Journal of Physical Education and Sport ® (JPES), Vol. 24 (issue 9), Art 232, pp. 1090 - 1098, September 2024
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Higher body mass index influences ambulatory blood pressure in police officers

FABIULA ISOTON NOVELLI[1], JAQUELINE ALVES ARAÚJO[2], PATRÍCIA MARINA SILVA SANTOS[3], SUSANE TAMANH[4], DÉBORA ANDREA CASTIGLIONI ALVES [5], LUCIELI TERESA CAMBRI [6]*
[1,2,3,4,5,6] Graduate Program in Physical Education, Federal University of Mato Grosso, Cuiabá, BRAZIL
[1] Medicine Department, Graduate Program in Sciences, University of São Paulo, São Paulo, BRAZIL
[2]Graduate Program in Health Sciences, Federal University of Mato Grosso, Cuiabá, BRAZIL

Published online: September 30, 2024
Accepted for publication: September 15, 2024
DOI:10.7752/jpes.2024.09232

Abstract
Introduction: High periods of sedentary behavior characterize most police duties. In addition, the profession is highly stressful and exposes policemen to higher adverse health outcome risks, such as obesity and hypertension. **Purpose**: This study aimed to analyze the imapct of higher body mass index (BMI) on ambulatory BP and heart rate variability (HRV) and, to examine the correlation between obesity indicators, lipid profile, ambulatory BP and HRV in police officers. **Methods**: Operational police officers (n= 38) were categorized into BMI: lower ($\leq$ 26.47 kg·m^{-2}) and higher (> 26.47 kg·m^{-2})). Clinical and ambulatory (24h, awake and asleep) BP, and HRV indices were assessed. **Results**: Officers with higher BMI group exhibited higher clinical systolic (SBP) and diastolic BP (DBP) compared to those with lower BMI. Similarly, the higher BMI showed higher ($p < 0.05$) values of 24h (71 ±7 *vs* 66 ± 6 mmHg), awake (73 ± 7 *vs* 68 ± 6) and asleep (64 ± 9 *vs* 58 ± 8) DBP compared to the lower BMI group, without impairment ambulatory HRV indices. Moreover, this group also attained less distance in 12-min running test (2,305.26 ± 236.22 *vs* 2,486.47 ± 222.72; p = 0.02) and VO_{2max} (40.25 ± 5.28 *vs* 44.36 ± 4.97 mL·kg^{-1}·min^{-1}; p = 0.02). Abdominal circumference correlated significantly with ambulatory BP (r = 0.35 to 0.49). Triglycerides (Rho/r = – 0.31 to – 0.33) and total cholesterol (Rho/r = – 0.37 to – 0.42) correlated significantly with ambulatory SDNN. Besides, triglycerides correlated significantly to awake and asleep (r/Rho = 0.34 and 0.38) DBP. **Conclusion**: Police officers with higher BMI showed higher ambulatory DBP, without evidence of cardiac autonomic modulation impairment. Obesity indicators correlated with ambulatory BP, while the lipid profile correlated with ambulatory DBP and HRV.
Key-words: abdominal circumference, ambulatory heart rate variability, diastolic blood pressure, obesity, policemen.

Introduction

High periods of sedentary behavior (e.g., patrolling vehicles and filling out police reports) (Plat et al., 2011) characterize most police duties. On the other hand, operational policing it is a dynamic and risky task that can cause a sudden increase in the physiological load to the body (Kales et al., 2009). Moreover, long working hours and sleep deprivation due to shift work makes this profession highly stressful and exposes them to higher adverse health outcome risks, such as obesity and hypertension (Braga Filho & D'Oliveira Junior, 2014; Violanti et al., 2009).

Obesity is a chronic and multifactor disease that can trigger cardiac autonomic and hemodynamic impairment (Kotsis et al., 2005). Parasympathetic reduction and sympathetic modulation increment can lead to blood pressure (BP) increment and, with this, cardiovascular disease development (Kotsis et al., 2010). Besides this, the pre-hypertension and stage 1 prevalence are 2.82 and 2.65 times higher, respectively, in individuals with overweight/obesity than normal-weight individuals (Dua et al., 2014). Studies with police officers have reported high obesity (Braga Filho & D'Oliveira Junior, 2014; Santos et al., 2021), hypertension (Franke et al., 2002; Kales et al., 2009), and greater chances of increased cholesterol and developing metabolic syndrome (Hartley et al., 2011), and consequently, greater incidence of cardiovascular disease than the general population (Wright et al., 2011). In a recent study, operational police officers were shown to have higher clinical systolic BP (SBP) than administrative police officers (Santos et al., 2021).

BP and cardiac autonomic modulation (measured by heart rate variability – HRV) evaluation can be evaluated through both clinical (short time) and ambulatory (long time) measures. The clinical measurements allow a punctual identification of the parameters for a small fraction of the whole day. On the other hand, the ambulatory measurements allow evaluation at different times of the day, including when performing daily activities and during the sleep period (McNarry & Lewis, 2012), which is considered relevant in cardiovascular risk prevention and stratification (Turner et al., 2015). The unfavorable cardiovascular prognosis of ambulatory BP may be related to subclinical cardiac damage. The isolated

Corresponding Author: LUCIELI TERESA CAMBRI, E-mail: lucambri@yahoo.com.br

elevated ambulatory BP (normal office and elevated out-of-office BP) has been associated to an increased risk of left ventricular structural alterations compared to true normotensive individuals (Cuspidi et al., 2015). A study with police officers verified that the occupational exposure to urban pollutants, a characteristic of operational police work, can increase over periods of 24h, or awake or asleep periods for both SBP and diastolic BP (DBP) (Tomei et al., 2004).

Few studies (Andrew et al., 2013; Charles et al., 2014; Santos et al., 2021) had evaluated cardiac autonomic modulation in police officers, with the impairment of clinical parasympathetic modulation identified by high BMI, hypertension, metabolic syndrome and, low physical activity (Charles et al., 2014). Obesity indicators were higher, and VO2max and HRV indices were lower in the less aerobic fit police group (Santos et al., 2021). On the other hand, lower central adiposity and higher physical activity have been shown to predict better parasympathetic modulation (Andrew et al., 2013). As far as we knew, only one study has evaluated ambulatory cardiac autonomic modulation in police officers, and it was observed that the police officers not adapted to night shifts showed higher sleep sympathetic modulation compared to those police officers who were accustomed to night shift work (Boudreau et al., 2013). Nevertheless, to our knowledge, there is no information about BMI's influence on ambulatory BP and HRV in operational police officers. The 24 h analysis investigates the effects of body weight excess, under real-life conditions. This information could enable adequate management of body mass excess and a consequent reduction in cardiovascular risk associated with hypertension and autonomic dysfunction in police officers.

So, the aim of this study was to analyze the effect of higher BMI on ambulatory BP and HRV in operational police officers and to verify the correlation between obesity indicators and lipid profile with ambulatory BP and, HRV. We hypothesized that police officers with higher BMI would show higher ambulatory BP and impaired HRV compared those with lower BMI.

Methods

Participants

A total of 85 operational police officers had been evaluated in a previous study about clinical measurements (Santos et al., 2021). Of these, a total of thirty-eight operational policemen (32.90 ± 6.03 years, 83.03 ± 9.11 kg, 26.80 ± 3.03 kg·m^{-2}, 26.00 ± 5.05 % of body fat), shift workers (24h/72h), performed all ambulatory assessments. The exclusion criteria were: not belonging to the institution's management, time in service < 2 years, morbid obesity (BMI ≥ 40 kg·m^{-2}), pre-existing disease (i.e. hypertension, diabetes mellitus, dyslipidemia, hyper/hypothyroidism), smoking, illicit drugs or medication consumption which could interfere in the evaluated variables, and osteoarticular problems that could make the physical exercise impossible to perform. The police officers were divided based by median body mass index (BMI), into a lower (≤ 26.47 kg·m^{-2}) and a higher (> 26.47 kg·m^{-2}) BMI group.

Three non-consecutive, morning visits (6:30 a.m. - 12:00 p.m.) were performed for clinical/ambulatory measures, blood sample collection, and a 12-min running test, with a 72h washout period. The participants were oriented to eat their last meal 1h before, not to perform physical exercise, not to drink stimulants (energetic, soda, coffee, etc) or alcoholic beverages 24h before the clinical/ambulatory measures, and 12-min running test and 12h fasting in the blood collection visit.

This study was approved by the Human Research Institutional Ethics Committee (CAAE 83903318.7.0000.8124) of Federal University of Mato Grosso, and it was performed following the ethical guidelines outlined in the Declaration of Helsinki. All the participants were informed of the study procedures and risks, and signed an informed consent form.

Anthropometric measures and body composition

Anamnesis, international physical activity questionnaire (IPAQ) (Committee IR, 2005) and body composition measurements: body mass (CAMRY balance, Brazil) and height (SANNY stadiometer, 0.1 cm, Brazil) to determine the BMI, and abdominal circumference (AC) (Cardiomed tape measure, 0.1 cm, Brazil), were performed. The percentage (%) of body fat was determined by bioimpedance (OMRON HBF-510W), according to the manufacturer's instruction. The participants were instructed not to drink anything and to empty their bladder 30 min before the evaluation.

Clinical/ambulatory blood pressure and heart rate variability

Clinic HR and HRV indices were evaluated during 15 min, with the participant seated on an upholstered chair. Right after, two BP (Microlife BP3T0-A) measurements at an interval of two minutes were performed. Whenever more than a 5-mmHg difference between the readings was found, an additional measurement was taken, and the average between two readings with the closest values was used (Pickering et al., 2005). The police officers with clinical SBP ≥ 130 and/or DBP ≥ 85 mmHg values were assified as high BP (Pickering et al., 2005).

Following that, an Ambulatory BP Monitor (ABPM) and a Holter monitor (CardioMapa, Cardios, Brazil; a sampling frequency of 800 Hz), were placed on each participant. The ABPM was placed on the participants' non-dominant arm. The Holter monitor was placed by fixing electrodes using four precordial derivations on specific points on the trunk, according to the manufacturer's instructions.

The police officers were instructed not to take off/turn off the equipment until the end of 24 h recording, not to take shower, not to adopt prone position while sleeping, and to put the monitor on the bed next to the head or chest, to maintain their normal daily activities, and to keep their arm relaxed and unmoving beside the body during the measurements.

The police officers had freedom to choose sleep and wake up times, always standardizing at 8 h of sleep. All police officers received a diary to record their daily schedule of activities, unusual physical activity episodes, humor/emotional state, sleep time, and finally stress moments during the time when wearing the equipment (Pickering et al., 2005). The equipment was defined for the so-called "blind function", to not show BP readings to the user after the measurement.

Blood collection

After 12 h fasting, a venous blood sample through the antecubital vein was obtained, to evaluate basic biochemical parameters, such as glucose, total cholesterol and triglycerides. The serum parameters were carried out using specific reagent kits (BIOCLIN, Brazil) for each analyte. Absorbance was determined on the microplate reader (KHB ST-360®, Japan).

12-min running test

The 12-min running test were performed on a 400 m track, looking for the longest distance covered (walking or running) in 12 min. The aerobic fitness was determined by the distance covered (m). The predicted maximal oxygen uptake (VO_{2max}), was estimated according to the following equation: VO_{2max}= (distance performed in meters - 504,9)/44,73 (Cooper, 1968).

Data analysis

During the last 10 min of rest, the clinical HRV data were recorded using a portable HR monitor (Polar, model RS800CX, Kempele, Finland) with beat-by-beat records, using RR intervals (RRi), analyzed through the Kubios HRV program (Kubios Oy, Version 3.2, Biosignal Analysis and Medical Imaging Group, Kuopio, Finland). Initially, a visual data inspection was realized, and the artifacts filtered at a moderate level. The percentage of error observed was less than 2 % (0.30 ± 0.51 %). Data acquired with a noninvasive HR monitor have been shown to have good reproducibility (Novelli et al., 2019).

Ambulatory SBP and DBP were measured for 24 h, every 15 min during awake time and every 30 min during asleep time. The police officers with SBP $\geq$ 135, 130 or 120, and/or DBP $\geq$ 85, 80 or 70 mmHg for awake, 24 h, and sleep values, respectively, were considered hypertensive (Unger et al., 2020). Ambulatory BP measures presented a mean of > 80 % valid data.

The HRV ambulatory data were recorded by Holter equipment, programmed to continuously measure RRi. The HR and HRV indices were analyzed by CardioSmart 540CS software (Cardios, Brazil – 800 pulse per second, with a resolution of 12bits) in the time domain: linear time-domain, the root mean square of successive RR differences (RMSSD); the SD of normal-to-normal RRi (SDNN) and frequency domain (by the Fast Fourier Transform method): HF (high-frequency component, varying from 0.15 to 0.4 Hz) in normalized units (n. u.); LF (low-frequency component, varying from 0.04 to 0.15 Hz) in normalized units (n. u.) (Task Force, 1996). For both analyses of BP and HRV, simple arithmetic averages for continuous segments of 24 h, awake and asleep period, were measured. The ambulatory HRV and BP presented acceptable reproducibility (Morrin et al., 2017). All police officers were evaluated by the same evaluator.

Statistical analysis

The Shapiro-Wilk and Levene's test were used to test data normality and homogeneity, respectively. Data were expressed as mean, standard deviation, minimum and maximum. To compare obesity indicators, the biochemical profile, aerobic fitness, clinical and ambulatory BP and HRV indices between the groups (higher and lower BMI) independent (unpaired) Student's *t*-test and Mann-Whitney *U* test were used, to compare parametric and non-parametric data, respectively.

The effect size (ES) was calculated by the Cohen's equation, considering the following values for interpretation: small (< 0.5), moderate (≥ 0.5 and < 0.8), and large (≥ 0.8) (Cohen, 1988). Categorical variables were compared using the chi-square test. The obesity indicators (body mass, BMI, AC, and body fat), and lipid profile (triglycerides and total cholesterol) were correlated with 24h, awake and asleep BP, and HRV, by Pearson and Spearman's Rank correlation, for parametric and non-parametric data, respectively. The significance level considered was 5 % ($p \leq 0.05$).

Results

As expected, the higher BMI group showed higher values of body mass, BMI, AC and, body fat percentage (Table 1). Moreover, this group also attained less distance in 12-min running test (2,305.26 ± 236.22 *vs* 2,486.47 ± 222.72; p = 0.02) and VO_{2max} (40.25 ± 5.28 *vs* 44.36 ± 4.97 $mL \cdot kg^{-1} \cdot min^{-1}$; p = 0.02). However, there were no differences between groups for glycemic or lipid profiles (Table 1).

Table 1. **Obesity indicators, physical activity, clinical blood pressure and cardiac autonomic modulation, and biochemical parameters**

	Lower BMI (n=19)	Higher BMI (n=19)	p	ES
Age (years)	31.73 ± 6.39	34.07 ± 5.56	0.24	0.39
Service time (years)*	9.15 ± 6.06	10.31 ± 5.90	0.47	0.19
Body mass (kg)	76.98 ± 6.52	89.08 ± 7.13	<0.01	1.77
Body mass index (kg·m^{-2})	24.45 ± 1.59	29.14 ± 2.19	<0.01	2.45
Abdominal circumference (cm)	84.58 ± 6.06	96.55 ± 4.78	<0.01	2.19
Body fat (%)	22.85 ± 4.38	29.15 ± 3.51	<0.01	1.58
Total METs (min·week^{-1})*	1,611.86 ± 1,438.11 (480/5,982)	**1,355.55 ± 2,131.05 (00.00/9,360)**	0.11	0.14
Systolic BP (mmHg)	119 ± 7	127 ± 10	0.02	0.81
Diastolic BP (mmHg)	75 ± 6	80 ± 8	0.04	0.70
Heart rate (bpm)	70 ± 7	68 ± =8	0.43	0.25
RMSSD (ms)*	35.98 ± 11.34 (17.50/53.63)	41.08 ± 19.01 (17.71/86.53)	0.84	0.32
SDNN(ms)*	40.55 ± 9.90 (25.00/57.51)	43.64 ± 14.72 (25.65/77.95)	0.82	0.24
HF (n. u.)	32.71 ± 13.07	36.43 ± 12.17	0.37	0.29
LF/HF*	2.71 ± 1.91 (0.76/8.25)	2.08 ± 1.15 (0.71/4.55)	0.49	0.39
Glucose (mg·dL^{-1})	84.84 ± 15.07	80.26 ± 4.38	0.30	0.39
Triglycerides (mg·dL^{-1})*	96.00 ± 58.84 (31.00/263.00)	123.31 ± 62.08 (53.00/296.00)	0.07	0.45
Total cholesterol (mg·dL^{-1})	161.10 ± 38.35	181.57 ± 43.89	0.13	0.49

BP: blood pressure; ES: Effect size. The data are presented as mean and standard deviation. * Mann Whitney U test for nonparametric data, with minimum, and maximum values.

The higher BMI group showed higher clinical SBP and DBP than the lower BMI group, moreover, 21 % ($p < 0.01$) of the participants in the higher group showed high BP values (≥ 130/85 mmHg). The higher BMI group did not show impairment in clinical HRV indices (Table 1). Similarly, to the clinical data, the higher BMI showed higher values of 24 h, awake and asleep DBP compared to the lower BMI group (Table 2). Moreover, 26.3, 15.8 and 31.1 % of the police officers in the higher BMI group showed high 24 h (≥ 130/80 mmHg), awake (≥ 135/85 mmHg) and, asleep (≥ 120/70 mmHg) BP, respectively, while 5.3, 5.3 and 21.1 % of the police officers in the lower BMI group showed high 24 h, awake and, asleep BP, respectively.

AC correlated significantly with both ambulatory (24h, awake and asleep) SBP ($r = 0.35$ to 0.38 – Figure 1A) and DBP ($r = 0.36$ to 0.49 – Figure 1B). Besides, body mass ($r = 0.31$ to 0.33) and BMI ($r = 0.32$ to 0.33) correlated to ambulatory SBP. Triglycerides (r/Rho = – 0.31 to – 0.33 – Figure 1C) and total cholesterol (r/Rho = – 0.37 to – 0.42 – Figure 1D) correlated significantly to ambulatory SDNN index. Besides, triglycerides correlated significantly to awake ($r = 0.34$) and asleep Rho = 0.38) DBP.

Table 2. **Ambulatory blood pressure and cardiac autonomic modulation**

	Lower BMI (n=19)	Higher BMI (n=19)	p	ES
	24h			
Systolic BP (mmHg)	119 ± 8	122 ± 9	0.21	0.41
Diastolic BP (mmHg)	66 ± 6	71 ± 7	**0.03**	0.71
Heart rate (bpm)	70 ± 7	71 ± 9	0.76	0.09
RMSSD (ms)*	44.75 ± 18.13 (23.13/76.67)	47.09 ± 25.65 (25.05/108.48)	0.95	0.10
SDNN (ms)*	99.10 ± 19.52 (66.33/133.71)	94.81 ± 28.32 (56.92/172.24)	0.28	0.17
HF (n. u.)	27.04 ± 9.01	29.04 ± 10.91	0.54	0.19
LF/HF*	4.64 ± 2.38 (1.90/10.15)	4.29 ± 2.26 (1.18/9.03)	0.56	0.14
	Awake			
Systolic BP (mmHg)	124 ± 8	121 ± 9	0.24	0.46
Diastolic BP (mmHg)	68 ± 6	73 ± 7	**0.03**	0.71
Heart rate (bpm)	74 ± 8	75 ± 9	0.82	0.07
RMSSD (ms)*	37.67 ± 16.33 (20.50/73.69)	39.93 ± 22.57 (19.64/92.60)	1.00	0.11
SDNN (ms) *	95.40 ± 17.64 (66.69/129.75)	91.66 ± 28.68 (57.50/175.71)	0.21	0.15
HF (n. u.)	22.28 ± 8.66	24.73 ± 10.48	0.44	0.25
LF/HF*	5.59 ± 2.96 (2.24/12.48)	5.04 ± 2.92 (1.25/11.91)	0.52	0.18
	Asleep			
Systolic BP (mmHg)	111 ± 10	116 ± 11	0.15	0.47
Diastolic BP (mmHg)*	58 ± 8 (40/68)	64 ± 9 (51/91)	**0.04**	0.64
Heart rate (bpm)*	62 ± 7 (52/75)	63 ± 9 (49/87)	0.78	0.09
RMSSD (ms)*	58.23 ± 24.10 (27.88/100.00)	64.21 ± 34.64 (24.71/138.25)	0.79	0.19
SDNN (ms)	106.56 ± 26.35	99.08 ± 34.84	0.46	0.24
HF (n. u.) *	35.93 ± 11.73 (13.28/55.50)	37.61 ± 15.26 (19.04/72.76)	0.77	0.12
LF/HF*	2.85 ± 1.63 (0.93/7.61)	2.85 ± 1.62 (0.40/5.49)	0.98	0.00

BP: blood pressure; ES: Effect size. The data are presented as mean and standard deviation. * Mann Whitney U test for nonparametric data, with minimum, and maximum values.

Discussion

The main findings of the present study suggest that the operational police officer's higher BMI negatively influenced ambulatory DBP, so the obesity indicators, mainly AC, was correlated to ambulatory BP, while the lipid profile correlated to ambulatory DBP and HRV.

The highlight of this study was demonstrate that higher BMI by itself was capable of increasing BP in operational police officers, confirming half of the present study hypothesis. BP and cardiac autonomic modulation assessment during 24 h are of great clinical relevance, helping in the cardiovascular risk stratification in asymptomatic individuals (Kleiger et al., 2005; Turner et al., 2015). It is worth highlighting, the operational police officers themselves had already shown higher values of clinic SBP compared to administrative police officers (Santos et al., 2021). Previous study has shown that the increase in one BMI unit resulted in an increase of 0.39 mmHg of DBP (An et al., 2020), and each score increased in the lifestyle risk category (smoking tobacco, alcohol, and coffee drinking) plus stress score (family and working stress), which increased 0.5 mmHg of DBP for police officers (An et al., 2020). As well as this, a meta-analysis has verified that each 5 mmHg increment for DBP resulted in a 4% increased risk of cardiovascular events, a 2% increased risk of coronary heart disease, a 3% increased risk of stroke, and a 2% increased risk of all-cause mortality (Luo et al., 2020). The high-normal BP stratum accounted for 16.9 and 15.8% of deaths from cardiovascular and coronary heart diseases, respectively, compared with normal BP individuals (Miura et al., 2001). In the same way, there was a 19 and 35% increased risk of cardiovascular events for normal BP (120-129/80-84 mmHg) and high-normal BP (130-139 and 85-89 mmHg), respectively, in comparison to optimal BP (< 120/80 mmHg) in of adults aged 18-45 (Luo et al., 2020). In a cohort study, higher 24 h and higher night-time BP, compared with clinical or day-time BP, were associated with greater risk of all-cause mortality and cardiovascular outcomes (Yang et al., 2019). Operational tasks can trigger increasing cardiovascular events in susceptible police officers (e.g., overweight, hyperglycemia, dyslipidemia). Recently, a study (Varvarigou et al., 2014) demonstrated that stressful, emergency, and physically demanding law enforcement activities were associated with higher cardiac sudden death risk compared to other police activities. In addition, urban pollutants and shift work (sleep disruption/deprivation) is occupational factor likely to contribute to increased cardiovascular disease risk among emergency responders (Kales et al., 2009). In this regard, higher 24 h, awake and asleep BP were observed in police officers exposed to urban pollutants (Tomei et al., 2004), and higher clinic DBP was found in the maladapted work shift police officers (Nevels et al., 2021). Additionally, a prospective cohort study has shown that poor sleep quality is a risk factor for hypertension in police officers (Ma et al., 2020).

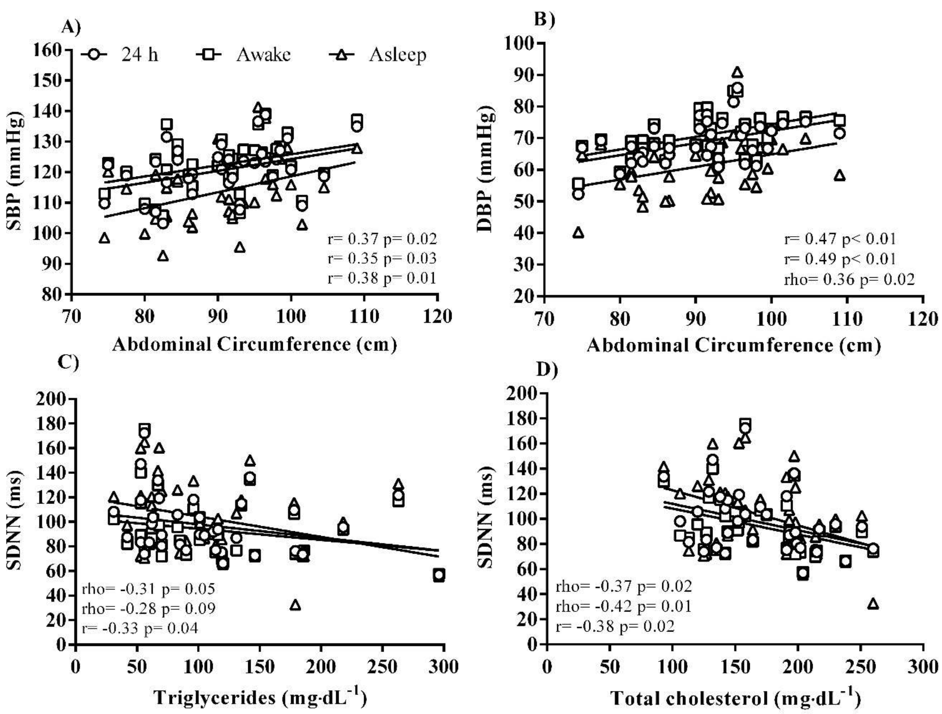

Figure 1: Correlation coefficients (*Rho/r*) of abdominal circumference with ambulatory (24h, awake and asleep) Systolic Blood Pressure - SBP (A), and Diastolic BP- DBP (B); and lipid profile (triglycerides – C – and total cholesterol – D) with the SDNN index

The mechanisms by which body mass excess changes BP have not been fully elucidated. However, the literature has considered some factors such as adipose tissue interaction (cytokines and adipokines), neuro-humoral pathway (autonomic nervous system, insulin, ghrelin, and leptin), circulating metabolites (free fatty acids and glucose), and modulation of vasodilator and vasoconstrictor mediators (nitric oxide, endothelin, and angiotensin) (Kotsis et al., 2010). As well, perceived stress, and plasma 8-iso-PGF2α levels (an oxidative stress marker) have been shown to affect the prevalence of hypertension in men, which may indicate a complex mechanism promoting the development of hypertension in occupational groups, such as the police (Janczura et al., 2021). A previous study (Charles et al., 2016) verified declines in endothelial function among policemen who worked afternoon or night shifts. In addition, three sequential night shifts deteriorated endothelial function through decreased nitric oxide production in healthy nurses (Kim et al., 2011). Another study (Violanti et al., 2018) suggested that an atypical or flatter waking cortisol pattern predicted a worsening of flow-mediated dilation percentage during a seven-year follow-up among police officers, highlighting that work shifts can negatively influence the endothelium function and, consequently, BP.

Only a few studies (Andrew et al., 2013; Charles et al., 2014; Santos et al., 2021) have evaluated cardiac autonomic modulation in police officers. Impairment of clinical parasympathetic modulation has been observed in police officers with high BMI, hypertension, metabolic syndrome and low physical activity (Charles et al., 2014). However, only a higher BMI was recorded in police officers of our study. So, it is noteworthy that isolated obesity seems not to influence clinical (Araujo et al., 2019; Tricot et al., 2021) and ambulatory cardiac autonomic modulation in obese adults (Dias et al., 2021; Tricot et al., 2021). Studies (Oliveira et al., 2020; Skrapari et al., 2007) that observed cardiac autonomic modulation impairment have shown other factors, such as severe obesity stages, older participants and, metabolic alterations (i. e. glycemia, and lipid profile). Therefore, the fact that police officers with higher BMI did not show cardiac autonomic modulation impairment was probably due to the lack of metabolic alterations, in particular their lipid profile and age, with few (~36 %) obese participants, all of them in stage 1. There were significant correlations between ambulatory HRV indices and, lipid profile, but no with obesity indicators. The average age (~ 32 years old) of participants in our study was lower than in others with police officers (~ 40 years old) (Andrew et al., 2013; Charles et al., 2014). However, we can suggest that due to higher obesity indicators, BP values, and lower aerobic fitness, these police officers, probably, might experience cardiac autonomic modulation impairment during aging. As far as we know only one study (Boudreau et al., 2013) evaluated ambulatory cardiac autonomic modulation with police officers, however did not consider the BMI. There was a trend for the HF power to be increased, and the LF/HF ratio decreased in the police officers accustomed to shift work, compared to non-adapted police officers (Boudreau et al., 2013). This study highlights the fact that operational police officer activity, performed in shifts, can disturb the circadian rhythm, decrease sleep quality/quantity (Boudreau et al., 2013), and is an additional source of chronic stress.

In addition, other factors those contribute to higher BP and, consequently to cardiovascular disease development in this population such as, lack of regular physical exercise, unbalanced eating habits (sometimes due to limited food choices during work), noise exposure, and post-traumatic stress disorder (Kales et al., 2009).

The operational police officers of our study performed systematized physical training (aerobic and dynamic exercise) for 60 min, plus 60 min of general police activities training, two days a week. This seems to have been insufficient to keep obesity indicators at acceptable levels, since 72.50 % of the participants were overweight or obese men. This indicates that, from a practical point of view, lifestyle changes, aiming to increase aerobic fitness levels, energy expenditure, and consequently, reducing body fat, can improve BP. In overweight adults with high-normal BP, weight loss and/or reduction in sodium intake were effective in lowering BP, mainly in the short-term, with reductions in hypertension incidence over time (Group, 1997). On the other hand, a 2-mm Hg decrease in DBP would result in a 17% decrease in the prevalence of hypertension as well as a 15% reduction in risk of stroke and transient ischemic attacks and a 6% reduction in the risk of coronary heart disease (Cook et al., 1995). One meta-analysis showed that ABPM predicted long-term cardiovascular outcomes independently of clinical BP. In addition, there was at least a 2-fold higher incidence of hypertension up to 6 years after rescreening, those with high-normal BP, overweight and obese persons (Piper et al., 2015). Given that the health of police officer's can reflect on their service performance, this is a relevant public health problem.

The present study has several limitations: 1) We did not evaluate sleep quality, psychological stress, eating habits, individual chronotypes, or adaptation to shift work. 2) We did not evaluate other biochemical, inflammatory, or oxidative stress parameters. 3) Because this is a transversal study, we cannot confirm if these police officers would have cardiac autonomic modulation impairment during aging as expected.

Conclusion

In summary, higher BMI operational police officers presented higher ambulatory DBP but no ambulatory cardiac autonomic modulation impairment. Besides this, obesity indicators, especially AC, were correlated to ambulatory BP, while, lipid profile correlated to ambulatory DBP and HRV.

We encourage ambulatory BP and HRV measurements, besides glycemic and lipid profiles as a part of routine health checks, mainly for police officers with overweight/obesity, to screen for hypertension and autonomic dysfunction early. Moreover, physical training programs, are needed to officer obesity, dyslipidemia, hypertension, and cardiac autonomic dysfunction risks are to be reduced. The police officer's health should be a concern of the police institution and can impact service performance. Further studies on the impact of aerobic fitness or physical activity on ambulatory BP and HRV, and metabolic profile could represent an interesting strategy for the prevention of hypertension and autonomic dysfunction in this specific group.

Acknowledgements
The English text of this paper has been revised by Sidney Pratt, Canadian, MAT (The Johns Hopkins University), RSAdip - TESL (Cambridge University).
Funding
This work was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES under Grant [Finance Code 001]. The biochemical reagents were donated by Quibasa-Bioclin.
Competing interests The authors declare no competing interests.

References

An, D. T. M., Hoat, L. N., Son, D. T., Toan, D. T., Minh, L. N., Mai, P. V., & Minh, H. V. (2020). Multilevel Analysis of 24-Hour Blood Pressure, Heart Rate, and Associated Factors among Police Officers in Hanoi, Vietnam. *Biomed Research International*, *2020*, 7494906. https://doi.org/10.1155/2020/7494906

Andrew, M. E., Shengqiao, L., Wactawski-Wende, J., Dorn, J. P., Mnatsakanova, A., Charles, L. E., Fekedulegn, D., Miller, D. B., Violanti, J. M., Burchfiel, C. M., & Sharp, D. S. (2013). Adiposity, muscle, and physical activity: predictors of perturbations in heart rate variability. *American Journal of Human Biology*, *25*(3), 370-377. https://doi.org/10.1002/ajhb.22379

Araujo, J. A., Queiroz, M. G., Dias, A. R. L., Sousa, L., Arsa, G., & Cambri, L. T. (2019). Isolated Obesity Is Not Enough to Impair Cardiac Autonomic Modulation in Metabolically Healthy Men. *Research Quarterly for Exercise and Sport*, *90*(1), 14-23. https://doi.org/10.1080/02701367.2018.1549357

Boudreau, P., Dumont, G. A., & Boivin, D. B. (2013). Circadian adaptation to night shift work influences sleep, performance, mood and the autonomic modulation of the heart. *PLoS One*, *8*(7), e70813. https://doi.org/10.1371/journal.pone.0070813

Braga Filho, R. T., & D'Oliveira Junior, A. (2014). Metabolic syndrome and military policemen's quality of life: an interdisciplinary comprehensive approach. *American Journal of Men's Health*, *8*(6), 503-509. https://doi.org/10.1177/1557988314526750

Charles, L. E., Andrew, M. E., Sarkisian, K., Shengqiao, L., Mnatsakanova, A., Violanti, J. M., Wilson, M., Gu, J. K., Miller, D. B., & Burchfiel, C. M. (2014). Associations between insulin and heart rate variability in police officers. *American Journal of Human Biology*, *26*(1), 56-63. https://doi.org/10.1002/ajhb.22475

Charles, L. E., Zhao, S., Fekedulegn, D., Violanti, J. M., Andrew, M. E., & Burchfiel, C. M. (2016). Shiftwork and decline in endothelial function among police officers. *American Journal of Industrial Medicine*, *59*(11), 1001-1008. https://doi.org/10.1002/ajim.22611

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. In L. E. Associates (Ed.), (2nd ed.).

Committee IR. (2005). *Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ)-Short and Long Forms*. Retrieved 23 August from http://www.ipaq ki se/scoring pdf

Cook, N. R., Cohen, J., Hebert, P. R., Taylor, J. O., & Hennekens, C. H. (1995). Implications of small reductions in diastolic blood pressure for primary prevention. *Archives of Internal Medicine*, *155*(7), 701-709. http://www.ncbi.nlm.nih.gov/pubmed/7695458

Cooper, K. H. (1968). A means of assessing maximal oxygen intake: correlation between field and treadmill testing. *The Journal of the American Medical Association*, *203*(3), 201-204.

Cuspidi, C., Sala, C., Tadic, M., Rescaldani, M., Grassi, G., & Mancia, G. (2015). Untreated Masked Hypertension and Subclinical Cardiac Damage: A Systematic Review and Meta-analysis. *American Journal of Hypertension*, *28*(6), 806-813. https://doi.org/10.1093/ajh/hpu231

Dias, A. R. L., de Souza, K. A., Dos Santos, K. M., Pecanha, T., Ferreira, J. C., Cambri, L. T., & Arsa, G. (2021). Acute Exercise Increases the Ambulatory Cardiac Modulation of Young Men With Overweight/Obesity. *Research Quarterly for Exercise and Sport*, *92*(4), 796-804. https://doi.org/10.1080/02701367.2020.1786488

Dua, S., Bhuker, M., Sharma, P., Dhall, M., & Kapoor, S. (2014). Body mass index relates to blood pressure among adults. *North American Journal of Medicine and Science*, *6*(2), 89-95. https://doi.org/10.4103/1947-2714.127751

Franke, W. D., Ramey, S. L., & Shelley, M. C., 2nd. (2002). Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *Journal of Occupational and Environmental Medicine*, *44*(12), 1182-1189. https://doi.org/10.1097/00043764-200212000-00014

Group, T. T. o. H. P. C. R. (1997). Effects of weight loss and sodium reduction intervention on blood pressure and hypertension incidence in overweight people with high-normal blood pressure. The Trials of Hypertension Prevention, phase II. The Trials of Hypertension Prevention Collaborative Research Group. *The Archives of Internal Medicine*, *157*(6), 657-667. https://doi.org/10.1001/archinte.1997.00440270105009

Hartley, T. A., Burchfiel, C. M., Fekedulegn, D., Andrew, M. E., & Violanti, J. M. (2011). Health disparities in police officers: comparisons to the U.S. general population. *International Journal of Emergency Mental Health*, *13*(4), 211-220. http://www.ncbi.nlm.nih.gov/pubmed/22900455

Janczura, M., Rosa, R., Dropinski, J., Gielicz, A., Stanisz, A., Kotula-Horowitz, K., & Domagala, T. (2021). The Associations of Perceived and Oxidative Stress with Hypertension in a Cohort of Police Officers. *Diabetes, Metabolic Syndrome and Obesity*, *14*, 1783-1797. https://doi.org/10.2147/DMSO.S298596

Kales, S. N., Tsismenakis, A. J., Zhang, C., & Soteriades, E. S. (2009). Blood pressure in firefighters, police officers, and other emergency responders. *American Journal of Hypertension*, *22*(1), 11-20. https://doi.org/10.1038/ajh.2008.296

Kim, W., Park, H. H., Park, C. S., Cho, E. K., Kang, W. Y., Lee, E. S., & Kim, W. (2011). Impaired endothelial function in medical personnel working sequential night shifts. *International Journal of Cardiology*, *151*(3), 377-378. https://doi.org/10.1016/j.ijcard.2011.06.109

Kleiger, R. E., Stein, P. K., & Bigger, J. T., Jr. (2005). Heart rate variability: measurement and clinical utility. *Annals of Noninvasive Electrocardiology*, *10*(1), 88-101. https://doi.org/10.1111/j.1542-474X.2005.10101.x

Kotsis, V., Stabouli, S., Bouldin, M., Low, A., Toumanidis, S., & Zakopoulos, N. (2005). Impact of obesity on 24-hour ambulatory blood pressure and hypertension. *Hypertension*, *45*(4), 602-607. https://doi.org/10.1161/01.HYP.0000158261.86674.8e

Kotsis, V., Stabouli, S., Papakatsika, S., Rizos, Z., & Parati, G. (2010). Mechanisms of obesity-induced hypertension. *Hypertension Research*, *33*(5), 386-393. https://doi.org/10.1038/hr.2010.9

Luo, D., Cheng, Y., Zhang, H., Ba, M., Chen, P., Li, H., Chen, K., Sha, W., Zhang, C., & Chen, H. (2020). Association between high blood pressure and long term cardiovascular events in young adults: systematic review and meta-analysis. *British Medical Journal*, *370*, m3222. https://doi.org/10.1136/bmj.m3222

Ma, C. C., Gu, J. K., Bhandari, R., Charles, L. E., Violanti, J. M., Fekedulegn, D., & Andrew, M. E. (2020). Associations of objectively measured sleep characteristics and incident hypertension among police officers: The role of obesity. *Journal of Sleep Research*, *29*(6), e12988. https://doi.org/10.1111/jsr.12988

McNarry, M. A., & Lewis, M. J. (2012). Interaction between age and aerobic fitness in determining heart rate dynamics. *Physiological Measurement*, *33*(6), 901-914. https://doi.org/10.1088/0967-3334/33/6/901

Miura, K., Daviglus, M. L., Dyer, A. R., Liu, K., Garside, D. B., Stamler, J., & Greenland, P. (2001). Relationship of blood pressure to 25-year mortality due to coronary heart disease, cardiovascular diseases, and all causes in young adult men: the Chicago Heart Association Detection Project in Industry. *The Archives of Internal Medicine*, *161*(12), 1501-1508. https://doi.org/10.1001/archinte.161.12.1501

Morrin, N. M., Stone, M. R., & Henderson, K. J. (2017). Reproducibility of 24-h ambulatory blood pressure and measures of autonomic function. *Blood Pressure Monitoring*, *22*(3), 169-172. https://doi.org/10.1097/MBP.0000000000000241

Nevels, T. L., Burch, J. B., Wirth, M. D., Ginsberg, J. P., McLain, A. C., Andrew, M. E., Allison, P., Fekedulegn, D., & Violanti, J. M. (2021). Shift Work Adaptation Among Police Officers: The BCOPS Study. *Chronobiology International*, *38*(6), 907-923. https://doi.org/10.1080/07420528.2021.1895824

Novelli, F. I., de Araujo, J. A., Tolazzi, G. J., Tricot, G. K., Arsa, G., & Cambri, L. T. (2019). Reproducibility of Heart Rate Variability Threshold in Untrained Individuals. *International Journal of Sports Medicine*, *40*(2), 95-99. https://doi.org/10.1055/a-0800-8633

Oliveira, C., Silveira, E. A., Rosa, L., Santos, A., Rodrigues, A. P., Mendonca, C., Silva, L., Gentil, P., & Rebelo, A. C. (2020). Risk Factors Associated with Cardiac Autonomic Modulation in Obese Individuals. *Journal of Obesity*, *2020*, 7185249. https://doi.org/10.1155/2020/7185249

Pickering, T. G., Hall, J. E., Appel, L. J., Falkner, B. E., Graves, J. W., Hill, M. N., Jones, D. H., Kurtz, T., Sheps, S. G., Roccella, E. J., Council on High Blood Pressure Research, P., & Public Education Subcommittee, A. H. A. (2005). Recommendations for blood pressure measurement in humans: an AHA scientific statement from the Council on High Blood Pressure Research Professional and Public

Education Subcommittee. *The Journal of Clinical Hypertension*, *7*(2), 102-109. https://doi.org/10.1111/j.1524-6175.2005.04377.x

Piper, M. A., Evans, C. V., Burda, B. U., Margolis, K. L., O'Connor, E., & Whitlock, E. P. (2015). Diagnostic and predictive accuracy of blood pressure screening methods with consideration of rescreening intervals: a systematic review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*, *162*(3), 192-204. https://doi.org/10.7326/M14-1539

Plat, M., Frings-Dresen, M., & Sluiter, J. (2011). A systematic review of job-specific workers' health surveillance activities for fire-fighting, ambulance, police and military personnel. *International Archives of Occupational and Environmental Health*, *84*(8), 839-857.

Santos, P. M. S., Novelli, F. I., Araujo, J. A., Tamanho, S., & Cambri, L. T. (2021). Aerobic fitness influences cardiac autonomic modulation in police officers regardless of specific duties. *Blood Pressure Monitoring*, *26*(3), 200-206. https://doi.org/10.1097/MBP.0000000000000518

Skrapari, I., Tentolouris, N., Perrea, D., Bakoyiannis, C., Papazafiropoulou, A., & Katsilambros, N. (2007). Baroreflex sensitivity in obesity: relationship with cardiac autonomic nervous system activity. *Obesity*, *15*(7), 1685-1693. https://doi.org/10.1038/oby.2007.201

Task Force, o. t. E. S. o. C. (1996). Heart rate variability, standards of measurement, physiological interpretation, and clinical use. *Circulation*, *93*, 1043-1065.

Tomei, F., Rosati, M. V., Baccolo, T. P., Cherubini, E., Ciarrocca, M., Caciari, T., & Tomao, E. (2004). Ambulatory (24 hour) blood pressure monitoring in police officers. *Journal of Occupational Health*, *46*(3), 235-243. https://doi.org/10.1539/joh.46.235

Tricot, G. K., Novelli, F. I. I., & Cambri, L. T. (2021). Obesity does not Impair Ambulatory Cardiovascular and Autonomic Responses Post-exercise. *International Journal of Sports Medicine*, *42*(12), 1083-1091. https://doi.org/10.1055/a-1393-6184

Turner, J. R., Viera, A. J., & Shimbo, D. (2015). Ambulatory blood pressure monitoring in clinical practice: a review. *The American Journal of Medicine*, *128*(1), 14-20. https://doi.org/10.1016/j.amjmed.2014.07.021

Unger, T., Borghi, C., Charchar, F., Khan, N. A., Poulter, N. R., Prabhakaran, D., Ramirez, A., Schlaich, M., Stergiou, G. S., Tomaszewski, M., Wainford, R. D., Williams, B., & Schutte, A. E. (2020). 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension*, *75*(6), 1334-1357. https://doi.org/10.1161/HYPERTENSIONAHA.120.15026

Varvarigou, V., Farioli, A., Korre, M., Sato, S., Dahabreh, I. J., & Kales, S. N. (2014). Law enforcement duties and sudden cardiac death among police officers in United States: case distribution study. *British Medical Journal*, *349*, g6534. https://doi.org/10.1136/bmj.g6534

Violanti, J. M., Burchfiel, C. M., Hartley, T. A., Mnatsakanova, A., Fekedulegn, D., Andrew, M. E., Charles, L. E., & Vila, B. J. (2009). Atypical work hours and metabolic syndrome among police officers. *Archives of Environmental & Occupational Health*, *64*(3), 194-201. https://doi.org/10.1080/19338240903241259

Violanti, J. M., Fekedulegn, D., Andrew, M. E., Charles, L. E., Gu, J. K., & Miller, D. B. (2018). Subclinical Markers of Cardiovascular Disease Among Police Officers: A Longitudinal Assessment of the Cortisol Awakening Response and Flow Mediated Artery Dilation. *Journal of Occupational and Environmental Medicine*, *60*(9), 853-859. https://doi.org/10.1097/JOM.0000000000001358

Wright, B. R., Barbosa-Leiker, C., & Hoekstra, T. (2011). Law enforcement officer versus non-law enforcement officer status as a longitudinal predictor of traditional and emerging cardiovascular risk factors. *Journal of Occupational and Environmental Medicine*, *53*(7), 730-734. https://doi.org/10.1097/JOM.0b013e318220c2da

Yang, W. Y., Melgarejo, J. D., Thijs, L., Zhang, Z. Y., Boggia, J., Wei, F. F., Hansen, T. W., Asayama, K., Ohkubo, T., Jeppesen, J., Dolan, E., Stolarz-Skrzypek, K., Malyutina, S., Casiglia, E., Lind, L., Filipovsky, J., Maestre, G. E., Li, Y., Wang, J. G., Imai, Y., Kawecka-Jaszcz, K., Sandoya, E., Narkiewicz, K., O'Brien, E., Verhamme, P., Staessen, J. A., & International Database on Ambulatory Blood Pressure in Relation to Cardiovascular Outcomes, I. (2019). Association of Office and Ambulatory Blood Pressure With Mortality and Cardiovascular Outcomes. *The Journal of the American Medical Association*, *322*(5), 409-420. https://doi.org/10.1001/jama.2019.9811