AGE, SEX AND ADIPOSITY CORRELATES OF PHYSICAL FITNESS IN COSTA RICAN POLICE ACADEMY CADETS

ACONDICIONAMIENTO FÍSICO EN CADETES DE POLICÍA COSTARRICENSES Y SU RELACIÓN CON LA EDAD, SEXO Y ADIPOSIDAD CORPORAL

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ABSTRACT

This study had the following objectives: (i) to characterize pre-academy physical fitness, (ii) to analyze differences by age and sex, and (iii) to examine the associations between body fat percentage (BC%) and physical fitness in Costa Rican police cadets. A total of 393 cadets participated (age = 24.98 ± 4.65 years, weight = 72.78 ± 12.39 kg, height = 1.70 ± 0.09 m). Data were stratified into groups of 20-29 and 30-39 years and analyzed by sex and BC%. The tests were performed between 1 and 3 weeks during the basic training, evaluating body composition, grip strength, flexibility (S&R), vertical jump (VJ), agility (Illinois test), speed (30 m), anaerobic (300 m) and aerobic (2.4 km) capacity. Physical fitness varied by sex ($p < 0.05$), except for BMI and S&R. In men, each 1% increase in body fat (%) was associated with a loss of +0.034 s in agility ($p = 0.004$), +0.025 s in 30 m-sprint ($p = 0.000$), -0.20 kg, and -0.19 kg in grip strength ($p = 0.010$; $p = 0.021$), -0.64 cm in VJ (CMJ, $p = 0.000$), and -0.36 $ml \cdot kg^{-1} \cdot min^{-1}$ in VO_2 max ($p = 0.000$). In women, it was associated with a loss of agility (+0.089 seconds, $p = 0.000$), VJ (CMJ = -0.39 cm, $p = 0.000$), 30 m sprint (+0.046 seconds, $p = 0.000$), 300 m sprint (+1.02 seconds; $p = 0.000$) and VO_2 max (-0.33 $ml \cdot kg^{-1} \cdot min^{-1}$, $p = 0.000$). The police cadets showed a suboptimal initial physical condition. Age, sex, and body fat (%) are key factors that affect their performance.

Keywords: physical activity, performance, physical training & conditioning, Costa Rican cadets

RESUMEN

Este estudio tuvo como objetivos: (i) caracterizar la condición física pre-academia, (ii) analizar diferencias por edad y sexo, y (iii) examinar las asociaciones entre el porcentaje de grasa corporal (GC%) y la condición física en cadetes de policía costarricenses. Participaron 393 cadetes (edad = 24,98 ± 4,65 años, peso = 72,78 ± 12,39 kg, talla = 1,70 ± 0,09 m). Los datos se estratificaron en grupos de 20-29 y 30-39 años y se analizaron por sexo y GC%. Las pruebas se realizaron entre 1 y 3 semanas durante el entrenamiento básico, evaluando composición corporal, fuerza de agarre, flexibilidad (S&R), salto vertical (VJ), agilidad (Illinois test), velocidad (30 m) y capacidad anaeróbica (300 m) y aeróbica (2,4 km). La condición física varió según el sexo ($p < 0,05$), excepto en IMC y S&R. En hombres, cada aumento del 1% en la grasa corporal (%) se asoció con una pérdida de +0,034 s en agilidad ($p = 0,004$), +0,025 s en 30 m-sprint ($p = 0,000$), -0,20 kg y -0,19 kg de fuerza de agarre ($p = 0,010$; $p = 0,021$), -0,64 cm en VJ (CMJ, $p = 0,000$) y -0,36 $ml \cdot kg^{-1} \cdot min^{-1}$ en VO_2 máx ($p = 0,000$). En mujeres, se asoció con una pérdida de agilidad (+0,089 segundos, $p = 0,000$), VJ (CMJ = -0,39 cm, $p = 0,000$), esprint de 30 m (+0,046 segundos, $p = 0,000$), esprint de 300 m (+1,02 segundos; $p = 0,000$) y VO_2 máx (-0,33 $ml \cdot kg^{-1} \cdot min^{-1}$, $p = 0,000$). Lo cadetes de policía mostraron una condición física inicial subóptima. La edad, sexo y grasa corporal (%) son factores clave que afectan su rendimiento.

Palabras clave: actividad física, desempeño, entrenamiento físico y acondicionamiento, cadetes costarricenses

INTRODUCTION

Police cadets and new tactical trainees are required to pass fitness assessments before graduation after undertaking physical training to condition them in several countries (Orr, Dawes et al., 2018). Tasks within law enforcement require physical fitness, and a low initial level can predispose police cadets to injuries and future health problems (Rosendal et al., 2003; Crawley et al., 2016). The scientific literature highlights that police students with a higher level of physical fitness are less likely to get injured and drop out of the academy, and fitness measures have been positively associated with grade point average, faster graduation, and better performance in occupational tasks (Dawes et al., 2017; Lockie et al., 2020; Koropanoski et al., 2019; Kukic et al., 2020).

It is also well documented that maintaining fitness and a healthy body weight can enhance police officer safety, de-escalation, and subsequently survivability in addition to overall health and wellness (Wagner et al., 2023). Due to the demanding nature of police work, officers are expected to maintain a higher level of physical fitness than individuals in many other professions (Violanti et al., 2017). Age, sex, and adiposity (body fat percentage, BF%) have been identified as factors that might influence physical fitness in police officers. For example, a general decline with age has been observed among men and women officers in key physical fitness components such as muscular endurance, strength, lower body power, and cardiorespiratory fitness (Marins et al., 2022). Similarly, scientific evidence shows that police officers aged 20–29 year typically exhibit the best physical performance (Dawes et al., 2017, Lockie et al., 2019).

Sex differences have also been reported, with men showing higher performance in weight, vertical jump (VJ), grip strength, leg/back dynamometer tests, push-ups, and shuttle runs compared to women (Dawes et al., 2017, Lockie et al., 2019). Furthermore, adiposity has been described as a factor that significantly affects the physical ability of police officers in areas that are important for their occupation. Thus, a 1% increase in BF% has been associated with poorer results in fitness assessments, including 2.4 km run, push-ups, and sit-ups (Violanti et al., 2017).

Some authors have highlighted the necessity to implement a pre-academy strength and conditioning training program to improve the cadet preparedness to undergo a demanding physical academy training (Lee et al., 1997; Knapik et al., 2006; Crawley et al., 2016). However, some law enforcement academies have training programs that lack evidence-based instruction on how to maintain personal physical fitness and wellness as a police officer and without adequate progression strategies that consider age, sex and BF% differences (Shell, 2002; Crawley et al., 2016).

Despite a recent international increase in studies that examine body composition and physical fitness in police jobs (Kukic, Dopsaj et al., 2018), evidence regarding Costa Rican officers remains lacking. Additionally, an occupational health approach could help determine how the body composition and physical fitness levels of the cadets differ (Kukic et al., 2020). Therefore, the purpose of the current study was: (i) to provide a baseline pre-academy physical fitness characterization; (ii) to investigate age- and sex-related differences on selected measures of physical fitness; and (iii) to examine associations between BF% and physical performance in Costa Rican police academy cadets.

MATERIALS AND METHODS

Design and Procedures

A cross-sectional study was conducted to characterize baseline pre-academic physical fitness and explore possible age or sex differences and the age and adiposity correlates of the physical characteristics of Costa Rican police cadets. Participants completed physical fitness tests using conventional field-based performance tests recommended by NSCA (Alver et al., 2017). Therefore, the main results of the study were age, body mass (in kg), height (in cm), body mass index (BMI, in kg·m^{-2}), fat mass (in both kg and %), skeletal muscle mass (in both kg and %), grip strength (in kg), lower body flexibility (in cm), vertical jump height (in cm), agility (in seconds, secs), speed (in secs), anaerobic resistance (in secs) and aerobic endurance (predicted mlO$_2$·kg^{-1}·min^{-1}). All required data collection was conducted in four visits to the police academy. The signed informed consent was obtained from all participants prior to data collection and once the study protocol was reviewed by the Scientific Ethics Committee of the University of Costa Rica and approved on July 8, 2020, according to the document CEC-294-2020. All participants provided written informed consent and received a copy of their assessment of body composition for their participation.

Participants

Three hundred ninety-three recruits (age = 24.98 ± 4.65 years, weight = 72.78 ± 12.39 kg; height = 1.70 ± 0.09 m) who were enrolled in the training of the national police academy volunteered for the study. The sample was stratified by sex (men and women) and age groups (group 1: 20–29 years and group 2: 30–39 years) (Dawes et al., 2017; Lockie et al., 2018; Lockie et al., 2019; Marins et al., 2019). Before enrolling in the study, all cadets had to successfully complete a standardized physical fitness police academy test and obtain medical clearance to participate in the academy's basic training, as inclusion criteria. Participants were recruited from four basic police training courses by an e-mail sent to the academy staff.

Measures

Demographics. Current demographic characteristics were collected using a brief survey that requested date of birth, sex, and contact information.

Physical Fitness Testing. Fitness testing was performed in weeks 1-3 basic training period of the police academy. Participants were encouraged to refrain from high intensity physical activity in the preceding 24 hours and to dress in a standard academy t-shirt and shorts and their own athletic shoes (Crawley et al., 2016). Participants refrained from eating within 2-3 hours before the testing session (Lockie et al., 2018). All tests were performed on the same day and sequenced between 8 AM and 4 PM. However, the rest intervals (~15-30 min) between the tests were not standardized due to academy-related duties included in their daily program, such as snacks and lunch times (Marins, Dawes & Del Vecchio, 2022). The order of the assessments went from nonfatiguing (body composition, hand grip, flexibility, and VJ, agility -Illinois-test-) to maximum speed (30 m-sprint) and ended with anaerobic (300-m sprint) and aerobic (2.4-km run) endurance tests.

Anthropometrics and Body Composition. Barefoot standing height was measured to the nearest 0.1 cm using standard procedures. A multifrequency bioelectrical impedance analysis machine (BIA) InBody 270 (Biospace Co. Ltd, Seoul, Korea) was used for measuring body weight and full body composition. Participants were instructed to come to the laboratory station after a minimum three-hour fast and were advised to empty their bladder before measurement (Schoenfeld et al., 2020). This method has been shown to be reliable (ICC = 0.97) and valid (r = .90 for men and r = .93 for women) compared to dual-energy x-ray absorptiometry [DXA]) method when used as a field test (Aandstad et al., 2014; Kukić et al., 2022. The BMI was then calculated using conventional methods.

Hand grip strength. Maximal grip strength was measured by hand dynamometry (TKK-5401, Takei, Niigata, Japan). Before testing, the grip size was adjusted so that the middle finger, second phalanx, was at a 90-degree angle around the grip (Crawley et al., 2016). The participant held the dynamometer and gripped it with maximum possible force while holding the torso and arms straight. Participants were not allowed to shake their body or bend their elbows during the measurement. Three measurements were recorded for both the dominant and nondominant hand. The best result was used as the final result (Kim et al., 2020).

Flexibility. Lower back and hamstring flexibility was measured via a sit-and-reach test digital flex-meter box to the nearest 0.1 cm (Takei Scientific Instruments, Japan). Cadets were instructed to maintain their feet against the box without shoes and reach forward as far as they could while touching the digital flex-meter slide (Schram et al., 2020). The staff ensured that the knees remained in full extension and that the movement was carried out slowly and smoothly. The participants performed three trials, each held for 1 to 2 seconds, and the farthest reach was recorded in centimeters (Crawley et al., 2016).

Vertical jump. Two types of VJ, such as the squat jump (SJ) and the countermovement jump (CMJ) were performed on a contact platform (Fusion Sport, Queensland: Australia). Participants were instructed to jump as high as possible (Schram et al., 2018). For both jumps, a member of the research team demonstrated and instructed the technique. For the SJ, participants performed a maximal concentric VJ from an initial squat position with a knee angle of approximately 90° with hands placed on the hips (visual estimation), while for the CMJ participants first descended into the same squat position immediately followed by a rapid maximal VJ and landing back to a comfortable squat position (Gheller et al., 2015). Participants were allowed a practice jump before performing three SJ trials and three CMJ trials and the maximum was recorded (Liew et al., 2016).

Agility. The Illinois Agility Test was used as a valid assessment of agility (Raya et al., 2013). Eight cones placed 3.3 m apart were used to mark the course of the weaving component (Orr, Schram et al., 2018). Participants began the test using a three-point position behind the start line, with either or both hands on the floor (Dawes, 2019). Participants were asked to run from the starting point 10 m forward to point one on the marked course of 5 m wide and continue the run between the cones comprised of a mixture of straight line running, change of direction, and weaving. After a slow completion of the course as a familiarization and warm-up, participants were instructed to complete the test as quickly as possible (Orr et al., 2019). The course time was measured by light gates (Fusion Sport, Brisbane, Queensland, Australia) recorded at the nearest 0.1 sec. The best time of three trials was considered for the analysis (Orr, Schram et al., 2018).

Speed. Participants performed three maximal 30-m sprints on a soccer pitch (artificial turf), with ~3-4 min of recovery between each trial. The warm-up protocol consisted of 5 min of low-intensity running, joint mobility, multidirectional displacements, and progressive 10- to 30-m sprints, with an overall duration of 15 min (Fink et al., 2022). The starting position was a two-point stand (i.e., both feet on the ground). The course time was measured using light gates (Fusion Sport, Brisbane, Queensland, Australia) and began when each cadet crossed the first gate and ended as they crossed the finish line running as fast as physically possible (Crawley et al., 2016;

Kukic et al., 2018, Fink et al., 2022). The time was recorded at the nearest 0.1 sec. The best time of three trials was considered for the analysis (Orr, Schram et al., 2018).

Anaerobic endurance. The cadets were instructed to run a 300-m distance on a predetermined course around the academy's soccer pitch. The course was selected based on distance and minimal changes in terrain and grade (Moreno et al., 2018). Course time was measured using light gates (Fusion Sport, Brisbane, Queensland, Australia) and a test trial was allowed at maximum speed (Cocke et al., 2016).

Aerobic capacity. The 2.4 km run was performed using 6.15 rounds on a 390-m course around the academy soccer field. Cadets were instructed to start running and cover the 2.4 km distance as fast as possible. The time to complete the 2.4 km run was recorded to the nearest second with a digital smartphone stopwatch. The 2.4 km run was completed last, with approximately ~30 minutes allotted between the completion of the other assessments (Cocke et al., 2016). The predictive equation applied to estimate $VO_{2\ max.}$ in $ml \cdot kg^{-1} \cdot min^{-1}$ was 3.5 + 483 / 1.5·time in minutes (ACSM, 2018).

Statistical Analyses

Two-way (age and sex) analyses of variance with Bonferroni post hoc for multiple pairwise comparisons were used to calculate the differences between age groups (20–29-y, 30–39-y) in body composition and fitness performance outcomes. Descriptive statistics (mean ± SD) were calculated by groups for both men and women. The linear regression model was then used to explore 1) the influence of age on body composition and physical fitness and 2) BF% on fitness performance by sex. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software (version 20.0; IBM Corporation, New York, NY). Data normality was analyzed by visual inspection (e.g., histograms), tests of skewness, kurtosis, and Kolmogorov-Smirnov (K-S).

RESULTS

A total of 393 police cadets participated in the study, with men comprising 68% (mean age: 24.53 ± 4.28 years; height: 1.75 ± 0.07 m; weight: 76.38 ± 11.48 kg; BMI: 25.01 ± 3.12 $kg \cdot m^{-2}$) and women comprising 32% of the sample (mean age: 25.96 ± 5.26 years; height: 1.60 ± 0.06 m; weight: 65.09 ± 10.67 kg; BMI: 25.28 ± 3.70 $kg \cdot m^{-2}$). Of these, 387 cadets were included in the final analysis: 20-29-year-old men (86%, height: 1.74 ± 0.06 m; weight: 75.79 ± 11.40 kg; BMI: 24.77 ± 3.08 $kg \cdot m^{-2}$), 30-39-year-old men (13%, height: 1.73 ± 0.07 m; weight: 79.86 ± 11.59 kg; BMI: 26.48 ± 3.07 $kg \cdot m^{-2}$), 20-29-year-old women (76%, height: 1.60 ± 0.05 m; weight: 63.91 ±

10.38 kg; BMI: 24.74 ± 3.65 kg·m^{-2}), and 30-39-year-old women (23%, height: 1.60 ± 0.05 m; weight: 68.44 ± 11.19 kg; BMI: 26.51 ± 3.37 kg·m^{-2}). Not all the cadets performed all body composition and fitness assessments due to potential work conflicts, willingness to participate (i.e., not required), or injury status (not reported) (Marins et al., 2022). (Cervantes-Sanabria et al., 2025).

All body composition results differed between men and women ($p < 0.05$), except for BMI (Table 1). Among men, those aged 30-39 were, on average, significantly heavier than those aged 20-29 (F = 4.027, p = 0.045) and had a significantly higher BMI (F = 8.848, p = 0.004), mean fat mass (F = 7.777, p = 0.06), and mean BF% (F = 9.869, p = 0.002). Men aged 30-39 also had a significantly lower mean in percent skeletal muscle mass (PSMM) (F = 9.470, p = 0.002) compared to 20-29-y men cadets. In men, age was associated with increases of 0.45 kg in body weight (p = 0.007), 0.17 kg·m^{-2} in BMI ($p < 0.001$), 0.25 kg in fat mass (p =0.023), 0.29% in BF% ($p < 0.001$) and a reduction of -0.15% in PSMM (p = 0.001) per year completed. On average, women were only significantly different in BMI by age (F = 6.599, p = 0.011): each year of age was associated with 0.16 kg·m^{-2} more BMI (*p* = 0.015) in women.

Table 1.

Mean results and SDs for body composition variables, by sex and age.

Variables	Women (n = 122)		Men (n = 265)	
	20-29 y (n = 93)	30-39 y (n = 29)	20-29 y (n = 230)	30-39 y (n = 35)
Height (m)	1.60 ± 0.05	1.60 ± 0.05	1.74 ± 0.06	1.73 ± 0.07†
Weight (kg)	63.91 ± 10.38	68.44 ± 11.19	75.79 ± 11.40	79.86 ± 11.59†‡
BMI (kg·m^{-2})	24.74 ± 3.65	26.51 ± 3.37‡	24.77 ± 3.08	26.48 ± 3.07‡
Fat mass (kg)	19.91 ± 6.43	22.64 ± 6.59	14.82 ± 7.86	17.78 ± 5.85†‡
BF%	30.52 ± 6.17	32.77 ± 5.94	18.59 ± 5.72	21.89 ± 5.01†‡
SMM (kg)	24.27 ± 3.38	25.33 ± 3.86	35.05 ± 4.65	35.51 ± 4.86†
PSMM (%)	38.26 ± 3.48	37.20 ± 3.42	46.47 ± 3.28	44.62 ± 2.86†‡

Note. BMI = body mass index; BF% = body fat (%); SMM = skeletal muscle mass; PSMM = percent skeletal muscle mass. †Significant differences between sex groups at $p \leq 0.05$. ‡Significant differences between age groups at $p \leq 0.05$. Source: Author's own elaboration.

All fitness results were different by sex, except the sit-and-reach test (Table 2). When comparing men by age, there were significant differences between the groups regarding SQJ (F = 7.762, p = 0.006) and CMJ (F = 9.133, p = 0.003), where men aged 20-29 obtained the highest VJ distance. Linear regressions revealed statistically significant decreases in VJ distance for every year of age in men (SQJ = -0.15 cm, p = 0.043; CMJ = -0.23 cm; p = 0.017). Furthermore, the regressions also showed a reduction in $VO_{2\ max}$ (-0.18 ml·kg^{-1}·min^{-1}) by age (p = 0.045). No statistically significant differences were observed in women between age groups. However, the linear regressions showed significant reductions in VJ (SQJ = -0.18 cm, $p = 0.013$; CMJ = -0.20 cm, $p = 0.018$) and sit-and-reach distance (-0.27 cm, $p = 0.050$) for every year of age in women.

Table 2.

Mean results and SDs for fitness variables, by sex and age.

Variables	Women				Men			
	n	**20-29 y**	**n**	**30-39 y**	**n**	**20-29 y**	**n**	**30-39 y**
GSRH (kg)	92	31.24 ± 4.60	28	31.45 ± 5.50	229	47.27 ± 7.59	34	46.76 ± 6.45†
GSLH (kg)	92	29.36 ± 5.14	28	28.34 ± 5.16	230	45.39 ± 8.07	34	44.27 ± 6.92†
S&R (cm)	91	38.22 ± 6.70	28	36.86 ± 8.86	230	38.10 ± 6.34	34	38.46 ± 7.06
SQJ (cm)	92	22.29 ± 3.79	28	20.50 ± 3.62	225	32.45 ± 5.15	34	30.01 ± 5.19†‡
CMJ (cm)	90	25.64 ± 4.45	28	23.97 ± 3.95	224	38.20 ± 6.55	34	34.96 ± 5.07†‡
Agility (s)	67	19.70 ± 1.40	22	19.43 ± 1.40	167	17.25 ± 0.96	28	17.57 ± 0.83†
30-m sprint (s)	75	5.66 ± 0.51	21	5.67 ± 0.41	197	4.66 ± 0.30	28	4.70 ± 0.25†
300-m sprint (s)	56	71.25 ± 12.21	21	74.46 ± 9.27	141	54.73 ± 9.96	27	55.03 ± 11.69†
2.4-km run ($VO_{2\ max}$)	62	32.50 ± 3.84	20	33.38 ± 5.28	165	41.44 ± 5.52	28	40.70 ± 4.82†

GSRH/LH = grip strength right-left hand; S&R = sit-and-reach; SQJ = squat jump; CMJ = counter movement jump. †Significant differences between sex at $p \leq 0.05$. ‡ Significant differences between age at $p \leq 0.05$. Source: Author's own elaboration.

Fitness and BF% were associated with some mean values of each fitness test in men and women. In men, every 1% increase in BF% was associated with an increase of 0.034 seconds in the agility test ($p = 0.004$) and 0.025 seconds in the 30 m-sprint ($p < 0.001$). Furthermore, BF% was related with decreases of -0.20 kg and -0.19 kg in right and left grip strength ($p = 0.010$; $p = 0.021$), -0.50 cm and -0.64 cm in VJ (SQJ, $p < 0.001$; CMJ, $p < 0.001$) and -0.36 $ml \cdot kg^{-1} \cdot min^{-1}$ in $VO_{2\ max}$ ($p < 0.001$). In women, BF% was similarly associated with the time in agility test (+0.089 seconds, $p < 0.001$), VJ (SQJ = -0.35 cm, $p < 0.001$; CMJ = -0.39 cm, $p < 0.001$), 30-m sprint (+0.046 seconds, $p < 0.001$), 300-m sprint (+1.02 seconds; $p < 0.001$) and $VO_{2\ max}$ (-0.33 $ml \cdot kg^{-1} \cdot min^{-1}$, $p < 0.001$).

DISCUSSION

This research determined pre-academy body composition and fitness profiles for Costa Rican police cadets and provided meaningful insight into their fitness levels according to age-sex and BF% influence. The findings suggest that Costa Rican police cadets had high levels of BF% and low levels of PSMM at the beginning of academy training, and their fitness performance is reduced according to an increased age and BF%. Scientific literature highlights that police students with higher level of physical fitness are less likely to be injured and drop out of the academy, and that fitness measures have been positively associated with grade point average, faster graduation, and better performance in occupational tasks (Dawes et al., 2017; Dawes et al., 2018; Lockie, Dawes et al., 2019; Koropanoski et al., 2020; Kukic et al., 2020).

Attaining and maintaining healthy body composition should be a primary concern in this population. Research indicates that anthropometric factors, such as excessive adiposity and higher BMI, may have a negative impact on performance in occupational tasks and measures of fitness and health (Čvorović et al., 2021). Although the present study did not find differences in BMI by sex, differences were noted across men´s groups. Individuals of both sexes aged 30-39 were classified as *clinically overweight* upon entry into the academy (Crawley et al., 2016). Furthermore, men in this age group were in the 40th percentile for BF%, while both women's age groups were classified in the 5th percentile (ACSM, 2018). This result contrasts with Crawley et al. (2016), who described in their study that cadets' BF% was better than the average compared to the general population. BF% has been described as one of the best predictors of physical performance in tactical professions (Ricciardi et al., 2007), reporting a range of approximately 12 to 28.2% in law enforcement (Marins et al., 2019).

In the present study, women were classified as having *insufficient* PSMM (%), while men aged 30-39 and 20-29 were classified as *below average* and *average* categories, respectively (Kukic & Dopsaj, 2016). The scientific literature describes that very active police officers had a higher PSMM (%) than those who were inactive or rarely active (Kukić et al., 2022). Furthermore, skeletal muscle mass (SMM) has been reported as a significant predictor of military-specific task performance, which are like operational job demands for police officers (Pihlainen et al., 2018). SMM has been correlated with VJ height, estimated peak power, push-ups, and bench press in tactical professions (Dawes et al., 2016; Pihlainen et al., 2018).

The observed results could be explained due to bureaucratic police hiring procedures and usual budget-related matters in Costa Rica, which can delay the start of the training course (~6-month) after basic physical testing in some cases. Typically, pre-candidates train to pass the required physical assessments, but enrollment in police academy is not immediate. It has been well-established that body composition promptly responds to physical activity, lifestyle, and the dietary habits of police officers (Kukic, Dopsaj et al., 2018; Demling & DeSanti, 2000; Kukić & Dopsaj, 2016; Vuković et al., 2020), so it is possible that recruits may have neglected their health behaviors while awaiting a response regarding their job application. Future research should attempt to analyze more information considering such situations.

Physical attributes are predictive of several essential job-related tasks in police officers, such as sustained sprinting pursuit, dodging, lifting and carrying, pushing, jumping, vaulting, crawling, and use of force situations (Dawes, Lindsay et al., 2017). In the present study, several components of physical fitness were categorized as *average* or *below average* at the beginning of the academy compared to the standards of police officers or age-specific general population norms (Davis et al., 2000; Cooper Institute, 2006; Crawley et al., 2016; ACSM, 2018; Dawes, 2019).

Scientific literature describes that low grip strength scores in recruits are indicative of greater susceptibility to failing occupational task assessment, performing more poorly in shooting marksmanship, and it could be even related to disability occurrence later in life (Orr et al.,, 2017; Orr et al., 2021). Furthermore, maximal strength is needed for load carriage, defensive tactics, firearm use, and drag tasks (Lockie et al., 2022).

The results of the isometric strength hand grip results varying from 24.1 to 65.3 kg (average mean values = 52.6 kg) in police officers has been reported previously (Marins et al., 2019). In our study, hand grip strength was classified as *fair* in both men´s age groups (20-29-y both hands mean = 92.86 ± 14.45 kg; 30-39-y both hands mean = 91.04 ± 12.32 kg) and *good* in both women´s age groups (20-29-y both hands mean = 60.61 ± 8.99 kg; 30-39-y both hands mean = 59.80 ± 9.56 kg) (ACSM, 2018). Therefore, it is crucial to optimize the grip strength of police recruits prior to enrollment, not only during training but also, if needed, throughout any rehabilitation process. Recruits with weaker grip strength may be at a higher risk of failing specialized police tasks (Orr et al., 2017).

Police work requires greater joint flexibility for an efficient and easier performance of tactical techniques, as it enables muscular activity at a longer distance, and consequently at a higher speed (Koropanovski, 2019). Police officers are expected to navigate critical situations as efficiently as possible while using the minimum necessary level of force. Simultaneously, they must reduce the risk of injury while maintaining a high flexibility reserve and adaptability (Stefanovic et al., 2010). Flexibility is necessary because it can assist in running tasks reliably and other specific tasks such as squatting to go through physical barriers (Marins et al., 2019).

In the present study, sit-and-reach flexibility was ranked in the *very good* category in the 20-29-y men´s and women´s groups and in the *excellent* and *very good* categories, respectively, in both 30-39-y sex groups (ACSM, 2018). This finding contrasts with Crawley et al. (2016), who reported low performance in flexibility cadets. The mean value of the Sit-and-reach test among police officers has been reported to be 30.8 cm in a range of 17.3 to 75.0 cm (Marins et al., 2019). Lower medical costs, sick leave, and reduced work capacity are some of the factors indicating that the level of flexibility should be developed and maintained in optimal levels in this population (Koropanovski, 2019).

Vertical jump is a correlate of leg power associated with injury and illness risk in the police population (Orr, Schram et al., 2018), although a recent study suggests that vertical jump is not a valid predictor of mechanical power due to various methodological limitations and a weak correlation at the individual level (Aragón-Vargas & González-Lutz, 2023). Future research involving tactical athletes should carefully address this issue, as VJ performance can contribute to obstacle clearance, fence climbs, and running tasks (Lockie et al., 2022). Our study described VJ (CMJ) was ranked in 10th percentile in the 20-29-y men´s group and in the 5th percentile in 30-39-y men´s group. Both age groups for women were ranked in 5th percentile for this variable (Cooper Institute, 2006). In contrast, VJ was in the 65th percentile in the cadets studied by Crawley et al. (2016). The mean value of VJ height performance has been described around 48.3 cm (range from 34.9 to 64.5 cm) among law enforcement populations (Marins et al., 2019).

Agility is a critical skill in law enforcement as officers must be proficient in changing directions, accelerating, and decelerating. Such abilities are essential when they perform lateral movements required for various tasks, including shooting, evading attacks or sustaining pursuits that involve frequent direction changes (Alver et al., 2017; Maupin et al., 2018; Orr et al., 2019; Papadakis et al., 2021; Streetman et al., 2022). In the current study, both sexes' agility was classified as *average* (Dawes, 2019). A lack of agility can challenge performance and increase the risk of on-the-job injuries (Bissett et al., 2012; Melton et al., 2023; Orr, Schram et al., 2018).

Sprint capacity has also been correlated with various occupational tasks, including fence jumping (1.22 m), victim dragging, and stepping out of a supine position (Aandstad et al., 2011; Canetti et al., 2021; Lockie et al., 2020; Streetman et al., 2022). In our study, 30-m sprint time was classified as *poor* in both sexes (Davis et al., 2000). A previous study reported results of 5.2 ± 0.4 s in this test in military police officers (Fernandes et al., 2015; Marins et al., 2019).

Short-distance sprints (i.e., 5 m, 10 m, and 20 m) can predict task performance in multiple scenarios such as rapidly sprinting to assist an injured victim, chasing a perpetrator over a short distance, or seeking cover under threat, all of which are critical for police officers (Orr et al., 2015; Canetti et al., 2021). For the 300-m anaerobic run test, both men´s age groups were classified in the 60th percentile, while 20-39-y and 30-39-y women´s groups were ranked in the 40th and 35th percentile, respectively (Cooper Institute, 2006). The 300-m run is a shorter duration test that takes approximately 60-70 s to be completed by healthy individuals (Cocke et al., 2016; Moreno et al., 2018). The scientific literature describes operational police officer running average distance as being around 87 m (in a range of 5-350 m) (Alver et al., 2017).

Aerobic capacity has also been shown to predict essential job tasks (Dawes et al., 2017; Čvorović et al., 2021). In the current study, aerobic fitness was classified in the 30th percentile for both the 20–29-y men's and women's groups, and in the 40th and 65th percentiles for the 30–39-y men's and women's groups, respectively (ACSM, 2018). The range of relative VO_2 max in police officers has been reported between 25.1–59.2 ml·kg^{-1}·min^{-1} (average of mean values = 41.3 ml·kg^{-1}·min^{-1}), and 44.8 ml·kg^{-1}·min^{-1} when measured indirectly (Marins et al., 2019).

Gender differences

Body composition and fitness performance were different between sexes in the present study, except for BMI and sit-and-reach test. Like in a previous study, women, except for the sit-and-reach, were commonly positioned in lower percentile ranks (Lockie et al., 2022). In the present study we found additional exceptions in women for hand grip, in contrast with Dawes et al., 2017, and agility test.

Women had approximately 66-67% of the hand grip strength, 67-68% of vertical jump height, 86-90% of agility time, 79-80% of 30-m sprint time, 65-70% of 300-m sprint time and 78-82% of $VO_{2\ max}$ of men measured in the present study. Previous studies have found similar differences in aerobic fitness (73-80%) in tactical personnel by sex (Pereira & Texeira, 2006; Marins et al., 2018). Moreover, available meta-analytic information describes higher results in tests of muscle strength (d=1.71; δ=1.81) and cardiorespiratory endurance (d=1.81; δ=2.01) in favor of men (Courtright et al., 2013).

There are several aspects that could explain the differences by sex. First, men had approximately 8% more height and 15-16% more weight than women in the present study. Weight can also be described as 27-34% less fat mass (kg) and 29-30% more SMM (kg). These results are similar to previous studies where, on average, policemen were heavier and taller than policewomen (Dawes et al., 2017). The scientific literature mentions that men have better performance due to greater proportion of type 2 fibers and higher cardiac output compared to women (Marins et al., 2018; Lockie et al., 2019).

Age

In the present study, significant differences between age groups were found in men´s body composition except SSM (kg); while women were different only in BMI. According to literature, the negative effect of aging on the body composition of police officers has been previously reported because officers' body fat mass tends to increase while skeletal mass decreases with age and time spent in service (Boyce et al., 2008; Ćopić et al., 2020; Kukic et al., 2019; Kukic et al., 2022).

A positive correlation between adiposity and age have been reported in those police cadets and officers who are men (Orr, Dawes et al., 2018) and this could explain differences founded in our study, but not for SMM. Women´s results contrast with previous studies which have described lower body composition results in policewomen under 29-years old compared to older (Kukic et al., 2022), and this could be explained because cadets in their 30s had body composition levels comparable to those in their 20s.

In our study, the fitness measures revealed significant differences by age only in the VJ tests for men, while no differences were observed in women´s fitness performance by age as expected (Dawes, Orr et al., 2017). In previous studies there were no significant differences between the 20-29 and 30-39 groups in any of the fitness tests applied (Lockie et al., 2022). However, as happened in the present study, a general decline in mean performance between men´s age groups (20-29-y vs > 30-y) in VJ has been reported (Dawes, Orr et al., 2017). The link between better jump performance with specific policing tasks such as vaulting barriers or suspect pursuit and its relationship with the reduction of illness and injury risk during the academy period remark relevance in these results, as previous studies have described (Lockie, Dawes et al., 2018).

Body adiposity

Body composition, in terms of BF%, is negatively associated with physical fitness performance (Sporiš et al., 2011; Kukic et al., 2017; Kim et al., 2020; Dawes et al., 2016). In the current study, every 1% increase in BF% was associated with a significant reduction in agility performance, sprint, handgrip, VJ and aerobic capacity in men, while it was associated with lower performance in agility, VJ, sprint, anerobic resistance, and aerobic capacity in women. Similar findings have been reported in previous studies, indicating that officers with higher BF% had lower cardiorespiratory capacity and lower dynamic strength (Violanti et al., 2017).

In the present study, the body composition and fitness profile of police cadets have been reported to be unhealthy in many assessed characteristics. Age, sex, and BF% demonstrated to be indicators that may influence their performance. To be active and respond effectively in every occupational situation, future officers must be able to move quickly, run, push, pull, and lift and carry heavy weights while wearing a bulletproof vest and carrying communication devices, weaponry, handcuffs, and other personal protective equipment (Kim et al., 2020). Moreover, cadets must be aware of the importance of maintaining good health.

Therefore, in many studies, and after completing physical fitness tests for police officers, numerous authors support and recommend the implementation of a targeted physical fitness regimen and the resources for a program designed to improve current health and fitness, to attenuate expected decreases with aging, and aimed to optimize occupational performance with the ultimate goal of safeguarding the lifelong health and well-being of officers (Frick et al., 2024).

LIMITATIONS

The current study is not without limitations. Other fitness measures were not available because of the limited time allocated by the police academy to assess personnel during daily cadets' activities or while on duty. Furthermore, nutritional, hydration and fatigue status were not controlled nor assessed during data collection, and these may have had an impact on performance (Čvorović et al., 2021). Also, there was a limited number of cadets from both sexes in the 30-39-y samples (Dawes, Orr et al., 2017).

PRACTICAL APPLICATIONS

Previous research highlights the importance of implementing a pre-academy strength and conditioning program when there is a wide range of initial physical fitness characteristics that could be improved in potential cadets (Crawley et al., 2016). The relevance of creating specific strength and conditioning programs for women to prepare them for the training academy has also been established (Lockie et al., 2022) as they may be in disadvantage regarding power- and resistance-based activities since the beginning (Lockie, Dawes et al., 2018). Traditionally, police academies have followed a militaristic approach regarding fitness conditioning (Charles, 1983). Such an approach not only may cause numerous injuries, but often could create resentment toward fitness training among the participants (Copay & Charles, 1998).

Additionally, there are some issues to account for a successful physical fitness regimen, in this case, for cadets and police officers. An important issue could be the existence of multiple barriers to the promotion of physical activity on the job, such as the low acceptability of physical activity in organization norms, the inadequacy of equipment or supervision, legal concerns and legal precedence for implementation, lack of resources, lack of knowledge, and more. Therefore, agency leaders should consider these elements when designing programs or initiatives to enhance physical fitness.

Future research and the successful implementation and maintenance of physical fitness programs should be related, in order to educate about the importance of physical fitness of police officers and how this can reflect in occupational performance, personnel safety, and therefore, the safety of the population (Marins et al. 2019). Also, the need for more structured physical training programs for police officers throughout their careers should be analyzed, to mitigate their risk of cardiovascular disease (Orr, Dawes et al., 2018). In addition, the inclusion of strength and conditioning professionals, ideally with a Tactical Strength and Conditioning Facilitator certification, would seem advantageous for this unique population (Crawley et al., 2016). And finally, the effects of excessive loads carried by police (eg, ballistic vest and weapons) on the components of physical fitness should be assessed. Altogether, these steps will lead security institutions to gain a better understanding of how their equipment impacts police task performance, enabling them to tailor physical exercise programs to be aligned with the actual demands of police occupational dynamics (Marins et al., 2019).

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