Heart Rate Variability and Myocardial Heart Condition in Obese Military Personnel

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Abstract Heart rate variability (HRV) is a simple, non-invasive, real-time analyzable, and highly reproducible measurement that captures incidences for assessing a person's health and physical condition. Public security jobs are characterized by major exposure to risk factors known to influence the cardiovascular response to stimuli, e.g., night shifts, highly physically demanding activity, and acute stress activity. This study aimed to evaluate the HRV parameters in a population of 112 male personnel of the special forces and public order of the Carabinieri, aged 25–59, when engaged in several duty tasks, such as paratroopers, night shift police station officers, night shift patrol, dynamic precision shooting evaluative team, dynamic precision shooting non-evaluative team, and office clerks (used as control group). During the specific task of each participant, the HRV parameters were collected with wearable devices and processed. The HRV parameters in the time and frequency domains collected were average heart rate, standard deviation of all normal RR intervals, root mean square of successive differences in adjacent normal-to-normal (NN) intervals, very-low-frequency power, low-frequency power, high-frequency power, stress index, parasympathetic nervous system activity index, and sympathetic nervous system activity index. Parametric tests for independent series to compare the HRV parameters by subgroups within the study subjects were used. A multivariate linear regression analysis was conducted to evaluate the association between the HRV parameters and some personal and organizational factors. The comparison between different subgroups showed that activities with a high demand for concentration and precision, as is the case with paratroopers and dynamic precision shooters, differ significantly from activities that can be defined as routine, such as office work. Other activities, such as patrolling or remote management from operations centers, although including critical elements, did not deviate significantly from the control group. The study of HRV parameters is therefore a useful tool for occupational physicians, both for addressing work suitability assessments and for better targeting health promotion campaigns, to be considered as being aimed at monitoring the subject's physiological parameters, and not at the diagnosis of any pathological condition, which should always be carried out by the medical specialist.

Keywords Heart rate variability, Cardiac impulse, Modulation factor, Patrol and platoon training

1. Introduction

Heart rate variability (HRV) is a simple, non-invasive, analyzable in real time, and highly reproducible measure that represents a significant indicator for assessing health and physical condition. HRV, detecting the oscillations in the interval between consecutive instant heartbeats or between the peak R of one beat and the next (RR interval) in the QRS complex, reflects the action that the two main components of the autonomic nervous system, sympathetic and parasympathetic, play on the sinoatrial node, the point of origin of the cardiac impulse, innervating it with numerous fibers coming in part from the thoracic nerves and in part from the vagus nerve (the tenth cranial nerve, also known as pneumogastric nerve), and acting as a modulation factor of the physiological processes of the human body both in both normal and pathological cases.

Measurement of HRV can be conducted, reliant on research interest and depending on the capabilities of the device used for recording, from half a minute (short-term) up to 24 h, in compliance with the dictates of the guidelines by the European Society of Cardiology (ESC) and by the North American Society of Electrophysiological Stimulation (NASPE). The measures and indicators used today are numerous [1] determined by three types of analysis: two linear, located in the time or frequency domain, and a non-linear one, based on the analysis of fractals (chaos theory), now increasingly used in the field of cardiological diagnosis.

HRV analysis consists of a series of measurements influenced by numerous factors such as age, posture, state of fatigue, and occupational factors such as stress, night shift work, and highly demanding psychophysical tasks. Changes in HRV can be examined under various conditions, such as

when asleep or awake, during physical exertion or relaxation, and even under a pathological condition as an indication of overall autonomic nervous system efficiency, and is therefore an indicator of general health. To date, a shortage of studies has assessed these changes during real working scenarios, especially in those job tasks known to require high psychophysical performance, as is the case with public security officers. Although many authors have studied HRV, few studies are currently available in the literature on HRV assessment in active-duty military personnel.

Public security activity can determine an occupational exposure to various factors, known to influence autonomic cardiovascular response to a variety of stimuli, such as night shifts, highly physically demanding activity, and acute stress activity (i.e., emergency call management and highly demanding training activity). The 1st "Tuscania" Carabinieri Paratrooper Regiment is one of the flagship units of the Carabinieri. It is part of the Special Crowning Operation Units (COOS TIER 3) of the Italian Special Forces. All of the staff in the department are authorized to skydive. This high-profile department has always carried out the typical, characteristic tasks of parachuting troops throughout its history. It has a staff of barely 500 men of various ranks. Regiment candidates, of all ranks, are previously subjected to psychophysical selection, aimed at ascertaining their aptitude for particular employment, and subsequently admitted to a training course, which lasts approximately nine months and includes the following:

- parachuting course;
- patrol and platoon training;
- individual and collective training in the use of weapons.

All operators of the Special Intervention Group (GIS) must pass through the 1st "Tuscania" Carabinieri Paratrooper Regiment. They are volunteers, with an age not exceeding 30 years and with an excellent disciplinary record. The selective tests to access the GIS are very demanding and also consist of medical visits and psycho-aptitude assessments aimed at ascertaining operational capacity in situations of high physical and psychological stress. The objective pursued by this intensive training is the use of a particularly selected element, deeply motivated and capable of distinguishing itself by technique, lucidity, and balance, especially in coordinated activities for special operations. Apart from special periodical training activity, the personnel are involved in all of the typical tasks of public security, e.g., emergency call response, night patrol activity, and coordination activities from operations centers. [2]

2. Materials and Methods

One hundred and twelve military, aged 25–59, also employed as public were enrolled in the study in the period between March and December 2019. The workers were engaged in several job tasks, divided into six different subgroups: paratroopers (PT), night shift police station officers (NSS), night shift patrol (NSP), dynamic precision shooting evaluative team (SET), and dynamic precision shooting non-evaluative team (NET), differentiated by the evaluation of the shooting test necessary for the ratification of access to the special corps. The last subgroup was represented by office clerks, used as control group (CG).

Each member of every group must maintain proficiency in different tasks, such as marksmanship and public security interventions, including specialized training and experience in performing discrimination tasks in high-threat environments.

Subjects were selected randomly to reduce the possibility of bias in self-selection, and participation was on a voluntary basis. All workers were recruited for their own particular tasks to the last control of health surveillance. This study was carried out during the Health Surveillance periodical controls according to Italian Legislative Decree 81/2008. All participants agreed to the processing of their personal data and understood that this information was categorized as "sensitive data" and treated in an anonymous and collective way, with scientific methods and for scientific purposes in accordance with the principles of the Declaration of Helsinki [8]. Having received exhaustive information on the study protocol, all participants gave their signed informed consent.

The response rate was 93%, due to refusal to undergo the measurement by six subjects, who were therefore excluded from the study.

For inclusion in the study, a questionnaire investigating anthropometric parameters, such as age, height, weight, and clinical history, including smoking habits, previous illnesses, ongoing medication, and physical activity, was administered to all workers by the occupational medicine physician and barracks nursing staff.

Any previous or current cardiovascular disease, such as recent myocardial infarction, angina pectoris, and ventricular tachycardia, atrial fibrillation, bearers of an implantable defibrillator, and other comorbidities such as decompensated diabetes with organ damage, were adopted as exclusion criteria, as well as a percentage of artefacts greater than 5% of the registration. Only one of the enrolled subjects was excluded due to exclusion criteria (heart disease). [3]

The measurements and analysis were therefore carried out on a final sample of 105 subjects, distributed as follows in the six subgroups: PT, n = 22; NSS, n = 16; NSP, n = 19; SET, n = 15; NET, n = 17; CG, n = 15. No participants were excluded for excessive signal artefacts in the physiological data, or for technical issues, such as those arising from excessive physical motion, weapon use, or experimental failure (i.e., battery drain or insufficient adhesion of the sensors to the subject's skin).

Every participant, in order to avoid any possible acute effect, did not smoke or drink coffee in the four hours prior to the start of registration; however, we considered smoking as a dichotomic variable, taking into account also its widely studied and known chronic effect. [4]

In order to collect the cardiovascular parameters throughout the study, the participants wore a device, snapped onto an adjustable on-board skin conductive electrode belt, i.e., the Zephyr BioHarness 3.0 (Zephyr Technology Corporation,

Annapolis, MD, USA—a division of Medtronic—Figure 1) capable of real-time and long-distance recording of various physiological parameters for up to 500 h, for a paltry weight of 89 g (belt 71 g and sensor 18 g). It captures a range of physiological information, such as heart rate (range: 0–240 ± 1 BPM), respiration (range: 0–120 ± 1 BPM), body temperature (range: 10–60 ± 2℃), movement (±180° thanks to an accelerometer on three axes, 16 g with a frequency of 100 Hz), one-lead electrocardiography (ECG) (frequency: 250 Hz) and, thanks to its on-board calculation algorithms, the estimated VO2max; our analysis focused only on the HRV. In a recent systematic review, Nazari claimed that the Zephyr BioHarness 3.0 device can provide reliable and valid measurements of heart rate across multiple contexts, and that it displayed good agreements with gold standard measurements, as also reported in previous validation studies. [5]
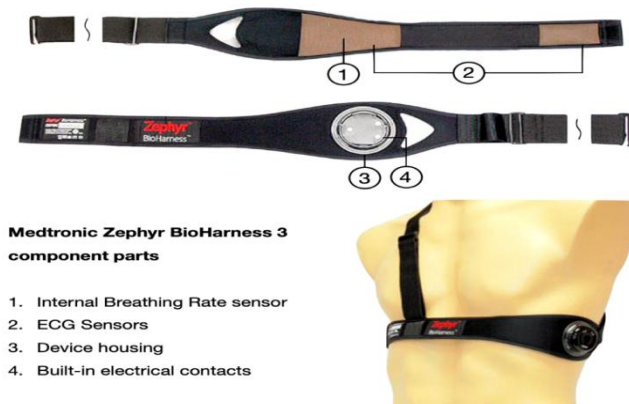

Figure 1

HRV indices represent a valid tool for the occupational physician to assess cardiac response to various occupational factors known to affect physical and psychological health, especially when acting with some modifiable and non-modifiable risk factors such as being overweight, smoking, physical inactivity, and increasing age. In addition, HRV assessment can represent a useful tool in the health monitoring of specific groups of workers, such as those engaged in special force activities or in specific training campaigns, such as parachuting and dynamic precision shooting.

The study of HRV parameters is thus a useful tool for occupational physicians, both for addressing work suitability assessments and also for filling in some lacunae such as return to work issues, i.e., after a long absence due to injury or illness, to be considered as being aimed at monitoring the subject's physiological parameters, and not at the diagnosis of any pathological condition, which should always be the task of medical specialists. [6]

Our findings have highlighted how highly demanding work activities can influence autonomic cardiac regulation and, therefore, also the cardiovascular health of workers and their ability to cope with stressful conditions. [7]

Our findings further demonstrate that tracking HRV may represent a powerful tool to motivate behavioral and lifestyle changes, which is thus far not available, even for excessive costs in past decades, to occupational physicians in the management of fitness for work—military personnel in this case—or for collecting information on vital signs during certain physical activities, such as parachuting or shooting tests. Thanks to the results obtained herein, we can assert that, although we believe it is always necessary to expand the case series under study, the evaluation of HRV parameters can be implemented in health surveillance protocols prior to the assignment of a worker to a specific highly demanding task or work activity.

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