Acute and Chronic Effects of Exercise in Health

Association between physical performance and health indicators of federal highway police officers from the state of Ceará-Brazil

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Abstract - Aim: To analyze the association between the physical performance and health parameters of highway police officers from Ceará, Brazil, and compare data from 2019 and 2020. **Methods:** We analyzed anthropometric data (body mass index - BMI), biochemical parameters (total cholesterol, triglycerides, fasting blood glucose), physical performance (sit-up, horizontal jump, push-ups, 12-min run), gender, age, and assignment data from the database of the Federal Highway Police Superintendency. Associations were tested using Spearman's correlation. A comparison between the years 2019 and 2020 was conducted using paired t-tests, Wilcoxon, and McNemar tests. **Results:** Out of 247 participants (8.5% women; 43.1 ± 6.6 years; 71.7% in operational roles), BMI data indicated that 57% were with overweight and 21.4% with obesity. Over 90% were considered fit in the physical performance tests, except for the running test, where approximately 40% did not reach the average level of physical performance. There was a reduction in physical performance between 2019 and 2020, except for the horizontal jump. The correlations were weak to moderate negative between age and all physical tests (r = -0.30 to -0.51), as well as for BMI (r = -0.16 to -0.36), in both years. The biochemical parameters had weak negative correlations with most of the physical tests, except for cholesterol. **Conclusion:** Most police officers who participated in the Federal Highway Police Physical Education program achieved average or above-average levels of physical performance. However, a decline was observed during the COVID-19 pandemic. Furthermore, BMI classification revealed concerning levels of overweight and obesity, highlighting the need for more comprehensive health evaluations.

Keywords: physical fitness, health, physical endurance, obesity.

Introduction

According to a statistical report from the World Health Organization (WHO), chronic non-communicable diseases (NCDs) were responsible for 74% of deaths that occurred globally in 2019[1]. In Brazil, according to the Noncommunicable Diseases Progress Monitor 2022, NCDs were the cause of 75% of total deaths in the country in 2019[1]. In addition to the high prevalence of NCDs, 47.2% of the Brazilian population is physically inactive[2], which is one of the modifiable risk factors in the etiology of some of these multifactorial diseases, such as diabetes, cardiovascular diseases and obesity.

Physical inactivity is characterized as not achieving physical activity recommendations in its different domains, which are: leisure, commuting, household, or work[3]. When performing their work activities, federal highway police officers engage in tasks of varying durations and types. These tasks include approaching people and vehicles, assisting highway users, handling accidents, and making arrests for traffic or criminal offenses[4]. These activities are performed while carrying, in addition to their body weight, weapons, and protective equipment, resulting in a substantial additional load of approximately 10 kg. This load is typically carried for extended periods of work, ranging from 10 to 12 hours, during 24-h shifts[5]. However, most of the police work is conducted in a sedentary manner, whether through overt patrolling in vehicles, approaching people and vehicles, or performing bureaucratic services within police units[6].

To perform tasks such as those mentioned above safely and effectively, police officers need to maintain adequate physical conditioning across various capacities, including power, strength, and cardiovascular endurance[7]. However, several studies have indicated insufficient physical fitness, excess body fat, high blood pressure, and other factors that contribute to an increased cardiovascular risk among police officers[8–10]. To enhance the quality of

life and health of its professionals, the Federal Highway Police established the Institutional Physical Education (IPE) program, in 2013. The program encourages voluntary participation in physical activities and requires an annual physical fitness assessment along with the submission of biochemical test results. Despite regular annual reassessments, there is uncertainty about the program's effectiveness in improving the health and physical condition of its participants[10], as well as whether there is an association between physical fitness performance and health among the participants.

Therefore, the primary objective of this study was to analyze the association between the physical performance and health parameters of federal highway police officers of the state of Ceará, Brazil. Additionally, the study aimed to compare the physical performance and health parameters between the years 2019 and 2020.

Methods

Study design

This is a quantitative observational study that utilized data from the database of the Federal Highway Police Superintendency of the state of Ceará. The study received approval from the research ethics committee of the Federal University of Ceará (CAAE: 70095523.1.0000.5054), with an exemption for the consent form due to the pre-existing nature of the collected data. Consent for the use of Federal Highway Police data was obtained.

Participants

The analysis focused on data from participants who underwent the physical performance test and enrolled in the IPE program in both 2019 and 2020. It is emphasized that participation in the IPE is voluntary. Due to the impact of the COVID-19 pandemic in 2020, not all individuals had complete data for both years. Therefore, to characterize participants in demographic, biochemical, and physical performance variables, and to compare them between 2019 and 2020, the total number of participants with data collected in both years was considered for each variable. For the correlation analysis, only individuals with complete data on all variables were included (n = 100). Additionally, demographic information such as age, sex, and capacity (i.e., operational or administrative) was taken into account, along with health and physical fitness data.

Assessment of health parameters

Total body mass and height were measured using a digital scale (Líder®, Brazil) and a measuring tape stadiometer (Cescorf®, Brazil), respectively. Body mass index (BMI) was calculated as an indicator of obesity, considering body weight divided by height squared (kg/m^2). Fasting blood glucose, triglycerides, and total cholesterol values were obtained from blood tests conducted in clinical analysis laboratories, covered by the expenses of the police officers participating in the IPE program.

Assessment of physical performance

The tests were conducted on a flat running track with a minimum length of 300 m. The physical fitness assessments comprised four tests in the following order: one-min sit-up, horizontal jump, one-min push-ups, and a 12-min run (Cooper test). The classification criterion for sufficient aptitude level in the tests is to achieve an index equal to or greater than three, following the internal regulations of the Federal Highway Police[11,12]. Index three is categorized as values within the average for sex and age on a five-point scale: poor, fair, average, good, and excellent. The classification is based and used on scientific evidence from the literature[9,13–15].

The procedures for the one-min sit-up test were the same for both men and women, according to previous study[16]. Participants began the test in the supine position, with knees flexed, feet on the ground positioned 30 cm away, 45 cm from the buttocks. Arms were crossed over the torso, with hands resting on opposite shoulders. To standardize the procedure, a person provided support on the feet for greater stability during the repetitions. The total number of valid repetitions performed in one min was considered, with participants flexing the spine until the elbow joint touched the patella and returning to the starting position.

The countermovement horizontal jump test, as an indirect measure of lower limb muscle power[17], followed the same procedures for men and women. Participants began in a standing position with feet separated and parallel (approximately 10 to 20 cm), positioned behind an exit line (5 cm wide - part of the value to be measured). In preparation for the jump, participants were allowed to swing their arms back and bend their knees. The jump was executed by extending the lower limbs during the movement. The distance achieved was measured from the initial reference line to the first point where the participant's body contacted the ground.

The one-min push-up test, to assess the muscular resistance of the upper limbs[16], followed varied procedures for men and women. For men, the test began in the prone position, arms outstretched, hands facing forward in line with the shoulders, legs together, and spine with preserved curvatures. From this position, they flexed their elbows, bringing their chest close to the floor, and then returned to the starting position. For women, the difference was the starting position on six supports, with the knees on the ground. The maximum number of valid repetitions performed in one min was then counted.

Lastly, was performed the Cooper 12-min run aimed to indirectly measure cardiorespiratory capacity[14]. The

protocol was the same for both men and women, with distances marked every 50 m. The next mark surpassed by the individual was considered as the result. The total distance covered during the 12-min duration was then measured.

Statistical analysis

Continuous data are presented as mean ± standard deviation, while categorical data are presented as absolute and relative frequency. Data normality was assessed using the Kolmogorov-Smirnov test. Due to the absence of normality for most variables, associations between health parameters and physical performance were evaluated using the Spearman correlation test for continuous data. Correlations were categorized as weak (0.1 to 0.35 or -0.1 to -0.35), moderate (0.36 to 0.67 or -0.36 to -0.67), or strong (0.68 to 1 or -0.68 to -1)[18]. To compare data between 2019 and 2020, a paired t-test was applied to the total body mass variable, the only one with normality. The Wilcoxon test was used for the other continuous variables. The McNemar test was employed for the categorical index variable of physical fitness tests. All analyses were conducted using the Statistical Package for Social Science (IBM SPSS Statistics, USA), version 21.0.

Result

We analyzed data from 247 federal highway police officers, of whom 226 (91.5%) were male. Among them, 177 (71.7%) were operational, with a mean age of 43.1 ± 6.6 (ranging from 29 to 68). Sociodemographic, health, and physical performance parameters are detailed in Table 1. Taking into account missing data, the table presents the total 'n' for each variable, based on valid data for both 2019 and 2020.

According to BMI, approximately 57% were classified with overweight, while 21% were identified with obesity in both years. In 2019, total cholesterol exceeded the normative threshold (i.e., > 190 mg/dL), and values increased in 2020 (p = 0.001). Fasting blood glucose, on average, was slightly elevated in 2019 compared to the normative criteria (i.e., < 100 mg/dL), with no significant variation observed in 2020. Additionally, triglyceride values showed no significant change from 2019 to 2020 (p = 0.115), remaining within the normative cut-off point (i.e., < 150 mg/dL).

Regarding physical performance, there was a significant reduction from 2019 to 2020 in the values of the sit-up (p = 0.00), push-up (p = 0.002), and 12-min run (p = 0.008) tests. Conversely, there was a significant

Table 1 - Demographic, health, and physical performance characteristics of the sample.

Characteristic	2019	2020	*p*
Height (m), n = 247	1.7 ± 0.6	1.7 ± 0.6	-
Total body mass (kg), n = 247	82.8 ± 11.8	83.1 ± 12.3	0.167
Body mass index (kg/m^2), n = 247	27.8 ± 3.2	27.8 ± 3.3	0.804
Overweight, n (%)	141 (57.5)	142 (57.4)	-
Obesity class I, n (%)	53 (21.4)	53 (21.4)	-
Obesity class II, n (%)	5 (2.0)	5 (2.0)	-
Obesity class III, n (%)	1 (0.4)	1 (0.4)	-
Sit-up (reps), n = 243	34.5 ± 8.9*	32.2 ± 9.9	0.000
Index < 3, n (%)	10 (4)	20 (8.1)	0.031
Index ≥ 3, n (%)	237 (96)	227 (91.9)	
Push-up (reps), n = 239	31.1 ± 10.6*	29.9 ± 10.6	0.002
Index < 3, n (%)	11 (4.5)	17 (6.9)	0.180
Index ≥ 3, n (%)	236 (95.5)	230 (93.1)	
12-min run (m), n = 237	1958.2 ± 378.6*	1910.1 ± 409.8	0.008
Index < 3, n (%)	98 (39.7)	105 (42.5)	0.382
Index ≥ 3, n (%)	149 (60.3)	142 (57.5)	
Horizontal jump (m), n = 235	1.9 ± 0.7*	2.1 ± 0.2	0.000
Index < 3, n (%)	21 (8.5)	15 (6.1)	0.307
Index ≥ 3, n (%)	226 (91.5)	232 (93.9)	
Total cholesterol (mg/dL), n = 100	190.7 ± 39.0*	200.3 ± 36.9	0.001
Fasting blood glucose (mg/dL), n = 104	103.9 ± 92.6	93.5 ± 12.4	0.739
Triglycerides (mg/dL), n = 103	135.5 ± 83.2	139.5 ± 79.6	0.115

Index < 3: the score classifies the participant as not fit (below average); Index ≥ 3: the score classifies the participant as fit (within average, or above average); *significantly different from 2020, p < 0.05.

increase in the result of the horizontal jump test (p = 0.00). More than 90% of the sample reached index three in the tests, except for the running test, for which the percentage varied from 60.3% to 57.5% between 2019 and 2020. In addition, there was a significant reduction in the percentage of participants categorized as index three in the sit-up test between the years.

Finally, moderate negative correlations were identified between age and performance in the physical fitness tests, except for a weak correlation with the 12-min run test (see Table 2). In both years, BMI showed a negative and weak correlation with the push-up test and the horizontal jump. However, it exhibited a negative and moderate correlation with the run test. The correlation with the sit-up test ranged from weak to moderate from 2019 to 2020. The biochemical parameters assessed demonstrated a negative and weak correlation with most of the conducted physical tests, except for cholesterol, which exhibited no correlation in 2019 and 2020. Additionally, the categorization of police officers into operational or administrative roles showed no correlation with physical fitness, biomarkers, and anthropometric data analyzed.

Discussion

This study describes the physical performance and health indicators of federal highway police officers in Ceará and compares data between the years 2019 and 2020. The sample consisted of police officers participating in the IPE program, which aims to maintain adequate physical conditioning and prevent NCDs. While these officers might be expected to be healthy and physically fit, caution is warranted when evaluating the program's effectiveness, as the study did not include a control group. Although 57.5% of police officers were classified with overweight and 23.8% with obesity based on their BMI, on average, they met the minimum physical fitness standards set by the Federal Highway Police.

The high prevalence of overweight and obesity observed in police officers is not a recent problem and has been previously identified. Studies in different cities in Brazil corroborate the data from the present study. In a cross-sectional study with 64 male federal highway police officers from Pelotas - RS, 23 of them (56.1%) were overweight, and 11 (26.8%) were obese[10]. In Russas - CE, out of 81 military police officers, 11 (14%) were classified with normal BMI, 50 (62%) with pre-obesity, and 20 (24%) with obesity[19]. Furthermore, in Barra do Garças - MT, 66.9% of police officers were classified as overweight and 16% as obese[20]. In police officers of Cianorte - PR, the prevalence of overweight and obesity was 54.9% and 16.5%, respectively[21]. Finally, in a large sample of the military police of the state of São Paulo, with 1,466 individuals, the prevalence of overweight and obesity was 47.2% and 29.7% in men, and 35.2% and 16.6% in women, respectively[22]. Thus, it appears that there is a pattern among states in the prevalence of overweight and obesity among federal highway police officers, which may be associated with exposure to their work routine.

Epidemiological studies have demonstrated overweight and obesity, classified by BMI, as a risk factor for NCDs, including cardiovascular diseases, diabetes mellitus, kidney disease, various types of cancer, and a series of musculoskeletal disorders[23]. Such health conditions may be more prevalent in police officers than in the general population, attributed to factors such as sleep deprivation due to shift work, physical inactivity, and stress[24]. This condition has been evident not only among Brazilian

Table 2 - Correlation between physical performance. health and demographic parameters. in the years 2019 and 2020 (n=100).

	Sit-up	Push-up	12MR	HJ	TC	TGL	FG
				2019			
Age	-0.50 (0.000)*	-0.53 (0.000)*	-0.32 (0.000)*	-0.45 (0.000)*	-0.014 (0.889)	0.33(0.001)*	0.40 (0.000)*
BMI	-0.30 (0.000)*	-0.27 (0.000)*	-0.49 (0.000)*	-0.16 (0.013)*	0.08 (0.383)	0.27 (0.005)*	0.30 (0.002)*
Assignment	-0.35 (0.591)	-0.05 (0.441)	0.05 (0.430)	-0.10 (0.110)	-0.16 (0.109)	-0.24 (0.012)*	-0.15 (0.107)
TC	0.174 (0.083)	0.11 (0.241)	-0.16 (0.116)	-0.02 (0.797)	-	-	-
TGL	-0.18 (0.063)	-0.22 (0.022)*	-0.23 (0.020)*	-0.12 (0.237)	-	-	-
FG	-0.23 (0.026)*	-0.22 (0.026)*	-0.19 (0.057)	-0.30 (0.002)*	-	-	-
				2020			
Age	-0.48 (0.000)*	-0.51 (0.000)*	-0.30 (0.000)*	-0.48 (0.000)*	-0.019 (0.853)	0.214 (0.029)*	0.33 (0.001)*
BMI	-0.36 (0.000)*	-0.24 (0.000)*	-0.38 (0.000)*	-0.29 (0.000)*	0.21(0.029)*	0.34 (0.000)*	0.11 (0.235)
Assignment	0.08 (0.193)	0.03 (0.598)	0.04 (0.455)	0.03 (0.604)	-0.03 (0.747)	-0.17 (0.073)	-0.10 (0.291)
TC	-0.55 (0.588)	0.003 (0.977)	-0.18 (0.066)	0.11(0.264)	-	-	-
TGL	-0.22 (0.023)*	-0.24 (0.015)*	-0.31 (0.001)*	-0.12 (0.203)	-	-	-
FG	-0.25 (0.011)*	-0.21 (0.028)*	-0.07 (0.461)	-0.14 (0.167)	-	-	-

12MR: 12-min run test; TC: total cholesterol; TGL: triglycerides; FG: fasting blood glucose *p < 0.05 significant correlation.

police officers but also in different countries[25,26]. In the present study, we used BMI to classify nutritional status, as it is a practical, more accessible, and low-cost measure, though it has limitations in differentiating tissue types and identifying the location of adipose tissue[27,28]. Therefore, the data suggest a need for more in-depth and detailed investigations into obesity among police officers.

In the analysis of biochemical markers between 2019 and 2020, we observed that there was no significant variation in average triglyceride values, which remained within normative cut-of point. A similar trend was observed with blood glucose, although the value of this marker classified the sample as pre-diabetes, in 2019, according to the guidelines of the Brazilian Diabetes Society[29]. Fasting blood glucose levels characteristic of pre-diabetes are associated with a higher cardiovascular risk, justifying institutional actions to identify individuals at greater risk. The presence of additional risk factors such as age over 45 years, obesity, high blood pressure and physical inactivity, conditions that coexist in the evaluated sample, further increases the risk of diabetes[29].

In relation to total cholesterol, there was a significant increase between the two years. In 2019, the sample average was already considered above the normative cutoff point by the Guidelines of the Brazilian Society of Cardiology[30]. These results are concerning, as elevated total cholesterol levels are considered a cardiovascular risk factor[31]. In federal highway police officers, cardiovascular diseases were the main cause of death among active officers (39.7%) between 2001 and 2020[26].

Regarding performance in physical tests, except for the horizontal jump test, values decreased between the years evaluated. There was a decline in abdominal and upper limb muscular resistance. However, the significant majority of participants in both years were considered physically fit based on the tests, a finding corroborated by a previous observational study involving 6212 federal highway police officers who participated in the national physical tests in 2016[32]. Physical activities in police actions, such as running, pushing, pulling, carrying, and dragging, are strongly correlated with muscular resistance[26]. Furthermore, low levels of muscular resistance may be considered a risk factor for injuries in army soldiers undergoing basic combat training and are associated with the incidence of low back pain in police officers[33].

The results of the 12-min run test decreased from 2019 to 2020. It is important to consider that the data from the year 2020 corresponds to the COVID-19 pandemic period, during which lifestyle changes occurred due to restrictive measures on the use of spaces and gatherings. However, in both years, unlike other tests in which the most of participants were considered physically fit, only approximately 60% reached the distance covered in the reference values for their sex and age. It is concerning that almost 40% of the sample did not reach adequate levels in a cardiorespiratory fitness test. Such results may be related to the characteristics of the test, in terms of duration and the type of continuous cyclical movement, which differ from the intermittent nature of routine police activities. Higher cardiorespiratory fitness values are closely linked to cardiovascular health, overall well-being, and a reduced risk of injuries or illnesses in a police officer[34]. These data highlight the need for institutional programs promoting exercise aimed at improving cardiorespiratory capacity.

According to the correlation data, it was observed that BMI showed a weak or moderate negative correlation with resistance tests for the abdominal, upper and lower limbs, as well as horizontal jumping, in 2019 and 2020. A negative and moderate correlation was observed during the analyzed period for the running test. These findings align with previous results from a study conducted with 495 North American highway police officers, where anthropometric tests and physical assessments, including push-ups, sit-ups, and vertical jump, among others, revealed that BMI was significantly higher in the less fit group compared to the fitter group[35]. Another study, involving 1826 male and 115 female North American police officers, discovered that body fat was inversely associated with fitness in each individual test, particularly in officers with high BMI. This association was observed irrespective of age, sex, or ethnicity[36].

Finally, age showed a moderate negative correlation with all physical fitness tests, except the 12-min run test, whose correlation was weakly negative. These findings corroborate the results found in a study with data from the national physical test in 2017, involving 7,044 men and women, which identified a general decline in average performance for older police officers in muscular strength, power of lower limbs, and cardiorespiratory fitness[15]. The association of aging with declines in aerobic and neuromuscular fitness is well established in the literature. In police officers, a study demonstrated that individuals aged over 38 years old exhibited lower performance in the horizontal jump, abdominal muscular resistance, aerobic capacity, and isometric strength and power compared to their younger counterparts[37]. Our data reinforce the relationship between age and physical performance, emphasizing the necessity for prevention and health promotion strategies among police officers. This is particularly crucial, given that a significant portion of the group is aged over 40 years old.

This study is not without limitations. As a cross-sectional study, it is constrained in determining causal relationships. The BMI measurement has limitations. Moreover, it's crucial to note that due to the COVID-19 pandemic, the requirement for submitting biochemical tests was suspended in 2020, resulting in many police officers not providing this data and significantly reducing the sample size. On the positive side, this is the first study to

analyze health parameters in federal highway police officers specifically in Ceará, as well as their relationship with performance in physical fitness tests.

Conclusions

According to the reference values established by the internal regulations of the Federal Highway Police, most officers participating in the IPE program demonstrated physical fitness levels that were average or above. However, a significant portion of the sample showed below-average cardiorespiratory capacity. When comparing the years 2019 and 2020, a decline in performance was observed, likely influenced by changes in lifestyle habits during the COVID-19 pandemic. The IPE program primarily advises and encourages physical activity but does not provide a structured or supervised exercise regimen. This highlights the need for program enhancements and comprehensive evaluations of its long-term effectiveness. Furthermore, our study revealed that more than half of the Federal Highway Police officers in Ceará are classified as overweight, with 20.1% categorized as obese as BMI, indicating the need for more in-depth health assessments.

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Manuscript received on November 22, 2023
Manuscript accepted on December 27, 2024