*Article*

# Metabolic and Inflammatory Profile of Physically Active and Less Active Military Police Officers

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**Abstract:** Obesity is related to the establishment of chronic inflammation and metabolic diseases, but it can be positively influenced by the regular practice of physical activity. The study aimed to compare the anthropometric, metabolic, and inflammatory parameters of physically active Military Police Officers (MPOs) with those who are less physically active. Sixty male MPOs, low activity (n=28) and physically active (n=32) participated. The following parameters were measured: plasma cytokine levels, C-reactive protein (CRP) levels, circulating glucose triglyceride (TAG) and high-density lipoprotein cholesterol (HDL-C) levels, and plasma glutamic oxalacetate transaminase (GOT), glutamic-pyruvate transaminase (GPT), and gamma-glutamyl transferase (GGT) activities. The physically active group presented lower body fat and reduced TAG and IL-8 levels compared to the low activity group. Moreover, a negative correlation between SPE and SBP, DBP, BPM was detected for the physically active group ($p<0.05$) but not in the low activity group. Furthermore, the physically active group's work time (WT) values were not correlated with the important metabolic markers SBP, DBP, BPM, GLU, TAG ($p>0.05$) but could be in the low activity group ($p<0.05$). These findings highlight the fundamental protective role of physical activity in controlling body composition, subclinical inflammation, and cardiovascular risk in MPOs.

**Keywords:** cardiovascular diseases; physical activity; physical exercise; sedentarism; quality of life

## 1. Introduction

Radio patrol Military Police Officers (MPOs) typically work 44 hours per week in 12-hour shifts [1], performing ostensible and preventive law enforcement activities using a vehicle as the primary form of transportation. The high demand to mediate various incidents impairs appropriate eating habits, increases stress and prevents or reduces physical activity consequently impacting the officers' personal health throughout their professional careers [2, 3]

Recently, our group showed, using a pedometer, that the number of steps police officers take during their radio patrol shift is below the number recommended by health agencies [4]. A high prevalence of metabolic syndrome (MetS) was also previously reported in these workers [5]. The consequences of reduced physical activity (PA) among police officers may involve an increased incidence of being overweight and obese, a higher risk for developing diabetes mellitus and cardiovascular disease [5, 6], and/or reduced aerobic capacity [7] jeopardizing the MPO'S ability to perform daily work tasks.

Previous studies have associated obesity-induced subclinical inflammation in the scenario of inappropriate working circumstances with unfavorable lifestyles (i.e., sedentarism, high work stress levels, long shifts and others) with chronic low-grade inflammation in MPOs [8-11]. Indeed, the induction of pro-inflammatory cytokine [e.g., tumor necrosis factor-alpha (TNF-$\alpha$) and interleukins (IL)-1β, IL-6, IL-8)] and C-reactive protein (CRP) [10-12], production can influence stress hormone, substance P, and ATP levels and activate the corticotropin-releasing hormone/substance P-histamine axis, ultimately promoting inflammation. Moreover, a low-grade chronic inflammation state triggers a cascade of inflammatory responses, culminating in persistent tissue damage, substantial cell injury, and organ dysfunction [13, 14]. In the case of MPOs, the inability to respond to life or death situations contributes to the removal of operational police activities and relocation to administrative activities, attenuated work performance and compulsory retirements.

Considering that military police officers (MPOs) are directly involved with the population's security and that the specific psychophysiological demands of this occupation can significantly impact their health, the present study sought to analyze the influence of PA levels on body composition and inflammatory responses in Brazilian MPOs. Additionally, to the best of our knowledge, no previous studies have attempted to compare the concentrations of inflammatory and metabolic biomarkers of physically active MPOs with those who are less physically active. Herein, the anthropometric and inflammatory parameters of Brazilian MPOs with different physical activity levels have been analyzed and compared. The results are of fundamental clinical/practical interest for health professionals developing optimal exercise programs to prevent or reduce the negative effects of physical inactivity.

## 2. Methods

### *2.1. Experimental Design*

This study was designed to assess and compare the anthropometric parameters and inflammatory biomarkers in MPOs (physically active and low activity) from the radio patrol program of the Military Police of Sao Paulo State (PMESP).

### *2.2. Participants*

The data were obtained from the Health Promotion of Military Police Study database, in which 104 MPOs from the radio patrol program of the battalions subordinated to the Metropolitan Police Area Command 1 (CPA/M1) were recruited, as described by Souza et al. al., (2021) [5] and Santos and Souza (2022) [4] . Data were collected in the year 2019.

A total of 60 MPOs responded to the International Physical Activity Questionnaire (IPAQ) and the Perceived Stress Scale (PSS-10), making them eligible to participate in the study. Thirty-two participants were considered physically active, and 28 were sedentary and less physically active. The Ethics Committee of the Cruzeiro do Sul University approved the experimental procedures (protocol number 3.272.747/19), and the experiments were conducted according to the Declaration of Helsinki. The participants signed an informed consent form to participate in all research procedures.

Exclusion criteria included: diagnosis of infectious disease, leukemia, asthma, or autoimmune disease, and/or taking immunosuppressive or anti-inflammatory medications. Participants who were on leave from military police work or failed to complete all recommendations for data collection were also excluded from this research.

All MPOs (n=60) were male with the following characteristics (mean±SEM): age, 35.5±1.0 years old; body mass (BM), 87.5±1.7 kg; height, 1.74±0.0 cm; waist-to-hip ratio (WHR), 0.94±0.0; and body mass index (BMI), 29.0±0.5 kg/m$^2$ (**Table 1)**.

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**Table 1.** Characteristics, body composition, inflammatory, clinical and plasma parameters of the military police officers (n= 60). The values of the low active and active groups are presented as the mean (M) ± standard error (SE).

| | Low-active (N=28) | | Active (N=32) | | Significance |
|---|---|---|---|---|---|
| **Volunteer Characteristics** | **M** | **SE** | **M** | **SE** | **(p)** |
| Age (years) | 38.2 | ±1.6 | 33.2 | ±1.2 | 0.02 |
| Body mass (kg) | 91.4 | ±2.4 | 84.1 | ±2.3 | 0.03 |
| Height (m) | 1.74 | ±0.01 | 1.73 | ±0.01 | >0.99 |
| Body mass index (kg/m²) | 30.1 | ±0.8 | 28.0 | ±0.7 | 0.07 |
| Waist circumference (cm) | 101.5 | ±2.3 | 94.3 | ±2.0 | 0.02 |
| Waist hup circumference (cm) | 0.96 | ±0.01 | 0.93 | ±0.01 | 0.03 |
| **Body composition parameters** | | | | | |
| Skeletal Muscle mass (kg) | 31.3 | ±0.5 | 30.3 | ±0.5 | 0.21 |
| Free fat mass (kg) | 63.7 | ±1.0 | 61.7 | ±1.0 | 0.18 |
| Absolut fat mass (kg) | 28.1 | ±1.9 | 21.8 | ±1.5 | 0.01 |
| Fat mass index (kg/m²) | 9.2 | ±0.6 | 7.2 | ±0.5 | 0.01 |
| Visceral fat (L) | 3.9 | ±0.3 | 3.1 | ±0.2 | 0.01 |
| **Inflammatory parameters** | | | | | |
| Tumor necrosis factor-α (pg.mL) | 0.09 | ±0.04 | 0.09 | ±0.02 | 0.26 |
| IL-6 (pg.mL) | 1.04 | ±0.13 | 0.85 | ±0.09 | 0.26 |
| IL-12p70 (pg.mL) | 0.63 | ±0.07 | 0.75 | ±0.04 | 0.41 |
| IL-10 (pg.mL) | 0.21 | ±0.03 | 0.16 | ±0.03 | 0.11 |
| CRP (mg/dL) | 0.30 | ±0.01 | 0.21 | ±0.01 | 0.37 |
| **Clinical and metabolic parameters** | | | | | |
| Systolic blood pressure (mmHg) | 131.3 | ±2.7 | 127.9 | ±2.1 | 0.32 |
| Diastolic blood pressure (mmHg) | 80.3 | ±2.2 | 77.0 | ±1.6 | 0.23 |
| Mean blood pressure (mmHg) | 97.7 | ±2.2 | 94.4 | ±1.6 | 0.23 |
| Gluclose (mg/dL) | 92.3 | ±1.0 | 91.1 | ±1.5 | 0.69 |
| TAG (mg/dL) | 150.1 | ±11.8 | 120.0 | ±8.8 | 0.04 |
| HDL-C | 40.6 | ±1.7 | 41.2 | ±1.1 | 0.76 |
| GOT (U/L) | 27.6 | ±1.6 | 23.7 | ±1.2 | 0.06 |
| GPT (U/L) | 31.6 | ±3.1 | 27.5 | ±2.5 | 0.34 |
| GGT (U/L) | 40.5 | ±4.2 | 27.7 | ±2.5 | 0.01 |
| Perceived stress (score) | 11.5 | ±1.2 | 8.3 | ±1.3 | 0.03 |

Note: Abbreviations: interleukin (IL); C-reactive protein (CRP); Triglycerides (TAG); glutamic oxyacetic transaminase (GOT); glutamic pyruvate transaminase (GPT); gamma-glutamyl transferase (GGT).

### *2.3. Experimental Protocol*

Initially, the subjects completed a questionnaire on perceived stress [Perceived Stress Scale (PSS-10)] and lifestyle behavior, including PA routine. The radio patrol years of service, age, and general health information were also collected from the participants. The MPOs were advised to get plenty of sleep, drink plenty of water, and avoid eating foods with high fat or protein content eight hours before the sample collection. Anthropometric measurements and blood sampling were conducted at the Physical Activity and Sports Sciences Institute (ICAFE) at Cruzeiro do Sul University (São Paulo, SP, Brazil).

#### 2.3.1. Physical Activity Levels

The PA levels (type of PA and number of hours per week) were evaluated using the International Physical Activity Questionnaire (IPAQ short form). Validation research in Latin America, specifically in Brazil, suggests that the IPAQ has moderate criteria validity and great reliability compared to accelerometers [15, 16]. The application and classification of the IPAQ followed the same criteria described in the study of Souza et al. (2019) [1]. Participants considered physically inactive or sedentary, according to the IPAQ, were placed in the "low activity" group, whereas participants classified as active or very active were placed in the "physically active" group.

2.3.2. Clinical and Anthropometric Measurements

The weight, height, BMI, waist circumference (WC), and WHR were recorded for each participant. The absolute fat mass (AFM), fat mass index (FMI), visceral adipose tissue (VAT)**, skeletal muscle mass (SMM), and** the values of **free fat mass (FFM)** were obtained using a bioimpedance device (mBCA 515, SECA, Hamburg, Germany). Diastolic and systolic blood pressure (DBP and SBP, respectively) were measured using a mercury sphygmomanometer (Premium, Zhejiang, China), with the subject at rest for at least 5 min [1, 5]. All the values from these measurements are summarized in Table 1.

2.3.3. Sample Collection

Blood samples were drawn from one of three main veins at the antecubital fossa: cephalic, basilic, or median cubital. Blood samples (20 mL of venous blood) were drawn into BD vacutainer tubes containing heparin. Samples were centrifuged at 400 × *g* for 10 min, and the plasma was stored at -80°C until analyzed for inflammatory and metabolic biomarkers [17, 18]. All samples were concurrently evaluated on a single day.

2.3.4. Assessment of Inflammatory and Metabolic Markers

Plasma cytokines (TNF-$\alpha$, IL-10, IL-1β, IL-6, IL-8, and IL12p70) were assessed using the Cytometric Bead Array (CBA) and Human CBA and flow cytometry (BD Accuri cytometer, Becton Dickinson, NJ, USA), according to the manufacturer's instructions [5, 19]. Plasma was not stored for more than three months.

The Diagnosis and Analysis Center (CDA) (São Paulo, SP, Brazil) carried out the laboratory measurements of CRP by immunoturbidimetry; glucose, triglycerides (TAG), and high-density lipoprotein cholesterol (HDL-C) using colorimetric enzymatic methods; and glutamic-oxaloacetate transaminase (GOT), glutamic-pyruvate transaminase (GPT), and gamma-glutamyl transferase (GGT) activities using kinetic enzyme assays. Samples were evaluated in duplicate, as previously described by Souza et al. [5].

*2.4. Statistical Analysis*

The values are presented as the mean±standard error (SE). For blood assessments, outliers were excluded from normally distributed data using the criteria of Chauvenet (R. Taylor John, 1997), where values lower or higher than two standard deviations in each group were excluded. The D'Agostino & Pearson normality test was used to assess the normality of the data distribution. The comparison between the physically active and low activity groups was performed by parametric tests (t-test) for the samples with normal distribution. The association between dichotomous variables was assessed using the Chi-Square test, and the linear relationships were determined by Pearson's correlation (data with normal distribution) or Spearman's correlation (data without normal distribution). The significance level was set at $p<0.05$, and all assessments were performed using the *GraphPad Prism* software v. 9.0 (GraphPad Software, CA, USA). The calculation of statistical power was performed by the *G*Power* program, version 3.1.9 (Dusseldorf, Germany), using the number of samples per group (nA=32; nB=28) and the alpha probabilistic error ($p<0.05$). Each variable's effect size was calculated utilizing the means and the square root of the mean of the standard deviations for each group. Statistical power was greater than 80% for main variables, including IL-8, metabolic equivalent spent per week, BMI, FMI, triglycerides, and perceived stress. Statistical analysis was performed in the year 2022.

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### 3. Results

The physically active and low activity groups had metabolic equivalents of 1422 [±155 (95% CI 1105-1739)] and 920 [±246 (95% CI 415-1424)], respectively. Higher metabolic equivalent (Δ=54.5%, p<0.01) and lower WC (Δ=7.62%, p<0.05), BM (Δ=8.63%, p<0.05), WHR (Δ=3.31%, p<0.05), AFM (Δ=28.9%, p<0.05), FMI (Δ=26.8%, p<0.05), and VAT (Δ=28.0%, p<0.05) were observed in the physically active group compared to the low activity group **(Figure 1). There were no significant differences in BMI, SMM, or FFM detected when comparing groups.**

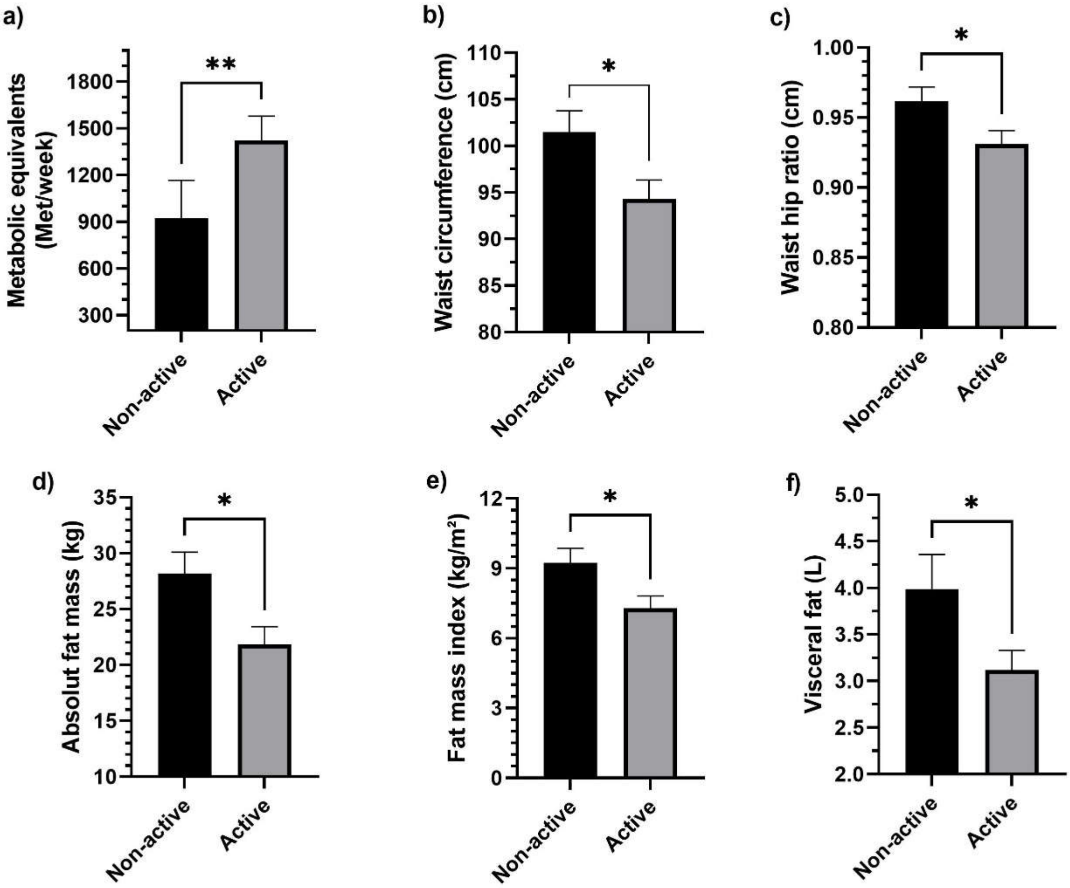


**Figure 1. Metabolic equivalents and body composition variables of the participants.** The results are presented as the mean±SE of the low activity (n=28) and physically active (n=32) groups. The level of significance was set to p<0.05*.

The physically active group presented lower plasma TAG (Δ=25.0%, p<0.05), IL-8 (Δ=34.2%, p<0.05), GGT (Δ=48.6%, p<0.05), and perceived stress (Δ=37.0%, p<0.05) levels than the low activity group **(Figure 2).** Additionally, GOT activity was reduced in the active group compared to the low activity group (Δ=16.2%), but this alteration failed to reach a level of statistical significance (p=0.06)**.** In contrast, the plasma **glucose concentration and mean blood pressure, SBP, DBP, MBP,** HDL-C, CRP, IL-1β, IL-6, IL-10, IL-12p70, TNF-a levels and GPT activity were not different between groups **(Table 1).**

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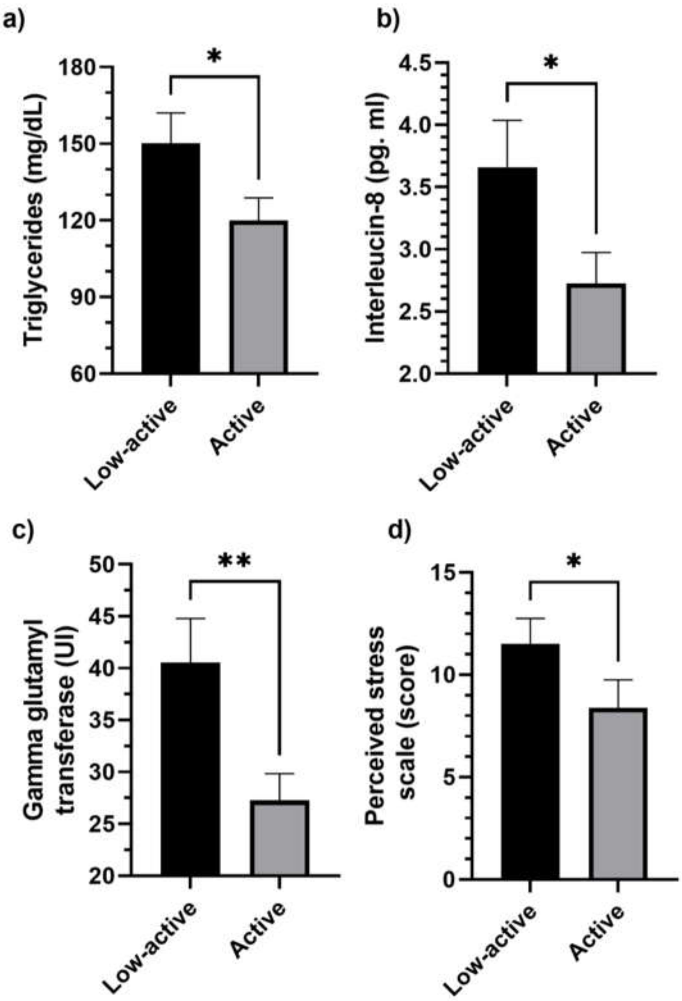


**Figure 2. Inflammatory and clinical variables of the participants**. The results are presented as the mean±SE among low activity (n=28) and physically active (n=32) groups. The level of significance was set to $p<0.05$*.

A negative correlation was found between SPE and the clinical markers SBP, DBP, and BPM ($p<0.05$) in the physically active group but not in the low activity group. Additionally, WT was not found to be correlated with the metabolic syndrome indicators SBP, DBP, BPM, GLU, TAG in the physically active group ($p>0.05$) but was in the low activity group ($p<0.05$) **(Figures 3.b and 3.c)**. Similar correlations were observed between GLU and TAG with AGE **(Figures 3.b and 3.c).** Lastly, IL-8 was correlated with WHR ($p<0.05$) in the low activity group, but this was not seen in the physically active group, indicating a possible protective effect of PA on this parameter **(Figures 3.b and 3.c).**

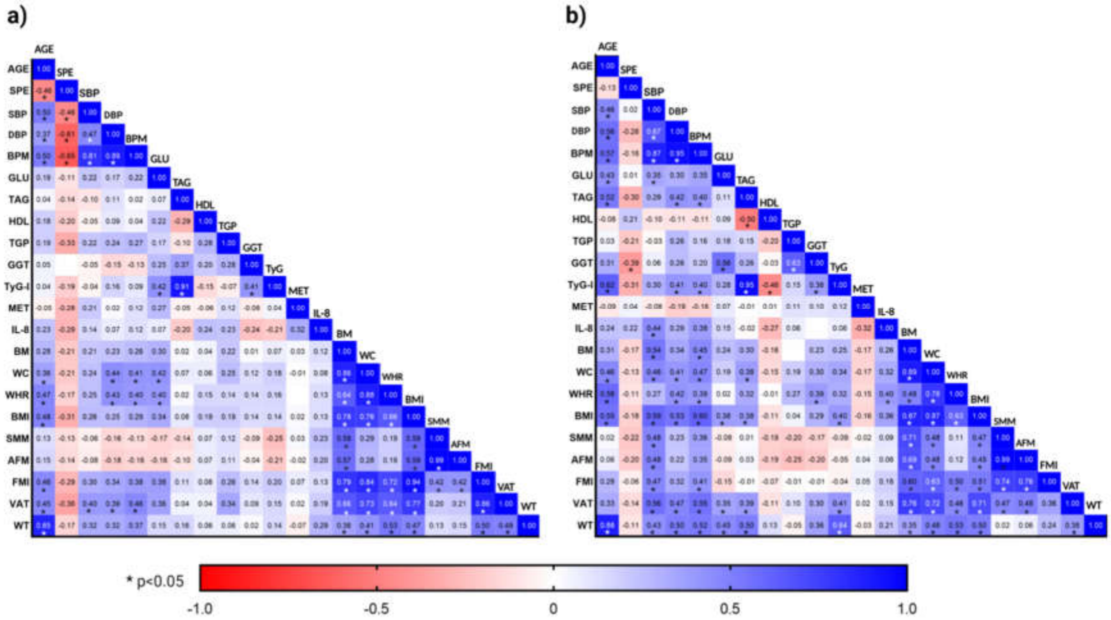


**Figure 3. Correlation matrix of body composition, inflammatory, and clinical variables of military police officers.** a) Correlation of the physically active group (n=32); **b)** Correlation of the low activity group (n=28). The results are displayed as r Pearson (-1 to 1), and the significance level was set to p<0.05*. Abbreviations: systolic blood pressure (SBP); diastolic blood pressure (DBP); blood pressure mean (BPM); plasma glucose (GLU); triglyceride (TAG); high density lipoprotein (HDL); glutamic-pyruvate transaminase (TGP); gamma-glutamyl transferase (GGT); glucose triglyceride index (TyG); metabolic equivalent (MET); interleukin-8 (IL-8) body mass (BM); waist circumference (WC); waist-hip ratio; body mass index (BMI); skeletal muscle mass (SMM); absolute fat mass (AFM); fat mass index (IMF); visceral adipose tissue (VAT); work time (WT).

## 4. Discussion

This study is the first to investigate the anthropometric, body composition, inflammatory, and metabolic differences between physically active and low activity MPOs. Notably, the physically active MPOs presented improved health indicators related to WC, WHR, AFM, FMI, VAT, TAG, and GG compared to MPOs with low physical activity. These findings are relevant because individuals who are overweight and obese are predisposed to chronic diseases, such as metabolic syndrome (MetS) with hypertension, insulin resistance, and dyslipidemias [20]. Herein, 53.5% of the low-active group were diagnosed with MetS, while 37.5% of the physically active group had this disease. It was previously reported that low PA levels and being overweight compromise physical fitness, daily work activities and the job performance of MPOs [21, 22].

Previous studies demonstrated that high deposition of visceral adipose and subcutaneous tissues is associated with IKKβ nuclear factor-kappaB axis activation, which upregulates the inflammatory cytokine expression, producing a chronic low-grade inflammatory state [23, 24]. In this sense, MPOs have a chronic subclinical inflammatory process [25, 26]. Furthermore, physically active MPOs presented downregulated IL-8 expression compared to the low activity group, which might indicate a decreased inflammatory state.

Additionally, in the low activity but not the physically active group, a positive correlation between IL-8 and WHR was detected. It has been reported that IL-8 is a biomarker that plays a central role in the inflammatory process [27]. Indeed, upregulated IL-8 expression has been related to the recruitment of monocytes and macrophages to the vessel wall, promoting or exacerbating blood vessel lesions, atherosclerotic plaque formation and adverse health outcomes [28-30]. For example, Bruun et al. [31] reported that higher circulating IL-8 concentration positively correlates with insulin sensitivity and adiposity, indicating IL-8 participation in some obesity-related health complications. The mechanisms involved and the clinical significance of downregulated IL-8 expression in the physically active group requires further investigation. It is plausible that this cytokine is an early marker of metabolic alterations.

Furthermore, it has been shown that the maintenance and control of inflammatory marker concentrations protect against the risk of developing cardiovascular and liver diseases [23]. This possibility is especially relevant to police officers with a high prevalence of MetS and death due to cerebrovascular and cardiovascular diseases [5, 32]. Thus, identifying verified markers of initial metabolic changes could facilitate the early diagnosis, treatment and intervention of various diseases and conditions.

Despite detecting attenuated GGT and TAG levels in the physically active group compared to low activity MPOs, no other differences in cardiometabolic risk indicators (e.g., HDL, glucose, SBP, DBP, and CRP) or cytokine levels were observed when comparing groups. The absence of differences among physically active and low activity MPOs may be due to the low mean age of the study population.

Law enforcement professionals are constantly exposed to stress factors due to the work responsibilities, risk of death, exposure to violence, irregular sleep schedule, and shift work [33, 34]. It is known that exposure to stress (e.g., traumatic stress) activates the hypothalamic-pituitary-adrenal axis and upregulates inflammatory biomarker expression [35, 36]. Additionally, chronic exposure to stress has become a public health and safety problem because it increases the risk of developing metabolic diseases and mental illnesses and can keep people from attending work [37, 38]. Notably, physically active MPOs have a lower stress perception than low activity ones, which suggests that PA could effectively reduce stress in this population. This possibility is consistent with a previous study stating that physical exercise can control parameters directly related to health and stress reduction [39].

The inferences of this research should be evaluated considering some limitations. First, the sample size was relatively small, which may restrict the generalizability of the results. Second, all MPOs in this research were men, and the inflammatory process is impacted by gender [40]. Thus, it could be challenging to translate these results to female MPOs directly. Moreover, more thorough nutritional monitoring should be performed in future research to assess how diet impacts metabolic and inflammatory states.

On the other hand, the strengths of this research include the incorporation of quantitative biochemical and physiological assessments. The samples were processed at a laboratory using standardized methods, and data (i.e., physical and blood work) was collected in a clinical setting with a well-trained staff. In addition, the research participants were selected from a population of active MPOs (instead of hospital sources). Thus, we can assume that the participants were otherwise healthy since they were not exposed to physical trauma, which could have induced an inflammatory response. Importantly, this study strengthens our confidence in exploring intervention programs for MPOs as a means to increase weekly PA and prevent the onset and/or development of metabolic and inflammatory diseases.

## 5. Conclusions

The physically active MPOs presented lower body fat, plasma TAG, and IL-8 levels than the low activity group. Moreover, there was a positive correlation between IL-8 and WHR in the low activity group. These findings indicate that PA, a nonpharmacological strategy, can effectively prevent subclinical inflammation and risk factors associated with cardiovascular diseases, including abdominal and body fat, triglycerides, perceived stress, and body composition in MPOs.

**Author Contributions:** DRS and LB wrote the manuscript and performed the statistical analysis. LCSO, ESN, LPS, JRM, DGSD, VLS, LPC, ALP, EH, MFCB AND LNM prepared the study data. TCPC, RG, RC and SMH revised and edited the manuscript. All authors read and agreed with the last version of the manuscript.

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## References


1. de Souza, D.R., et al., Efficacy of a Health Promotion Guidance Program Applied to the Police of São Paulo City. Journal of Archives in Military Medicine, 2018. 6(4).
2. Garbarino, S., et al., Sleepiness and sleep disorders in shift workers: a study on a group of italian police officers. Sleep, 2002. 25(6): p. 648-653.
3. Puttonen, S., M. Härmä, and C. Hublin, Shift work and cardiovascular disease - pathways from circadian stress to morbidity. Scand J Work Environ Health, 2010. 36(2): p. 96-108.
4. dos Santos, L.P., et al., Association between the number of steps performed during work and metabolic syndrome indicators in São Paulo city military police officers: The health promotion of Military Police (HPMP) study. Research, Society and Development, 2022. 11(2): p. e13511225376-e13511225376.
5. Souza, D.R.d., et al., Prevalence of Metabolic Syndrome in Military Police Officers of São Paulo City: The Health Promotion in Military Police (HPMP) Study. Research, Society and Development, 2021. 10(14 SE -): p. e61101421142-e61101421142.
6. Parkash, J., et al., Prevalence of Hypertension and its Determinants among Policemen in a City of Haryana, India. International journal of applied & basic medical research, 2019. 9(3): p. 143-147.
7. Sörensen, L., et al., Physical activity, fitness and body composition of Finnish police officers: a 15-year follow-up study. Occupational medicine (Oxford, England), 2000. 50(1): p. 3-10.
8. Bouayed, J., H. Rammal, and R. Soulimani, Oxidative stress and anxiety: relationship and cellular pathways. Oxidative medicine and cellular longevity, 2009. 2(2): p. 63-67.
9. Ghezzi, P., et al., Oxidative Stress and Inflammation Induced by Environmental and Psychological Stressors: A Biomarker Perspective. Antioxidants & redox signaling, 2018. 28(9): p. 852-872.
10. Nevels, T.L., et al., Shift Work Adaptation Among Police Officers: The BCOPS Study. Chronobiology international, 2021. 38(6): p. 907-923.
11. Puttonen, S., K. Viitasalo, and M. Härmä, Effect of shiftwork on systemic markers of inflammation. Chronobiology international, 2011. 28(6): p. 528-535.
12. Elenkov, I.J., Neurohormonal-cytokine interactions: implications for inflammation, common human diseases and well-being. Neurochemistry international, 2008. 52(1-2): p. 40-51.
13. Rius-Pérez, S., et al., PGC-1$\alpha$, Inflammation, and Oxidative Stress: An Integrative View in Metabolism. Oxidative medicine and cellular longevity, 2020. 2020: p. 1452696-1452696.
14. Vaziri, N.D., Causal link between oxidative stress, inflammation, and hypertension. Iranian journal of kidney diseases, 2008. 2(1): p. 1-10.
15. Matsudo, S., et al., Questinário internacional de atividade f1sica (IPAQ): estudo de validade e reprodutibilidade no Brasil. Rev. bras. ativ. fís. saúde, 2001: p. 05-18.
16. Hallal, P.C., et al., Lessons learned after 10 years of IPAQ use in Brazil and Colombia. Journal of physical activity & health, 2010. 7 Suppl 2: p. S259-64.
17. Cury-Boaventura, M.F., et al., The effect of a competitive futsal match on T lymphocyte surface receptor signaling and functions. Frontiers in Physiology, 2018. 9: p. 202.
18. de Moura, N.R., et al., Muscle lesions and inflammation in futsal players according to their tactical positions. The Journal of Strength & Conditioning Research, 2013. 27(9): p. 2612-2618.
19. Morgan, E., et al., Cytometric bead array: a multiplexed assay platform with applications in various areas of biology. Clin Immunol, 2004. 110(3): p. 252-66.
20. Nieves, D.J., et al., The atherogenic lipoprotein profile associated with obesity and insulin resistance is largely attributable to intra-abdominal fat. Diabetes, 2003. 52(1): p. 172-179.
21. Minayo, M.C.d.S., S.G. de Assis, and R.V.C. de Oliveira, [The impact of professional activities on the physical and mental health of the civil and military police of Rio de Janeiro (RJ, Brazil)]. Ciencia & saude coletiva, 2011. 16(4): p. 2199-2209.
22. Violanti, J.M., et al., Associations Between Body Fat Percentage and Fitness among Police Officers: A Statewide Study. Saf Health Work, 2017. 8(1): p. 36-41.
23. Cao, H., Adipocytokines in obesity and metabolic disease. Journal of endocrinology, 2014. 220(2): p. T47-T59.
24. Shoelson, S.E., J. Lee, and M. Yuan, Inflammation and the IKK beta/I kappa B/NF-kappa B axis in obesity- and diet-induced insulin resistance. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity, 2003. 27 Suppl 3: p. S49-52.
25. Wirth, M.D., et al., Association of a dietary inflammatory index with inflammatory indices and metabolic syndrome among police officers. J Occup Environ Med, 2014. 56(9): p. 986-9.
26. Wirth, M.D., et al., Longitudinal and cross-sectional associations between the dietary inflammatory index and objectively and subjectively measured sleep among police officers. Journal of sleep research, 2021: p. e13543-e13543.

 doi:10.20944/preprints202211.0403.v1


27. Doszhan, A., et al., [THE ROLE OF INTERLEUKIN 8 / CXCL8 IN THE IMMUNOPATHOGENESIS AND CARCINOGENESIS OF INFLAMMATORY BOWEL DISEASES (REVIEW)]. Georgian medical news, 2019(296): p. 150-153.
28. Ito, T. and U. Ikeda, Inflammatory cytokines and cardiovascular disease. Current Drug Targets-Inflammation & Allergy, 2003. 2(3): p. 257-265.
29. Romuk, E., et al., Selectin-P and interleukin-8 plasma levels in coronary heart disease patients. European journal of clinical investigation, 2002. 32(9): p. 657-661.
30. Trøseid, M., et al., Exercise reduces plasma levels of the chemokines MCP-1 and IL-8 in subjects with the metabolic syndrome. European heart journal, 2004. 25(4): p. 349-355.
31. Bruun, J.M., et al., Association between measures of insulin sensitivity and circulating levels of interleukin-8, interleukin-6 and tumor necrosis factor-alpha. Effect of weight loss in obese men. European journal of endocrinology, 2003. 148(5): p. 535-542.
32. Violanti, J.M., et al., Dying for the job: police mortality, 1950–2018. Policing: An International Journal, 2021.
33. Frank, J., E.G. Lambert, and H. Qureshi, Examining police officer work stress using the job demands–resources model. Journal of Contemporary Criminal Justice, 2017. 33(4): p. 348-367.
34. Velazquez, E. and M. Hernandez, Effects of police officer exposure to traumatic experiences and recognizing the stigma associated with police officer mental health: A state-of-the-art review. Policing: An International Journal, 2019.
35. Spitzer, C., et al., Association of posttraumatic stress disorder with low-grade elevation of C-reactive protein: evidence from the general population. Journal of psychiatric research, 2010. 44(1): p. 15-21.
36. Zhou, D., et al., Exposure to physical and psychological stressors elevates plasma interleukin 6: relationship to the activation of hypothalamic-pituitary-adrenal axis. Endocrinology, 1993. 133(6): p. 2523-2530.
37. Garbarino, S. and N. Magnavita, Work Stress and Metabolic Syndrome in Police Officers. A Prospective Study. PLoS One, 2015. 10(12): p. e0144318.
38. Kuo, W.-C., et al., The association between psychological stress and metabolic syndrome: A systematic review and meta-analysis. Obesity reviews : an official journal of the International Association for the Study of Obesity, 2019. 20(11): p. 1651-1664.
39. Bischoff, L.L., et al., The effect of physical activity interventions on occupational stress for health personnel: A systematic review. International journal of nursing studies, 2019. 97: p. 94-104.
40. van Eijk, L.T., et al., Gender differences in the innate immune response and vascular reactivity following the administration of endotoxin to human volunteers. Critical care medicine, 2007. 35(6): p. 1464-1469.