from 10 to 12 a.m.) and during nighttime (NIGHT, from 1 a.m. to 4 a.m.) for power spectral analysis. On these selections, an iterated analysis on windows of 250 consecutive RR intervals, with superposition of 200, was performed. The median of the whole distribution was taken as representative [8]. Mean (μ_{RR}) and variance (σ^2_{RR}) of RR

Table 2. Characterization of the subject’s habits in SMART and OFFICE working situations.

Index	SMART	OFFICE
Sleep per night [hours]	7.2±0.6	6.6±0.4
Regular physical exercise [%]	59	59
Physical exercise [$hours \cdot week^{-1}$]	2.8±1.3	3.3±1.8
Working hours [$hours \cdot day^{-1}$]	8.4±0.9	8.3±0.6
Stress by VAS	4.8±1.5	6.8±1.1 *

SMART: regular working day in remote modality; OFFICE: regular working day in the office. Interval variables are expressed as mean±standard deviation. Categorical variables are expressed as percentage. The symbol *indicates $p<0.05$ vs OFFICE.

series were calculated, and expressed in ms and ms^2, respectively.

3.2. Power spectral analysis

RR series were described as a realization of an autoregressive process, whose order was chosen according to Akaike information criterion, and decomposed in power spectral components. The sum of the power spectral components whose central frequency dropped in the high frequency (HF) band (0.15-0.4 Hz) [9] was labelled as HFa_{RR}, expressed in absolute units (i.e. ms^2) and taken as an index of the cardiac modulation directed to the heart [10, 11].

3.3. Statistical analysis

Categorical data were reported as percentage and continuous data as mean±standard deviation. The differences between SMART and PRESENCE conditions were tested by paired t-test, or Wilcoxon signed rank test when appropriate over continuous variables and by $\chi 2$ test, over categorical data.

Two-way repeated measures analysis of variance (two factor repetition, Holm-Sidak test for multiple comparisons) was performed to check the differences of the RR variability indexes between the two experimental conditions (i.e. SMART and OFFICE) within the same period of analysis (i.e. DAY or NIGHT) and between periods of analysis within the same working condition. A $p<0.05$ was always considered significant. Statistical analyses were carried out using Sigmaplot, Systat Software, Inc., Chicago, IL, version 11.0.

4. Results

Characterization of the subject's habits during the SMART and OFFICE working situations is reported in Table 2. As to number of sleeping hours per night, of working hours per day and of physical activity per day, no differences were detected between SMART and OFFICE. The VAS score was higher during OFFICE than SMART condition.

The results of the RR variability analysis are given in Table 3. μ_{RR} increased during NIGHT compared to DAY during both SMART and OFFICE. During NIGHT σ^2_{RR} was higher in SMART than in OFFICE. The same tendency was observed for the HFa_{RR} power, although statistical significancy was not reached.

5. Discussion

The spread of the pandemics due to SARS-Cov-2 has profoundly changed the work organization in order to limit personal contacts and preserve public health. As a consequence, this rapid change forced to prefer smart working from traditional working in the office. In many contexts, the alternation of these two working methods was thus implemented. Advantages and disadvantages of this organizational approach for everyone's physiological conditions are not known. In addition, it is difficult to standardize and measure all the variables that could be influenced by this new work style [3, 4].

The main finding of this project is that the index of vagal modulation directed to the heart during NIGHT is higher in SMART compared to OFFICE. At the same time, the perceived stress is lower. Both the increase of the vagal tone and the reduction of the levels of stress are considered protective against cardiovascular disease [12, 13] suggesting that smart working could represent a more favorable or less stressful condition. This is in line with other studies [14] that addressed the effects of organizational support, including the evaluation of job resources and demands, and found positive associations between work at home and less time pressure, less role conflict and greater autonomy, thus resulting in less psychological exhaustion.

It is of interest that, in these preliminary data, no differences in number of working hours, hours of sleep per night and physical activity were found, suggesting that the daily-life habits, other than work, were not changed.

Gender differences could not be tested due to the limited number of subjects enrolled in the study. Indeed, in other studies [15-17] higher levels of exhaustion and stress associated with increased unhappiness were reported by

Table 3. Results of the RR variability analysis

Index	SMART		OFFICE	
	DAY	NIGHT	DAY	NIGHT
μ_{RR} [ms]	810.57±98.40 #	939.05±121.91	799.86±112.74 #	946.29±105.27
σ^2_{RR} [ms^2]	3367.62±1607.53	4297.95±4112.07 *	3195.15±1763.87	2877.29±2359.92
HFa_{RR} [ms^2]	333.54±320.49	1405.85±2825.69	325.34±361.21	871.29±1280.35

SMART: regular working day in remote modality; OFFICE: regular working day in the office; DAY: daytime period; NIGHT: nighttime period; RR: interval between two consecutive R-wave peaks; μ_{RR}: mean RR; σ^2_{RR}, RR variance; HF, high frequency; HFa_{RR}: HF power of the RR series expressed in absolute units; The symbol * indicates $p<0.05$ versus OFFICE within the same period of analysis. The symbol # indicates a $p<0.05$ versus NIGHT within the same working condition.

females. Future developments should focus on a rigorous evaluation of gender differences. In addition, assessment of the complexity of the cardiac control should be deepen [18].

As the study was conducted in the period between the first and second outbreak of Covid-19 in Italy, we cannot exclude a relation of the results with the specific Italian situation during the two pandemic waves. In addition, the period of monitoring was relatively small (i.e. from July to September 2020). The particular brevity of the study might have limited variability of results since it is well-known that other factors like longer social isolation could play a role.

6. Conclusion

Smart working is characterized by an increase in the vagal tone during nighttime and a less perceived level of stress when compared to work in the office. The study of HRV could be of support for an objective measurement of the health status during different working conditions.

In this pilot study we collected some environmental, psychological and biological variables that will be used to provide a comprehensive evaluation.

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Address for correspondence:

Francesca Perego, MD, PhD
IRCCS Istituti Clinici Scientifici Maugeri
Via Camaldoli 64, 20138, Milan, Italy.
Phone: +39 02 50725239
Email: francesca.perego@icsmaugeri.it