Rev Bras Cineantropom Desempenho Hum original article

https://doi.org/10.1590/1980-0037.2025v27e107121

Police officers with higher aerobic fitness exhibit less pressor hyperresponsiveness to mental stress

Policiais com maior aptidão aeróbia apresentam menos hiperresponsividade pressórica ao estresse mental

Jaqueline Alves de Araújo[1]
https ://orcid.org/0000-0003-2998-3090
Débora Andréa Castiglioni Alves[2]
https ://orcid.org/0000-0002-2771-1211
Susane Tamanho[3]
https ://orcid.org/0000-0002-1263-9878
Karen Dennise Lozada Tobar[2]
https ://orcid.org/0009-0000-5905-8459
Lidiana Laura Campos Borralho de Arruda[4]
https ://orcid.org/0009-0008-9686-8344
Amílcar Sabino Damazo[1]
https ://orcid.org/0000-0003-2323-008X
Lucieli Teresa Cambri[1,2]
https ://orcid.org/0000-0002-5609-7249

1 Federal University of Mato Grosso. Graduate Program in Health Sciences. Cuiabá, MT. Brazil.
2 Federal University of Mato Grosso. Graduate Program in Physical Education. Cuiabá, MT. Brazil.
3 Military Police of the State of Mato Grosso. Cuiabá, MT. Brazil.
4 Federal University of Mato Grosso. Júlio Müller University Hospital. Cuiabá, MT. Brazil.

Received: April 24, 2025
Accepted: June 16, 2025

How to cite this article
Araújo JA, Alves DAC, Tamanho S, Tobar KDL, Arruda LLCB, Damazo AS, Cambri LT. Police officers with higher aerobic fitness exhibit less pressor hyperresponsiveness to mental stress. Rev Bras Cineantropom Desempenho Hum 2025, 27:e107121. DOI: https://doi.org/10.1590/1980-0037.2025v27e107121

Corresponding author
Lucieli Teresa Cambri.
Federal University of Mato Grosso
Av. Fernando Corrêa da Costa, 2367, 78060-900, Boa Esperança, Cuiabá (MT), Brazil.

Scientific Editor:
Diego Augusto Santos Silva

Abstract – Higher aerobic fitness has been associated with lower cardiovascular reactivity to stress. However, this relationship remains underexplored in professionals exposed to high levels of stressors. This study evaluated whether police with higher aerobic fitness exhibited lower blood pressure (BP) reactivity to mental stress. A cross-sectional study was conducted with 41 police officers divided into lower (n = 21) and higher aerobic fitness groups (n = 20), based on median peak oxygen consumption (VO_2peak). Police officers were subjected to the Stroop Color and Word Test, with BP and heart rate (HR) measured at rest and during the stress condition. Cardiovascular reactivity was determined by the peak delta (Δ) of systolic BP (SBP), diastolic BP (DBP), and HR. Police officers were classified as hyperresponders based on the 75th percentile of these deltas. Police with higher aerobic fitness did not show lower SBP (↑VO_2peak: 19 ± 8 mmHg vs. ↓VO_2peak: 19 ± 11, p = 0.836), DBP (13 ± 5 vs. 15 ± 6 mmHg, p = 0.276), or HR (12 ± 8 vs. 8 ± 7 bpm, p = 0.102) reactivity. However, they exhibited less hyperresponsiveness for SBP (2 [18.2%] vs 9 [81.8%], p = 0.018) and DBP (2 [20%] vs 8 [80%], p = 0.036), with no difference for HR (7 [70%] vs 3 [30%], p = 0.123). In summary, police officers with higher aerobic fitness did not exhibit lower average pressor reactivity to mental stress, but they showed less hyperresponsiveness.

Key words: Blood pressure; Cardiorespiratory fitness; Occupational health; Psychological stress; Police professionals.

Resumo – *Aptidão aeróbia elevada tem sido associada a menor reatividade cardiovascular ao estresse. No entanto, essa relação permanece pouco explorada em profissionais expostos a altos níveis de estressores. Este estudo avaliou se policiais com maior aptidão aeróbica apresentam menor reatividade da pressão arterial (PA) ao estresse mental. Um estudo transversal foi conduzido com 41 policiais militares, divididos em baixa (n = 21) e elevada aptidão aeróbia (n = 20), com base no consumo médio de oxigênio de pico (VO_2pico). Os policiais foram submetidos ao Teste de Cor e Palavra de Stroop, com aferição da PA e da frequência cardíaca (FC) mensuradas em repouso e durante o estresse. A reatividade cardiovascular foi determinada a partir do pico delta (Δ) da PA sistólica (PAS) e diastólica (PAD) e da FC. Os policiais foram classificados como hiperresponsivos com base no percentil 75 desses deltas. Policiais com maior aptidão aeróbica não apresentaram menor reatividade da PAS. (↑VO_2pico: 19 ± 8 vs ↓VO_2pico: 19 ± 11 mmHg, p = 0,836), PAD (13 ± 5 vs 15 ± 6 mmHg, p = 0,276) e FC (12 ± 8 vs 8 ± 7 bpm, p = 0,102). No entanto, apresentaram menos hiperresponsividade para PAS (2 [18,2%] vs. 9 [81,8%], p = 0,018) e PAD (2 [20%] vs. 8 [80%], p = 0,036), sem diferença para FC (7 [70%] vs 3 [30%], p = 0,123). Em resumo, policiais militares com maior aptidão aeróbica não apresentaram menor reatividade pressórica média ao estresse mental, mas demonstraram menor hiperresponsividade.*

Palavras-chave: *Pressão arterial; Aptidão cardiorrespiratória; Saúde ocupacional; Estresse psicológico; Profissionais de polícia.*

INTRODUCTION

The increasing prevalence of hypertension reflects not only biological and behavioral factors but also the influence of other elements, such as occupational stress[1-3]. Among high-risk professions, police work imposes constant challenges, including unexpected confrontations, physical threats, decision-making under pressure, and irregular shifts[4-6], contributing to blood pressure (BP) variability. Unsurprisingly, the prevalence of hypertension among police officers ranges from 60.5% to 67.9%[7,8], approximately twice the rate observed in the general Brazilian population[9].

Beyond traditional risk factors, chronic and repeated exposure to stress may also contribute to adverse cardiovascular outcomes[10-12]. Individuals who exhibit exacerbated pressor responses to psychological stressors are at increased risk of developing hypertension[13]. Among operational police officers, this situation is further aggravated by continuous exposure to confrontations and physical threats[8], emphasizing the importance of protective factors to mitigate responses to daily stressors and improve cardiovascular risk management.

Aerobic fitness has been identified as a protective factor capable of attenuating the magnitude of the hemodynamic response to various stressors[14-17]. A recent meta-analysis demonstrated that aerobic training helps reduce BP reactivity to stress, particularly in hypertensive individuals, promoting a more adaptive cardiovascular response to stressful situations[15]. In Swiss army recruits, higher levels of aerobic fitness were associated with more appropriate cardiac responses to acute stress, suggesting an important protective role against exacerbated stress reactions[17]. However, results in the literature remain controversial, with some studies reporting no effect of aerobic fitness on the attenuation of hemodynamic reactivity to stress[18]. Thus, physical fitness emerges as a potential confounding factor in investigations of cardiovascular reactivity to stress and should be measured and considered in analyses.

Despite the high occupational exposure to stressors and the high prevalence of hypertension among police officers, the influence of aerobic fitness on BP reactivity to mental stress in this group remains poorly explored. Moreover, given the absence of standardized cutoff values for pressor hyperreactivity, additional analyses should be explored, such as those used in the study by Simoes GM, Campagnaro BPAB[19], to identify individuals who are hyperresponsiveness to stress.

The objective of this study was to evaluate whether police officers with higher levels of aerobic fitness exhibited lower BP reactivity to mental stress. We hypothesized that police officers with higher levels of aerobic fitness would exhibit lower BP reactivity in response to mental stress and a lower likelihood of pressor hyperreactivity, based on the proposed hyperreactivity criteria.

METHODS

Participants

Forty-one male operational police officers participated in the study. Before participation, all participants received a detailed explanation of the experimental procedures and provided written informed consent. The experimental procedures were conducted following the Declaration of Helsinki, and the study was approved by the Institutional Human Research Ethics Committee (protocol no. 67074223.8.0000.8124). To be eligible for participation, the policemen had to be between 20 and 50 years old, be active employees of the institution, and have at least two years of service in the operational sector. Exclusion criteria included pre-existing cardiac diseases, osteoarticular conditions that prevented engagement in physical exercise, and color blindness.

Study design

This cross-sectional study was conducted in two morning sessions, separated by a minimum interval of 72 hours. To assess the influence of aerobic fitness, participants were divided into two groups based on the median value of peak oxygen consumption (VO_2peak). The cutoff point adopted was 42.95 $ml \cdot kg^{-1} \cdot min^{-1}$, resulting in two groups: low aerobic fitness (VO_2peak ≤ 42.95 $ml \cdot kg^{-1} \cdot min^{-1}$) and high aerobic fitness (VO_2peak > 42.95 $ml \cdot kg^{-1} \cdot min^{-1}$).

Clinical evaluations were conducted during the first laboratory visit, including a maximal cardiopulmonary exercise test. During the second visit, participants underwent the experimental session to assess cardiovascular reactivity to mental stress. Participants were instructed to avoid vigorous exercise, as well as the consumption of tobacco, alcohol, and stimulant substances, in the 24 hours preceding each session. The Police officers from our sample worked in two different shift schedule rotations, 12h/24h and 12h/72h (i.e., 12h at-work, 24h or 72h off-work). To minimize the effects of sleep loss, all assessments occurred during the 72h off-work period after the participants had at least a regular night of sleep at home.

Clinical evaluation

Initially, participants underwent preliminary assessments, which included the administration of an anamnesis to obtain personal information (i.e., age, smoking and alcohol consumption habits), professional data (i.e., years of military service, years of operational service, work shift information), family history, medical (i.e., pre-existing heart diseases, osteoarticular conditions that prevented physical exercise, and color blindness) and medication use. Subsequently, the police completed the International Physical Activity Questionnaire (IPAQ)[20] and the Effort-Reward Imbalance (ERI) questionnaire, which assesses effort, reward, and overcommitment, enabling the identification of occupational stress.

Body composition was assessed by measuring body mass (digital scale, CAMRY) and height (stadiometer, SANNY, 0.1 cm precision), allowing for the calculation of body mass index (BMI). Abdominal circumference was measured using a measuring tape (Cardiomed, 0.1 cm precision), and body fat percentage was determined by bioelectrical impedance analysis (OMRON HBF-510W).

All participants performed a maximal cardiopulmonary exercise test on a treadmill (Micromed, Centurion 300), conducted under specialized medical supervision. The protocol used was the Bruce protocol[21], with progressive increases in speed and incline every three minutes. Respiratory variables were obtained using a portable gas analyzer (VO2000, Medical Graphics, USA). The criteria for determining VO_2peak, perceived exertion, and the validation of maximal effort followed previously published protocols[22]

Experimental protocol and measurements

BP was measured on the left arm using an automated oscillometric device (MICROLIFE, BP 3BT0-A®), while heart rate (HR) was monitored with a Polar V800 device. HR data were exported to the Polar Precision Performance software (v.5.0) and analyzed using Kubios HRV® software (v.2.1), considering the final five minutes of resting. Assessments were performed at rest and during the Stroop Color and Word Test (SCWT). At rest, participants remained seated for 10 minutes. BP was measured twice with a two-minute interval. If a difference of 5 mmHg or more between measurements was observed, a third measurement was taken, and the mean of the two closest values was considered.

The SCWT was used to induce mental stress. The test consisted of the presentation of color-naming words printed in incongruent ink colors (e.g., the word "red" printed in blue), displayed for 1 second each. Participants were instructed to name the color of the ink while ignoring the written word[23]. An additional auditory stimulus, consisting of words different from those visually displayed, was included to intensify cognitive load. The test lasted 4 minutes[24]. After its completion, participants remained seated for a 5-minute recovery period. BP was recorded at 2 and 4 minutes during the SCWT. HR was continuously monitored. Participants also rated their perceived stress on a scale from 0 (none) to 4 (extreme).

Cardiovascular reactivity to mental stress was determined based on the peak delta (Δ) of BP and HR. The Δpeak was calculated as the difference between the highest value recorded during the test (at 2 or 4 minutes) and the pre-test values. Participants were classified as pressor and chronotropic hyper-responders based on the 75th percentile of the peak delta values for SBP, DBP, and HR. The cut-off points for defining hyperresponsiveness were: SBP 26 mmHg, DBP 17 mmHg, and HR 15.5 bpm.

Statistical analysis

Data normality was assessed using the Shapiro-Wilk test. Continuous variables were described as mean and standard deviation, while categorical variables were expressed as absolute and relative frequencies. Group comparisons were performed using the t-test for parametric variables and the Mann-Whitney U test for nonparametric variables. Categorical variables were analyzed using Pearson's chi-square test (χ^2). The significance level was set at $p \leq 0.05$.

RESULTS

Participant characteristics

Forty-one police officers participated in the study. The higher aerobic fitness group showed a higher frequency of physically active individuals ($p = 0.025$) and higher VO_2peak values ($p < 0.001$) compared to the group with lower aerobic fitness. No significant differences ($p > 0.05$) were observed between the groups for the other characterization variables (Table 1).

Table 1. Clinical characterization.

	Lower aerobic fitness (n= 21)	Higher aerobic fitness (n= 20)	p value
Age (years)*	35.85 ± 4.14	33.91 ± 3.45	0.090
Body mass index (kg.m^{-2})*	27.44 ± 28.82	27.16 ± 2.79	0.865
Abdominal circumference (cm)	93.76 ± 7.86	90.70 ± 7.75	0.217
Body fat (%)	26.42 ± 4.38	26.13 ± 3.67	0.818
Physically active, n (%)	11 (52.4%)	17 (85%)	0.025
Current smoker, n (%)	5 (23.8%)	3 (15%)	0.477

Note. The independent samples t-test and Mann-Whitney U test were used to compare clinical parameters between groups.
*Nonparametric data.

Table 1. Continuation.

	Lower aerobic fitness (n= 21)	Higher aerobic fitness (n= 20)	p value
Alcohol consumption, n (%)	17 (81%)	11 (55%)	0.074
Professional characteristics			
Military service time (years)*	10.86 ± 3.56	9.85 ± 2.94	0.097
Military operational service (years)*	9.19 ± 3.82	9.25 ± 3.51	0.706
Hemodynamic variables and physical fitness			
Heart rate (beats.min)	67 ± 10	69 ± 12	0.586
Systolic blood pressure (mm.Hg)*	124 ± 9	124 ± 8	0.946
Diastolic blood pressure (mm.Hg)	77 ± 8	76 ± 8	0.896
Heart rate peak (beats.min)	184 ± 11	185 ± 6	0.607
VO_2peak (ml.kg^{-1}.min^{-1})*	37.40 ± 5.85	47.38 ± 3.09	p < 0.001
Subjective perception*	19.43 ± 1.21	19.20 ± 1.67	0.973
Respiratory quotient*	1.09 ± 0.07	1.07 ± 0.05	0.351

Note. The independent samples t-test and Mann-Whitney U test were used to compare clinical parameters between groups. *Nonparametric data.

Hemodynamic reactivity

There were no differences in SBP (19 ± 8 vs19 ± 11 mmHg, p = 0.836), DBP (13 ± 5 vs 15 ± 6 mmHg, p = 0.276) and HR (12 ± 8 vs 8 ± 7 bpm; p = 0.102) reactivity to the mental stress test between higher and lower aerobic fitness groups - Figure 1. There were also no differences in the perceived stress between higher and lower aerobic fitness groups (1.60 ± 0.82 vs 1.57 ± 0.81 p = 0.966).

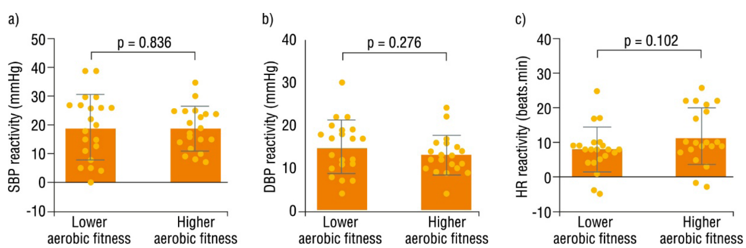

Figure 1. Systolic and diastolic blood pressure (SBP and DBP), and heart rate (HR) reactivity to the stroop color and word test. The independent samples t-test was used to compare SBP, DBP, and HR responses during mental stress. P ≤ 0.05.

The proportion of police officers who exhibited pressor and chronotropic hyperresponsiveness to the mental stress test is presented in Figure 2. Among the 41 policemen evaluated, 11 showed hyperresponsive SBP, 10 showed hyperresponsive DBP, and 10 showed hyperresponsive HR.

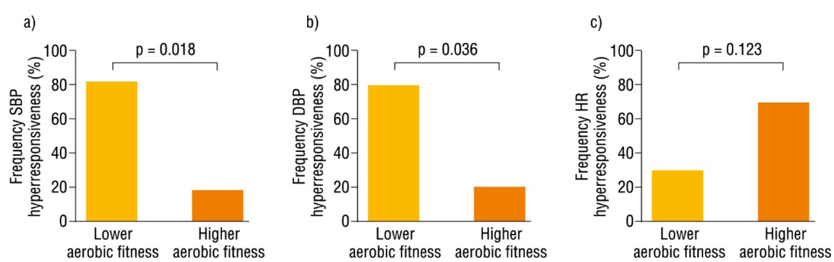

Figure 2. Percentage of police officers with pressor (BP) and chronotropic (HR) hyperresponsiveness to mental stress according to aerobic fitness. The data in the graphs refer to police exhibiting hemodynamic hyperresponsiveness (SBP = 11; DBP = 10; HR = 10). The Pearson chi-square test was used to compare the percentage of police with hemodynamic hyperresponsiveness between the low and high aerobic fitness groups. p ≤ 0.05.

Hemodynamic hyperresponsiveness

Interestingly, the high aerobic fitness group showed fewer policemen classified as hyperresponsive to mental stress compared to the low aerobic fitness group for SBP (2 [18.2%] vs n = 9 [81.8%], p = 0.018) and DBP (2 [20%] vs n = 8 [80%], p = 0.036), with no significant difference between the groups for HR hyperresponsiveness (7 [70%] vs n = 3 [30%], p = 0.123) (Figure 2).

DISCUSSION

In the present study, we evaluated whether police officers with higher levels of aerobic fitness exhibited lower pressor reactivity to mental stress. Our hypothesis was partially confirmed: although no significant difference was observed in the mean values of pressor reactivity, policemen with higher aerobic fitness showed less hyperresponsiveness to stress.

These findings are consistent, in part, with the "cross-stressor adaptation" hypothesis, which posits that regular exercise promotes adaptations in stress response systems, resulting in less intense physiological reactions to psychological stressors[25]. This theory is grounded in the similarities between central and peripheral mechanisms activated by both physical exercise and mental stressors[25].

Although this hypothesis has been widely investigated, the results remain inconsistent. One meta-analysis identified attenuated SBP and HR reactivity in individuals with higher aerobic fitness, although the study had high methodological heterogeneity[14]. Complementarily, a more recent meta-analysis demonstrated that aerobic training reduces pressor reactivity to stress, particularly in individuals with hypertension[15]. Among Swiss army recruits, higher fitness was associated with more adequate cardiac responses to acute stress[17]. On the other hand, a systematic review of studies using the Trier Social Stress Test found a significant association in only 40% of the studies, with methodological limitations regarding the measurement of fitness and heterogeneous cutoff points[16]. In police officers, Schilling et al.[26] observed lower HR variability reactivity in officers with higher levels of cardiorespiratory fitness, although aerobic fitness was estimated using a submaximal test, without direct gas analysis.

The present study is strengthened by the use of a direct measure of VO_2peak and by considering not only average reactivity values, but also the number of individuals classified as hyperresponsive. This approach contributes to a broader understanding of how aerobic fitness may modulate individual vulnerability to stress, particularly among professionals exposed to high occupational demands.

In parallel, our findings reflect results from more methodologically rigorous studies that did not identify consistent effects of aerobic fitness on cardiovascular reactivity[18,27]. In a previous meta-regression, randomized controlled trials using VO_2peak as the measure of aerobic fitness found no significant differences[18]. Similarly, after eight weeks of training, students with higher VO_2max did not exhibit attenuated HR reactivity[27].

Thus, the results of the present study align with the literature suggesting that the impact of aerobic fitness on stress reactivity may be null or small when only group means are considered. However, by identifying a lower percent of hyperresponsiveness among the fittest individuals, our study adds a relevant perspective to the literature, suggesting that an analysis of the distribution of response profiles, beyond group averages, may be a more sensitive approach to understanding the effects of aerobic fitness on cardiovascular health. In addition to the use of direct measures of aerobic fitness, our study is also strengthened by evaluating police officers, a group known to experience high levels of occupational stress.

This study presents some limitations that should be considered when interpreting the results: 1) No experimental manipulation of aerobic fitness through physical training was performed. The observed outcomes were based on comparisons between groups with previously differing fitness levels, which limited causal inference. 2) The stress test was conducted in a laboratory setting, reducing its ecological validity, as the responses may not reflect reactivity to stress in daily life. 3) Physiological parameters that could explain the mechanisms underlying the clinical responses observed were not assessed. 4) Only male police officers were investigated, limiting the generalizability of the results to female officers. Future studies with experimental designs and the inclusion of additional physiological parameters are needed to elucidate the underlying mechanisms and validate these findings in other occupational populations.

CONCLUSION

In summary, police officers with higher aerobic fitness did not exhibit lower average pressor reactivity to mental stress but showed less pressor hyperresponsiveness. These findings partially support the hypothesis that higher levels of cardiorespiratory fitness may influence cardiovascular responses to stress. Moreover, the results highlight the importance of considering not only group averages but also the distribution of response profiles, which may enhance cardiovascular health screening among professionals exposed to occupational stressors. In addition, encouraging physical training programs is necessary to maintain/improve the aerobic fitness of police officers, reduce stress reactivity and minimize the risk of hypertension.

ACKNOWLEDGEMENTS

The English text of this paper has been revised by Sidney Pratt, Canadian, MAT (The Johns Hopkins University), RSAdip - TESL (Cambridge University).

COMPLIANCE WITH ETHICAL STANDARDS

Funding

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoa de Nível Superior – Brazil (CAPES) – Financial Code 001.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Ethical approval

Ethical approval was obtained from the Human Research Ethics Committee of the Federal University of Mato Grosso (protocol number: 67074223.8.0000.8124) and the protocol was written in accordance with the standards established by the Helsinki Declaration.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conception and design of the experiment: JAA, LTC; Experiment execution: JAA, ST, DACA, KDLT, LLCBA; Data analysis: JAA. Contribution with reagents/research materials/analysis tools: LTC, ST, DACA; Article writing: JAA, ST, DACA, KDLT, LLCBA, ASD, LTC. All authors read and approved the final version of the manuscript.

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