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Originales

Does physical effort affect the cognitive performance of police officers?

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ABSTRACT

Objective: The duty of police officers involves various cognitive processes, especially when it is necessary to use a firearm, which is usually preceded by foot pursuits. Hence, it is important to understand whether physical exertion impairs police officers' cognitive performance. We aimed to evaluate the effect of physical exertion on cognitive performance in police officers.
Methods: The sample consisted of 14 male police officers (34.0±5.6 years old; 81.8±9.0 kg; 172±5.79 cm; 27.8±2.3 kg/m^2; 44 .9±4.1 ml. kg^{-1}.min^{-1}) with ≥ 6 years of experience. Participants ran a ~300 m course simulating a foot chase. Cognitive performance was evaluated using the Stroop test, which measures inhibitory control and selective attention, before and after physical exertion. The response time (RT) and accuracy for the neutral, congruent, and incongruent stimuli were used for the analysis. The Stroop interference (difference between neutral and incongruent stimuli) was also measured.
Results: There was no significant change from pre- to post-exertion in RT and accuracy for congruent (all p>0.62), neutral (all p>0.77), or incongruent trials (all p>0.15) of the Stroop test as well as the Stroop interference when considering RT (p=0.594) or accuracy (p=0.826).
Conclusions: These findings indicate that physical effort does not affect police officers' cognitive performance. Future research should explore the influence of physical effort performed while utilizing duty-related equipment, the nature and length of the effort, and the effect of physical effort on other cognitive functions/domains, as well as including randomized controlled designs.

Keywords: Cognition; physical exertion; inhibitory control; police officers.

¿El esfuerzo físico afecta el rendimiento cognitivo de los agentes de policía?

RESUMEN

Objetivo: El deber de los oficiales de policía implica varios procesos cognitivos, especialmente cuando es necesario usar un arma de fuego, lo cual suele estar precedido por persecuciones a pie. Por lo tanto, es importante entender si el esfuerzo físico afecta el rendimiento cognitivo de los oficiales de policía. Nuestro objetivo fue evaluar el efecto del esfuerzo físico en el rendimiento cognitivo de los oficiales de policía.
Métodos: La muestra consistió en 14 oficiales de policía masculinos (34,0±5,6 años; 81,8±9,0 kg; 172±5,79 cm; 27,8±2,3 kg/m^2; 44,9±4,1 ml.kg^{-1}.min^{-1}) con ≥ 6 años de experiencia. Los participantes corrieron un recorrido de ~300 m simulando una persecución a pie. El rendimiento cognitivo se evaluó utilizando la prueba Stroop, que mide el control inhibitorio y la atención selectiva, antes y después del esfuerzo físico. El tiempo de respuesta (TR) y la precisión para los estímulos neutrales, congruentes e incongruentes se utilizaron para el análisis. También se midió la interferencia Stroop (diferencia entre estímulos neutrales e incongruentes).
Resultados: No hubo cambios significativos de antes a después del esfuerzo en el TR y la precisión para las pruebas congruentes (todos p>0,62), neutrales (todos p>0,77) o incongruentes (todos p>0,15) de la prueba Stroop, así como la interferencia Stroop al considerar TR (p=0,594) o precisión (p=0,826).
Conclusiones: Estos hallazgos indican que el esfuerzo físico no afecta el rendimiento cognitivo de los oficiales de policía. Investigaciones futuras deberían explorar la influencia del esfuerzo físico realizado mientras se utiliza equipo relacionado con el deber, la naturaleza y duración del esfuerzo, y el efecto del esfuerzo físico en otras funciones/dominios cognitivos, así como incluir diseños controlados aleatorios.

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Palabras clave: Cognición; esfuerzo físico; control inhibitorio; oficiales de policía.

O esforço físico afeta o desempenho cognitivo dos policiais?

RESUMO

Objetivo: O dever dos policiais envolve vários processos cognitivos, especialmente quando é necessário usar uma arma de fogo, o que geralmente é precedido por perseguições a pé. Portanto, é importante entender se o esforço físico prejudica o desempenho cognitivo dos policiais. Nosso objetivo foi avaliar o efeito do esforço físico no desempenho cognitivo dos policiais.

Métodos: A amostra consistiu em 14 policiais masculinos (34,0±5,6 anos; 81,8±9,0 kg; 172±5,79 cm; 27,8±2,3 kg/m^2; 44,9±4,1 ml.kg^{-1}.min^{-1}) com ≥ 6 anos de experiência. Os participantes correram um percurso de ~300 m simulando uma perseguição a pé. O desempenho cognitivo foi avaliado usando o teste Stroop, que mede o controle inibitório e a atenção seletiva, antes e depois do esforço físico. O tempo de resposta (TR) e a precisão para os estímulos neutros, congruentes e incongruentes foram usados para a análise. A interferência Stroop (diferença entre estímulos neutros e incongruentes) também foi medida.

Resultados: Não houve mudança significativa de pré para pós-esforço no TR e na precisão para os testes congruentes (todos p>0,62), neutros (todos p>0,77) ou incongruentes (todos p>0,15) do teste Stroop, assim como a interferência Stroop ao considerar TR (p=0,594) ou precisão (p=0,826).

Conclusões: Esses achados indicam que o esforço físico não afeta o desempenho cognitivo dos policiais. Pesquisas futuras devem explorar a influência do esforço físico realizado enquanto se utiliza equipamento relacionado ao dever, a natureza e a duração do esforço, e o efeito do esforço físico em outras funções/domínios cognitivos, bem como incluir desenhos controlados randomizados.

Palavras-chave: Cognição; esforço físico; controle inibitório; policiais.

Introduction

Police officers work daily in the cities, dealing mostly with criminal-related actions. Their duties are similar around the world,[1] and the level of work-related risk can vary among locations (e.g., local crime rate). Police officers deal with an unpredictable environment, stressful situations, and high levels of anxiety during work[2]. Motor vehicles, horseback riding, and even foot chases can be used in their actions, but regardless of the situation, police officers have the precedent for the use of firearms in the prevention and repression of violent acts and/or with potential collateral damage in armed conflicts (e.g., shooting between criminals and the police, hostage situation, etc.), in the interest of citizen safety, as well as the defense of public property and their own lives. Like other aspects of police duties, shooting depends on several key physiological and cognitive processes, which are especially important in scenarios involving the use of firearms.

Cognitive functions are present in a police officer's daily life and must be preserved due to the dangers involved in their occupation. Working memory (e.g., keeping recent information about an individual, vehicle, and/or address characteristics, instructions, or other relevant details active in mind)[3] and attention[4] (i.e., divided attention, focused attention; e.g., search and/or identification of illicit/suspicious activities) are two of these functions needed during the work required by the police. Processing speed[5] (e.g., the ability to process information fast) is another crucial cognitive skill that police officers must have because any relevant information from on-duty calls must be processed quickly. Dual tasking[6,7] (e.g., driving and responding to the radio at the same time) and decision-making (e.g., deciding when and how to act) are other examples of cognitive skills necessary for police personnel. Furthermore, inhibitory control is required when it is constantly necessary to suppress urges to make impulsive actions.[4,8] Failures in this executive function might result in more impulsive actions and/or errors, increasing the hazards to themselves, their team, civilians, and personal well-being.

Similar to cognitive performance, physical exertion is often present in the police's routine. Although regular exercise, particularly aerobic exercise, can improve cognitive performance in different populations,[9,10] the acute effect appears to be dependent on the intensity of the effort, individual fitness level, and timing of assessment.[11] For example, while a maximum incremental test did not affect cognitive performance in physically active individuals,. untrained individuals had lower cognitive levels while performing high-intensity exercise.[12] Elite athletes, on the other hand, appear to have beneficial adaptations in cognitive performance to maintain it even under conditions of high physical effort and/or muscle fatigue.[13] Such scenarios, however, do not fully represent the reality experienced by police officers, which is a population with a specific level of physical fitness required for the role but who is not generally similar to a high-performance athlete.

In this regard, studies have demonstrated that police officers' shooting performance (number of hits per shot/number of points per shot) does not decline and may even improve after physical exertion.[14] Moreover, physical exertion appears to affect performance in mathematics tasks and shooting-related decision-making during simulated combat situations, according to a study with infantrymen.[15] However, research on the impact of physical exertion that closely resembles police officers' regular activities on cognitive function is relatively limited. Such information is critical in light of the potential impact of physical effort on cognitive performance and its relevance to this population's involvement in urban life. A deterioration in inhibitory control processes, processing speed, and attention can be detrimental to police activity, particularly when utilizing a firearm that requires recognizing a potentially dangerous situation, correctly selecting a target, aiming, and responding quickly and accurately to events that may develop. Hence, the current study sought to assess the impact of physical effort on cognitive function in police officers. We hypothesized that physical activity would impair cognitive performance.[15]

Materials and methods

Study design

This cross-sectional and quasi-experimental investigation took place in two sessions. The first session included an anthropometric evaluation (height, weight, and BMI) and cardiorespiratory fitness testing. In the second session, participants completed a cognitive test (the Stroop test) before and after completing a running exercise that simulated a foot chase. Participants were asked not to consume caffeine, or alcohol, and not to engage in physical activity in the 24 hours preceding the evaluations. The Institutional Ethics Committee approved the study (protocol number: 752.339; CAAE: 31266114.3.0000.5537) and it was conducted following the Declaration of Helsinki. All participants signed an informed consent form before being admitted to the study.

Sample

The sample consisted of 14 male police officers (34.0 ± 5.6 years old; 81.8 ± 9.0 kg; 172 ± 5.79 cm; 27.8 ± 2.3 kg/m^2; 44 .9 ± 4.1 ml.kg^{-1}.min^{-1}) with ≥6 years of experience. The police officers were recruited by convenience from a military group in Natal, RN, Brazil. The inclusion criteria were as follows: being a member of the Police working in ostensive urban policing; having a body mass index (BMI) of <30 kg/m^2; not having musculoskeletal problems that could preclude the performance of physical exertion tests; and not taking medications that alter heart rate (HR). Eighteen police officers participated in the study, three withdrew due to scheduling constraints and one was excluded due to missing data (i.e., software-related problems).

Anthropometric and cardiorespiratory fitness assessment

Body mass, in kilograms, was measured using a digital scale (Welmy®, W110H, Santa Bárbara do Oeste, SP, Brazil), and height was measured in centimeters using a stadiometer attached to the scale. Additionally, BMI was calculated using the ratio between weight and the square of height.

Peak oxygen consumption (VO_{2peak}) was evaluated in a maximum incremental test with progressive speed on a treadmill (Inbramed, ATL, Porto Alegre, RS, Brazil). Before the test, participants performed a five-minute warm-up at a constant speed of 5 km.h^{-1} without inclination. The test started with a speed of 8 km.h^{-1} and increments of 1 km.h^{-1} every minute until volitional exhaustion. The test was considered maximal when ≥2 of the following criteria was met: (1) perceived exertion ≥19 on the Borg scale (6-20), (2) ≥95% of predicted maximum HR (220-age), (3) ratio of respiratory exchanges >1.1. The HR was continuously monitored during the test using a cardiac monitor (RS800cx, Polar Electro OU, Kempele, Finland). Gas exchange analysis was performed by an automatic breath-by-breath gas analyzer (Cosmed, Quark CPET, Rome, Italy). Following the manufacturer's recommendations, the device was calibrated before each measurement using a sample of standard gases and a 3L syringe. After the test, a 20-second average was applied to the raw data for further analysis. The highest average value of 20 seconds during the incremental test was considered as VO_{2peak}.

Assessment of cognitive performance

Selective attention, inhibitory control, and processing speed were assessed using a computerized version of the Stroop color-word test (TESTINPACS®)[16]. The test shows two response options, which are selectable using the keyboard's left (<) and right (>) directional buttons (Figure 1). The test is divided into three blocks of 12 stimuli each. In the congruent block, the participant must select the name of the rectangle's color displayed. In the neutral block, the participant must indicate the color's name printed in white ink. In the incongruent block, the participant must indicate the font color while ignoring the color's name (word interference). Response time (RT) and accuracy were automatically recorded in a spreadsheet. The RT of the correctly answered stimuli and the percentage of correct answers were considered for analysis. Additionally, we calculated the difference in RT and the number of errors between the incongruent and neutral phases to determine the Stroop effect/interference as a measure of inhibitory control. Before test administration, individuals received a verbal explanation of the test's objectives and procedures and performed three attempts to familiarize themselves.

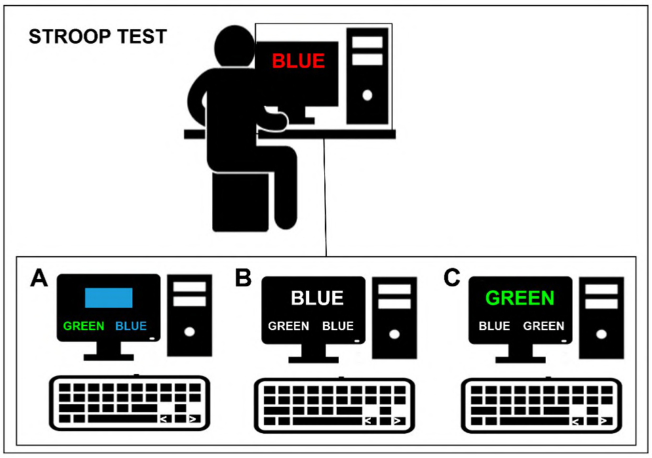

Figure 1. Stroop Test panel – A = Congruent stimuli block, B = Neutral stimuli block, C = Incongruent stimuli block

Running Circuit

Participants ran a 297-meter course (Figure 2) with five obstacles to mimic a foot chase: (1) going up and down a soft sand hill approximately 30 meters similar to a dune (15 m uphill and 15 m downhill); (2) after running in a straight line, participants entered a room construction and exited jumping over a wall approximately 1.2 m height; (3) perform a sinuous race (zigzag) between three flagpoles positioned one meter apart from each other; (4) take the kneeling shooting position (one knee on the ground, the other bent forward to provide support) in four locations delineated by cones two meters apart, in an approximate Z shape; (5) cross the first obstacle of the circuit in the opposite direction, ending at the same starting point. Participants were encouraged to complete the circuit in the shortest amount of time possible, and verbal encouragement was provided throughout the test. A digital stopwatch was used to record their time to finish the course, and HR was continually recorded. The officers were dressed in light clothing and shoes appropriate for physical exercise.

Figure 2. Running circuit map; Satellite image, obtained through Google Maps, of the place where the physical effort was carried out and edited with the indication of obstacles on the track. Zero (0) indicates the starting and ending point near which the shooting tests were carried out. The arrows indicate the direction of running. The numbers correspond to the type of

obstacle: (1) up/down a sandy soil; (2) entering a room and jumping over a 1-meter-high wall; (3) zigzag running using flagpoles; (4) four repetitions of kneeling shooting aiming; (5) up/down a sandy soil.

Statistical Analysis

Data were reported as mean and standard deviation for parametric data and median and interquartile range for non-parametric data, according to the analysis of data normality using the Shapiro-Wilk test. The student's t-test was used to compare the RT for each stimuli type before and after physical exertion and the Stroop Effect for this variable. The Wilcoxon test was used to compare the accuracy and Stroop effect of the pre- and post-physical exertion. All statistical analyses were performed using SPSS 28.0, adopting p<0.05.

Results

The paired t-test confirmed that the RT of the incongruent trials was significantly higher than the neutral trials both before (p=0.001) and after (p<0.001) exercise. This confirms that the Stroop test used induced the Stroop effect. Participants completed the running task in 75.4 ± 4.5 seconds and reached approximately 85% of the maximum HR.

Concerning the cognitive performance before and after the physical effort, there were no significant differences in RT for any stimulus types (all p>0.05; Figure 3). Similarly, there were no significant differences between accuracy before and after physical exertion (all p>0.05; Figure 3). Finally, there was also no difference in inhibitory control (Stroop interference) when comparing the additional errors [-4.5% (-17 - 0.00) vs. -16.0% (-25 - 0.00); Z=-0.22; p=0.826] or the additional RT [376.0±373 vs. 320±258 t(13) = 0.547, p = 0.594] before and after exercise, respectively.

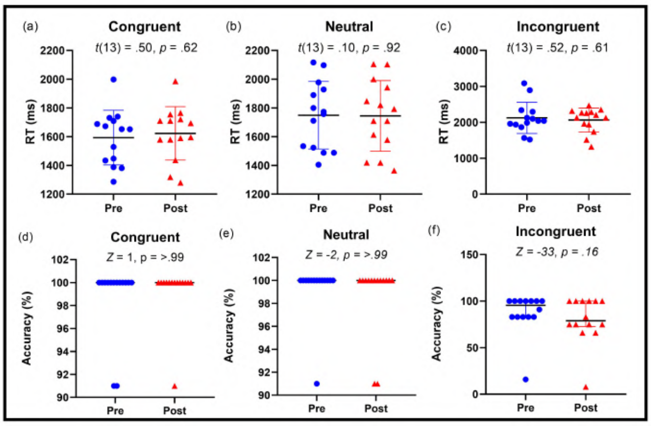

Figure 3. Reaction time (RT) and accuracy comparison between before and after physical effort in police officers for congruent, neutral, and incongruent stimuli of the Stroop test.

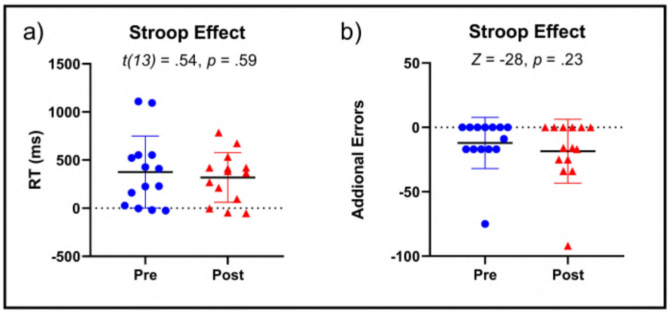

Figure 4. Comparison of the Stroop Effect (incongruent minus neutral stimuli) in terms of reaction time and accuracy (i.e., additional errors committed) before and after physical effort in police officers.

Discussion

This study aimed to investigate whether physical effort, replicating a daily situation of a police foot chase, would impair the cognitive function of military police officers. The current investigation found no evidence of a significant effect of effort on inhibitory control (i.e., RT and accuracy). Even under the acute effect of high-intensity physical exercise (85% HRmax), the police officers maintained their cognitive performance, namely inhibitory control. This suggests that the physical effort performed in the present study was not an agent with a significant negative effect on cognitive performance, particularly when measuring the reaction time and/or accuracy of individuals in the Stroop Test.

The lack of significant changes in accuracy after physical effort contrasts with Nibbeling et al.,[15] which found a performance impairment in mathematics tasks and shooting decision-making in infantry soldiers during simulated conflict situations after they performed physical effort on an obstacle course. The difference between studies may be explained by the cognitive function assessed (i.e., inhibitory control vs. math skills), weapon characteristics (i.e., pistol (short barrel) vs. rifle (long barrel), and sample characteristics (i.e., experienced military police vs. recruit soldiers). Considering that the cognitive capacity used in mathematical skills may not be directly related to actions performed in a shooting context or a typical policing situation, the use of this cognitive function may not be highly required in this context, despite evidence demonstrating a negative change in cognitive performance after physical exertion in a population similar to police officers.

In terms of physical effort, exercise-induced fatigue, and shooting, it should be noted that while controlling impulsive responses is important in police officers duties, particularly when using firearms (i.e., impulsive shooting control), slow or delayed decision-making can also be harmful (i.e., deciding to shoot when the shot fired will no longer inhibit a lethal criminal action for victims or police) as seen in previous studies.[17] Nibbeling et al.,[15] demonstrated that exercise can protect against the negative effects of excessive anxiety on decision-making performance in infantry soldiers. However, the effect of physical exercise without creating significant anxiety levels has not been studied.[15] Considering the proposed association, it is possible to suggest that interventions aimed at enhancing cognitive function in military personnel may also benefit shooting performance, even though the current study did not examine shooting-related decision-making. Future research should investigate this link and the impact of interventions to manipulate such variables.

Despite the hypothesis that physical effort would impair cognitive function, some factors may have been critical in causing the results to be unexpected. The exercise intensity may have been a decisive factor, because despite being instructed to complete the circuit at the fastest possible speed (and thus at the highest intensity), some police officers may have avoided attaining their real maximum intensity during the test. Furthermore, no external stress was imposed on the volunteers compared with real-life chasing scenarios, where the level of effort can vary as well as the internal and external sources of stress. Hence, the current results might have resulted from the design of the physical test performed in the current study. Despite the attempt to reproduce an ecological situation, the characteristics of the effort undertaken may not have been sufficient to reproduce what the police may encounter in the 'real world'. Perhaps another effort structure, such as a combination of anaerobic and aerobic effort (e.g., longer distance, test with endurance characteristics, more obstacles, etc.), would be better for inducing a higher level of physical fatigue, thus providing a more accurate measurement of the effort-cognition relationship. Furthermore, the duration of the effort may have been responsible for the lack of a significant worsening of cognitive functions during the tests because even at relatively high intensity, the phenomenon of fatigue was not reached,[18] which would facilitate the maintenance, or even improvement, of cognitive performance.

Another possibility for rejecting our hypothesis was that the cognitive test utilized in the evaluation did not exhibit the appropriate level of difficulty for measuring cognitive function (i.e., it was too easy). This is indicated by the accuracy of 100% before and after exercise for congruent and neutral blocks and over 75% for incongruent blocks. The relatively large RT also suggests a trade-off between RT and accuracy. In this regard, Diamond. suggested that cognitive tests with separate stimuli types (congruent, neutral, and incongruent blocks) may not be the best test structure for measuring inhibitory control because the individual, theoretically, would not fully use his inhibitory control while keeping a single active rule in mind (e.g., congruent phase: associate the font color with the responded color and get the answer right, etc.). This might be seen when comparing the utilization of blocks of specific versus mixed stimulus types within blocks. Another possible alternative to increase the test difficulty viable alternative would be to increase the number of possible responses to the stimuli. The test used in the present study had two response options. However, if four response options were available, one for each of the possible colors in the Stroop Test, individuals would be more prone to make mistakes due to not being able to inhibit an impulsive and incorrect response, resulting in a better balance of working memory and inhibitory control. Future studies should consider the cognitive test structure when trying to replicate and/or expand this finding.

The fact that the running task was performed in light clothing and running shoes can be considered a limitation because police officers use several pieces of equipment that add extra weight and may increase fatigue and reduce mobility. In fact, it has been demonstrated that carrying more weight, and for a longer time, seems to affect cognition (i.e., working memory and inhibitory control) in military men and women at moderate-intensity marches.[19] It should also be highlighted that we measured only inhibitory control, which is one measure among several executive function abilities from a single cognitive domain. As a result, the effect of physical exertion may differ depending on cognitive functions and domains assessed. Moreover, the lack of a control session, for example, without physical exertion, performed in randomized order, is a limitation of the present study, as it does not allow for control for the effect of potentially confounding variables, such as a learning effect of the cognitive test. However, it should be noted that aiming to decrease any learning effect, besides fully explaining the cognitive test objectives and procedures, participants performed the Stroop test three times to familiarize themselves and learn how to perform the test. Researchers should consider such constraints when designing future studies with comparable objectives. On the other hand, the findings point to the importance of maintaining cognition in a high-risk position like military police because it avoids multiple collateral effects if skills like inhibitory control, working memory, attention, and processing speed are compromised. The present study adds to the existing literature on the acute effect of high-intensity physical exertion in a trained, non-athlete population, but with a direct influence on urban life.

The current study's findings indicate that physical effort does not affect police officers' cognitive performance. Future research should explore the influence of physical effort performed while utilizing duty-related equipment, the nature and length of the effort, and the effect of physical effort on other cognitive functions/ domains, as well as including randomized controlled designs.

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