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ORIGINAL ARTICLE

Longitudinal Changes in Physical Fitness Attributes of Male Police Officers During a 12-Week Physical Training Program

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Abstract

This study aims to evaluate the effect of a 12-week physical training program on police officers' physical fitness attributes. Thirty male police officers (age, 31.03 ± 3.15 years) participated in this experimental study, having carried out a 12-week physical training program (01−04/2023), 3 times/week with an average duration of 1 h/session (through circuit work, body weight exercises, and exercises with additional weight). The physical fitness evaluations were performed at three time points (weeks: 0, T0; 8, T1; 12, T2), and consisted of morphological (height, weight, waist circumference, fat and muscle mass, body mass index, and waist-to-height ratio) and fitness (push-ups; sit-ups; pull-ups; handgrip; horizontal jump; shuttle-run test; *t*-test; sit-reach test) evaluations. Were observed significant improvements at (i) 8 week (T1), in waist circumference, waist-to-height ratio, and all fitness tests (except in flexibility, handgrip right/left sum, and VO_{2max}); and (ii) 12 weeks (T2), in relative fat mass, relative muscle mass, waist circumference, waist-to-height ratio, and all the fitness tests. Although 8 weeks of training allowed us to observe improvements in most of the physical fitness attributes, all of them improved significantly in the 12-week physical training program. In accordance, prolonging the duration of the training program from, 8 to 12 weeks, results in strong improvement in the physical fitness of police officers.

Keywords Fitness · Law enforcement · Morphology · Tactical athlete

Introduction

Regular, adequate, and adjusted physical exercise, besides providing several health benefits (physical and psychological) [2, 23, 30], is essential for police officers to maintain fitness levels adequate to the demanding tasks they are asked to perform [18, 20]. The absence of physical exercise or insufficient exercise [the World Health Organization [WHO] recommends a minimum of 50 min, 3 times/week [28], can lead to a decrease in physical fitness levels.

According to the literature, the physical fitness of police officers is below the recommended standards for general health [16]. This factor may be related to the high number of annual injuries, occurring on average in the US between 240 and 250 injuries per year per 1000 police officers [2], and according to data from the Department of Labor and Statistics, each police officer misses on average 15 days per year for injury reasons [28].

In this sense, it is of utmost importance that the physical exercise practice of police officers occurs not only in their initial training, being this phase important to prepare and develop the body to perform the main physical tasks required of policemen [1, 17]. But also, it is as important (or even more important) that the practice of sports is maintained throughout the professional career to prepare them to resist stress, anxiety, and risk of injury during service [4], otherwise, there is the possibility that they put at risk the safety of the community or even, their safety [16].

In the last ten years, a considerable number of studies have been conducted regarding the application of physical

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training programs in tactical populations. Recently, a systematic review that deals with applying for physical training programs in tactical populations found 23 studies (that met the eligibility criteria) [21]. However, ten studies were conducted with recruits/cadets, and this is not the phase of the police career (that presents the greatest problems in this area). It should also be noted that only four studies were conducted with policemen, and of these, two were dedicated to studying overweight or obese policemen.

Nevertheless, (i) Crawley et al. [7], observed significant improvements in a considerable number of fitness parameters in police academy cadets after 8 weeks of the training program (and no significant improvement from 8 to 16 weeks); (ii) Čvorović et al. [8], observed significant improvements in anthropometric parameters and performance among police recruits after a 12-week training program; and (iii) Sá et al. [24] suggested that a 16-week combined training program helps increase physical fitness in Portuguese elite police officers.

This emphasizes that training programs are an effective approach to physical fitness improvements. However, in many studies, the duration of training programs varies between 8 and 12 weeks. Nevertheless, Rasteiro et al. [21] suggested that a training program to influence physical fitness attributes must be a minimum of 8-week long and a weekly frequency of at least three times. In accordance, this study aims to evaluate the effect of a 12-week physical training program on police officers' physical fitness attributes.

Methods

Experimental Approach to the Problem

The research methodology was quantitative, with an experimental (intervention) study design (without a control group). In the present study, all participants included in the sample and eligible for the study kept their usual routine at work, having additionally carried out a physical training program for a period of 12 weeks. The dimensions (i) morphology (weight, waist circumference, body mass index—BMI, waist-to-height ratio—WHR, relative fat mass, and relative muscle mass), and (ii) fitness (endurance strength, muscle power, aerobic capacity, agility, and flexibility) were evaluated in three pre-defined moments (week: 0, T0; 8, T1; 12, T2).

Subjects

Thirty male police officers with duties at the Police Intervention and Inspection Police Station of the Amadora Police Division (Lisbon, Portugal), which is part of the Lisbon Metropolitan Command of the Public Security Police, participated in this study (age, 31.03 ± 3.15 years old; height, 1.78 ± 0.06 m; weight, 80.90 ± 8.19 kg), who volunteered for the study and were randomly divided into five intervention groups (Table 1).

Inclusion criteria were the absence of medical contraindications for physical exercise and consent to participate in the study. On the other hand, the exclusion criteria were defined as the police officers did not (i) complete all three moments of evaluation; and (ii) perform a minimum of 80% of all the training sessions included in the study.

The research, conducted from January to April 2023, met the conditions of the Declaration of Helsinki: Recommendations Guiding Physicians in Biomedical Research Involving Human Subjects, and had the approval of the Public Security Police and Higher Institute of Police Sciences and Internal Security (1300-352 Lisbon, Portugal; reference number 261/SECDE/2022).

Physical Fitness Evaluation

Anthropometric measurements were collected according to the protocol defined by Marfell-Jones et al. [15], meeting the standards established by the International Society for the Advancement of Kinanthropometry (ISAK). Total height was obtained using an anthropometer (Anthropometric Kit Siber-Hegner Machines SA GPM, 2008), and for body mass, a bioimpedance scale (Body Mass Scale OMRON, HBF-511B-E, 2006) clinically validated by Bosy-Westphal et al. [3] was used. Body mass index (BMI) was calculated using the equation: Weight (kg) / (Height (m))^2. Using a bioimpedance scale, it was also possible to quantify the relative fat mass and relative muscle mass of the participants. A measuring tape was used to obtain waist circumference, according to the protocol established by the WHO [TRS 854, 1995], at the level of the navel [10].

Table 1 Distribution and characterization of participants (T0) by training group (G)

Variable	G1 ($n=6$)		G2 ($n=7$)		G3 ($n=5$)		G4 ($n=7$)		G5 ($n=5$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	31.67	2.73	30.71	3.50	29.40	2.41	31.71	3.04	31.40	4.39
Height (m)	1.78	0.07	1.80	0.07	1.76	0.04	1.77	0.04	1.80	0.07
Weight (kg)	81.30	11.64	82.86	6.51	77.90	7.84	80.67	7.01	80.98	10.01

SD standard deviation

The fitness tests were performed at three-time points (week: 0, T0; 8, T1; 12, T2). They were always performed at the same time (8:30 a.m.–10:00 a.m.) and in the same place, with similar weather conditions. Before the physical fitness tests, there was a warm-up phase, lasting an average of 10 min. After the tests, there was a calm-down phase (recovery run + static stretching), lasting an average of 10 min. The sequence of the tests tried to respect a progressive increase in fatigue, starting with the morphology evaluation tests (height, weight, waist circumference, relative fat mass, relative muscle mass, body mass index, and waist-to-height ratio) followed by the fitness tests (push-ups—60 s; sit-ups—60 s; pull-ups—maximum; right- and left-hand grip; horizontal jump; shuttle-run test; *t*-test; sit-reach test).

Push-ups (60 s). For this test, the subjects were asked to stand in a plank position (only supporting feet and hands on the ground, with hands approximately shoulder-width apart, with fingers pointing forward and with the back sealed). One repetition was counted whenever, after flexing the upper limbs, the subject touched the wooden plate (T-shaped) with the chest and returned to the starting position. The participants were allowed to rest on the "top", but always maintained the plank position. The test lasted 60 s [7].

Sit-ups (60 s). To begin, the subject was asked to lie on the ground in a supine position, with knees bent at 90°, feet shoulder-width apart, and hands overlapped behind the head. The feet were held at the rated person's discretion, in one of the following options: by an external performer or by the person himself on the backrest. After the signal (whistle), the performer was asked to bring the elbow to or over the imaginary knee line. He then returned to the starting position (resting his shoulder blades on the ground). The test lasted 60 s. The result obtained consisted of the number of (well) performed executions.

Pull-ups (maximum). On a horizontal bar (placed approximately 2.50 m from the ground), the performers were asked to stand in suspension (no ground support), with hands in pronation and approximately shoulder width apart, with the upper limbs in extension (elbow extended), perform the pull-up movement, without moving the lower limbs (no swing), until the chin goes beyond the bar, then returning to the starting position. This movement consisted of one repetition. The result obtained consisted of the number of (well) executions performed [22].

Handgrip. For this test, we used a handgrip hydraulic hand dynamometer (model J00105—Sammons Preston, Bolingbrook, Illinois)—to record the handgrip strength. According to the size of their hands, the subjects placed the dynamometer to the extent that best suited them, and then they could place it beside or in front of their bodies to perform the grip. Both limbs were evaluated twice each, recording the best result in each limb [19].

Horizontal jump. A tape measure was placed along an athletics track. The performers were asked to place their feet approximately shoulder-width apart and to perform a horizontal jump with only a body swing. Once the "0" point was defined, the performer could not step on or over this limit during the initial jump. The result of the test consisted of the mark obtained between the support closest to point "0" and the distance to point "0". The test was performed twice, and the best mark was recorded in meters (m).

Shuttle Run. To perform this test, two marks were placed on the athletics track at 20 m. The policemen were instructed to cover this distance, crossing the mark (with both feet) and only being allowed to start a new course after the auditory signal (beep). The beeps were pre-recorded, starting with a speed of 8.5 km/h, progressively increasing by 0.5 km/h at each level (7/8 runs). The test ended when the runner could not reach, for the second time, the 20 m mark before the beep, or after giving up. The result obtained was given as a function of the number of runs performed (*n*) [14]. Through this test, it was possible to obtain the predicted VO_{2max} (mL/kg/min), through the formula: $VO_{2max} = -24.4 + 6.0\ X$, being X, the speed (km/h) of the stage in which they were in the last run performed [9].

T-test. Four cones were placed in a "T" formation. The participants started the test by standing behind the cone that formed the base of the "T". After the signal (whistle), they ran to the central cone (10 m), touched the base of this cone, moved laterally (without crossing the feet) to the left cone (5 m), after touching the base of the cone, moved (laterally) to the right cone (10 m), returned to the central cone (5 m), in lateral displacement, touched its base and returned to the starting point in "back" running (5 m). The performers were given one training opportunity, and the second was an evaluation. The result of the performance was obtained through the performer's mark in seconds [7].

Sit and reach. The subjects were asked to initially take a sitting position with their lower limbs in full extension and their feet resting on the vertical surface of the measuring box (Acuflex I, by Novel Products Inc. P.O. Box 408, Rockton, IL 61072). After placing themselves in this position, they were asked to place their upper limbs parallel, stretched out, supported on the graduated ruler, with hands overlapped and middle fingertips in contact with the cursor, to push the cursor along its natural course, parallel to the graduated ruler, progressively, as far as they could without flexing their lower limbs. The result was obtained using the device's scale, in centimeters [19].

Physical Training Program

Taking into consideration previous research [21], the physical training program applied lasted for 12 weeks and was divided into three mesocycles (of 4-week each).

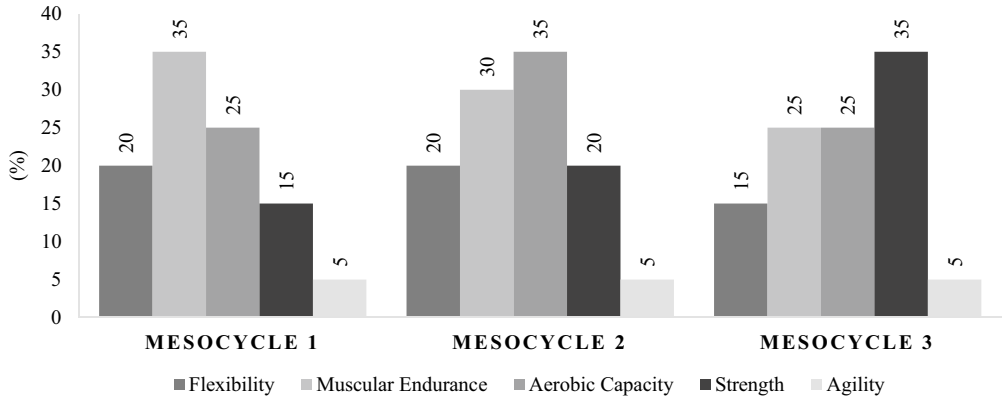

Fig. 1 Sequencing and periodization of training (mesocycles)

The objective of the 1st mesocycle (weeks 1–4), was a first adaptation to the stimulus (general adaptation and assimilation of exercises), using mostly bodyweight exercises, through circuit work (e.g.: abdominal plank; burpees; pull-ups). Each session lasted an average of 60 min. On average, this mesocycle had a percentage of flexibility work of approximately 20%, muscular endurance 35%, aerobic capacity 25%, strength 15%, and agility 5%. Focus: muscular endurance.

In the 2nd mesocycle (weeks 5–8), there was an initial increase in work intensity, followed by an increase in volume. There was a decrease in rest time between sets, and the workload was increased to 80% of 1RM. The average duration of the sessions increased to 65 min. On average, this mesocycle had a percentage of flexibility work of approximately 15%, muscular endurance 25%, aerobic capacity 35%, strength 20%, and agility 5%. Focus: aerobic endurance.

In the 3rd and last mesocycle (weeks 9–12), there was again an increase in work volume and intensity, increasing the load (85% of 1RM) and maintaining the number of sets and repetitions. In this mesocycle, there was, on average, a percentage of flexibility work of approximately 10%, muscular endurance 25%, aerobic capacity 25%, strength 35%, and agility 5%. Focus: muscular strength.

Periodization and programming are presented in Fig. 1 and Table 2, respectively.

Statistical Analysis

Descriptive statistics were used to characterize the sample, i.e., measures of central tendency (mean) and dispersion (standard deviation).

Given the non-normality of some variables under study (assessed using the Shapiro–Wilk test), we chose to use non-parametric tests to perform the inferential analysis, i.e., to assess the significance of the evolution of physical fitness attributes of police officers we used Friedman's nonparametric-test (T0, T1, T2), and to identify the moments in which physical fitness attributes varied significantly (T0-T1; T1-T2; T0-T2), we used the multiple comparisons of means of orders. In addition, the effect size (non-parametric tests) was calculated using the equation: $\frac{Z}{\sqrt{N}}$, and the magnitude of the effect was evaluated according to Cohen's [6] proposal, i.e., absolute value: 0.00–0.10, Null—Irritable; 0.11–0.29, Weak; 0.30–0.49, Moderate; ≥ 0.50, Strong.

The Statistical Package for the Social Sciences (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp) was the computer program used for descriptive statistical analysis and inference (with $\alpha = 0.05$).

Results

Regarding the morphology of the participants, it was observed that the abdominal circumference [$X^2_F(2) = 26.021$], the waist-to-height ratio [$X^2_F(2) = 18.053$], the relative muscle mass [$X^2_F(2) = 18.189$] and the relative fat mass [$X^2_F(2) = 15.486$] have undergone statistically significant changes ($P < 0.0001$) between the three evaluated moments (pre-, T0; week 8, T1; week 12, T2). However, of the four attributes mentioned, only waist circumference ($P < 0.01$) and waist-to-height ratio ($P < 0.05$) had significant changes at week 8 (T1).

Regarding the fitness attributes, a significant improvement was observed, in all the attributes studied, between the three moments evaluated, i.e., push-ups [$X^2_F(2) = 26.241$, $P < 0.0001$], sit-ups [$X^2_F(2) = 30.053$, $P < 0.0001$], pull-ups [$X^2_F(2) = 39.083$, $P < 0.001$], handgrip [dir., $X^2_F(2) = 19.421$, $P < 0.001$; esq., $X^2_F(2) = 12.574$, $P < 0.01$; mean dir./esq., $X^2_F(2) = 13.544$, $P < 0.001$; sum right + left, $X^2_F(2) = 8.190$, $P < 0.05$],

Table 2 Physical training program

Week	Day 1	Day 2	Day 3
1–4	10 min—Dynamic warming	10 min—Dynamic warming	10 min—Dynamic warming
	10 min—Flexibility (static stretches)	10 min—Flexibility (PNF)	10 min—Flexibility (PNF)
	30 min—Run	30 min—Circuit Training (3 × 60 s) (plank; burpees; battle rope (Bilateral waves); push-ups)	30 min—Run in series (5 × 400 m)
	10 min—Cool down	10 min—Cool down	10 min—Cool down
5–8	10 min—Dynamic warming	10 min—Dynamic warming	10 min—Dynamic warming
	10 min—Flexibility (PNF)	10 min—Flexibility (static stretches)	10 min—Flexibility (PNF)
	15 min—Run	40 min	30 min—Run in series (5 × 400 m)
	15 min—Circuit training (3 × 60 s: push-ups; sit-ups; pull-ups)	80%RM × 3 (8 × 8 × 6):	10 min—Cool down
	10 min—Cool down	Squat (with bar) + box jump;	
		Barbell bench press + push-ups;	
		Deadlift + kettlebell sumo high pull (dumbbells);	
		Pull-ups + barbell bent-over row	
		10 min—Cool down	
8–12	10 min—Dynamic warming	10 min—Dynamic warming	10 min—Dynamic warming
	10 min—Flexibility (PNF)	40 min	10 min—Flexibility (PNF)
	20 min—Run	85%RM × 3 (8 × 6 × 6):	20 min—Run in series (5 × 400 m)
	20 min—Circuit training (4 × 60 s: push-ups; sit-ups; pull-ups)	Squat (with bar) + box jump;	20 min—Circuit Training (4 × 60 s: push-ups; sit-ups; pull-ups)
		Barbell bench press + push-ups;	10 min—Cool down
		Deadlift + kettlebell sumo high pull (dumbbells);	
		Pull-ups + barbell bent-over row	
	10 min—Cool down	10 min—Cool down	

PNF proprioceptive neuromuscular facilitation

horizontal jump [$X^2_F(2) = 41.257$, $P < 0.0001$], shuttle run [$X^2_F(2) = 25.896$, $P < 0.0001$], VO_{2max} [$X^2_F(2) = 15.108$, $P < 0.001$], *t*-test [$X^2_F(2) = 37.661$, $P < 0.0001$] and sit and reach [$X^2_F(2) = 22.598$, $P < 0.0001$]. However, similar to what was observed in the morphological construct, only in nine (of the twelve fitness variables), significant differences were observed at week 8 (T1), i.e., in the push-ups ($P < 0.01$), sit-ups ($P < 0.001$), pull-ups ($P < 0.01$), handgrip (right, left, and middle right/left: all, $P < 0.05$), horizontal jump ($P < 0.001$), shuttle run ($P < 0.05$) and *t*-test ($P < 0.001$).

The results are presented in Table 3, and the differences between the initial performance and the evaluations performed at week 8 (delta T1–T0) and week 12 (delta T2–T0) are presented in Fig. 2.

In addition, it was observed, in the morphological attributes, the moderate effect of the training program at the end of the 8 weeks (and strong in waist circumference), and strong in all attributes at 12 weeks of training. In the fitness attributes it was observed that (i) at week 8 of training the effect size was moderate for the sum of handgrip strength (right + left), predicted VO_{2max} and sit and reach, and strong in the remaining attributes; but (ii) at the end of intervention (week 12) the effect was strong for all attributes except for the sum of handgrip strength (right + left) which maintained the effect observed at week 8. The effect magnitudes of the observed differences are presented in Table 4 and Fig. 3.

Discussion

The present study aimed to evaluate the effect of a 12-week physical training program on police officers' physical fitness attributes.

The physical program applied allowed us to realize that not all individual parameters of physical fitness present significant improvements in short periods (8 weeks). It was found that 12 weeks allows for significant improvement in the individual parameters associated with flexibility, agility, aerobic capacity, muscular endurance, and muscular strength.

Table 3 Descriptive and inferential analysis of morphological and fitness attributes of police officers ($n=30$) who participated in the 12-week physical training program

Variables	T0			T1 (8 weeks)			T2 (12 weeks)			Friedman's test				Multiple comparisons [B]		
										$X^2(2)$	Sig.[A]	CI 99%				
	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank			LL	UL	T0–T1	T1–T2	T0–T2
Weight (kg)	80.90	8.19	2.27	80.68	7.98	1.97	80.37	8.10	1.77	4.000	0.137	0.128	0.146			
Body Mass Index (kg/m^2)	25.39	1.86	2.17	25.33	1.69	1.98	25.23	1.73	1.85	1.529	0.500	0.487	0.513			
Waist circumference (cm)	87.00	4.61	2.67	85.40	4.21	1.78	84.37	4.66	1.55	26.021	< 0.0001	0.000	0.000	0.002		< 0.001
Waist to height ratio	48.79	2.45	2.58	47.92	2.51	1.88	47.33	2.63	1.53	18.053	< 0.0001	0.000	0.000	0.020		< 0.001
Muscle mass (%)	37.59	2.37	1.47	37.73	2.27	2.03	38.09	2.57	2.50	18.189	< 0.0001	0.000	0.000			< 0.001
Fat mass (%)	22.58	3.94	2.47	22.28	3.73	2.03	21.79	3.97	1.50	15.486	< 0.001	0.000	0.001			0.001
Push-Ups—60 s (n)	42.83	12.64	1.32	47.17	12.38	2.13	48.63	12.16	2.55	26.241	< 0.0001	0.000	0.000	0.005		< 0.001
Sit-Ups—60 s (n)	40.80	7.53	1.22	45.70	6.03	2.27	46.37	5.97	2.52	30.053	< 0.0001	0.000	0.000	< 0.001		< 0.001
Pull-Ups—maximum (n)	10.00	4.61	1.23	12.27	4.79	2.10	13.33	4.79	2.67	39.083	< 0.0001	0.000	0.000	0.002		< 0.001
Handgrip—right (kg)	45.20	8.44	1.38	48.35	10.40	2.25	49.25	10.53	2.37	19.421	< 0.001	0.000	0.000	0.002		< 0.001
Handgrip—left (kg)	43.57	7.92	1.50	46.25	8.69	2.28	45.90	9.30	2.22	12.574	0.002	0.001	0.003	0.007		0.017
Handgrip—mean right/left (kg)	44.38	7.93	1.47	47.30	9.34	2.23	47.58	9.55	2.30	13.544	< 0.001	0.000	0.002	0.009		0.004
Handgrip—sum right + left (kg)	88.77	15.86	1.58	93.55	17.91	2.17	93.48	18.65	2.25	8.190	0.015	0.012	0.018			0.029
Horizontal jump (m)	2.18	0.20	1.10	2.29	0.18	2.25	2.34	0.18	2.65	41.257	< 0.0001	0.000	0.000	< 0.001		< 0.001
Shuttle run (n)	57.47	10.64	1.33	63.17	14.88	2.05	67.23	14.54	2.62	25.896	< 0.0001	0.000	0.000	0.017		< 0.001
Predicted VO_{2max} (mL/kg/min)	42.70	3.74	1.55	44.60	4.46	2.17	45.30	4.29	2.28	15.108	< 0.001	0.000	0.001			0.014
T-test (s)	13.06	0.87	2.87	12.35	0.82	1.72	12.12	0.77	1.42	37.661	< 0.0001	0.000	0.000	< 0.001		< 0.001
Sit and reach (cm)	43.45	9.71	1.47	44.07	9.36	1.92	47.13	9.26	2.62	22.598	< 0.0001	0.000	0.000		0.020	< 0.001

SD standard deviation, *CI* confidence interval, *LL* lower limit, *UL* upper limit, T0, start; T1, after 8 weeks; T2, after 12 weeks

[A]Monte Carlo

[B]Significance was adjusted by Bonferroni correction for multiple tests

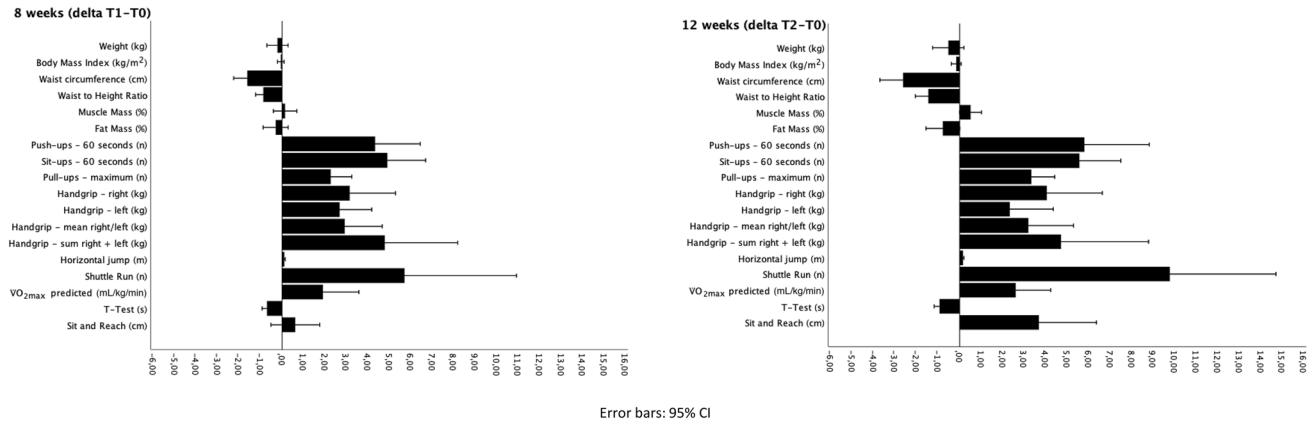

Fig. 2 Graphical representation of the differences (Delta) in morphological and fitness attributes of police officers after 8 weeks (T1–T0) and after 12 weeks (T2–T0) of training program application

Table 4 The magnitude of the effect of the physical training program on the morphological attributes and physical fitness of the police officers participating in the study ($n = 30$)

	Delta (T1–T0)	Delta (T2–T0)	Delta (T2–T1)
Weight (kg)	–	–	–
Body mass index (kg/m^2)	–	–	–
Waist circumference (cm)	0.62	0.79	0.17
Waist to height ratio	0.49	0.74	0.25
Muscle mass (%)	0.40	0.73	0.33
Fat mass (%)	0.31	0.68	0.38
Push-ups—60 s (n)	0.58	0.87	0.29
Sit-ups—60 s (n)	0.74	0.92	0.18
Pull-ups—maximum (n)	0.61	1.01	0.40
Handgrip—right (kg)	0.61	0.70	0.08
Handgrip—left (kg)	0.55	0.51	-0.05
Handgrip—mean right/left (kg)	0.54	0.59	0.05
Handgrip—sum right + left (kg)	0.41	0.47	0.06
Horizontal jump (m)	0.81	1.10	0.28
Shuttle run (n)	0.51	0.91	0.40
VO_{2max} predicted (mL/kg/min)	0.44	0.52	0.08
T-test (s)	0.81	1.03	0.21
Sit and reach (cm)	0.32	0.81	0.49

Regarding morphology, in the first 8 weeks, significant improvements were only observed in waist circumference and waist-to-height ratio. In the second assessment (T2), significant improvements were already observed in all variables, except for the variables body mass and body mass index (BMI). However, it is important to point out that body mass and BMI are variables with less and less relevance in the literature, since they may lead us erroneously to associate high body mass with overweight, which may be incorrect. In other words, high percentages of muscle mass and low percentages of fat mass will be associated with high body mass, which, by itself, does not mean that the person is in a state of obesity or overweight. In accordance, it is more important to understand body morphology through other types of information such as relative muscle mass and relative fat mass. Regarding relative muscle mass and relative fat mass, we can infer that for statistically significant improvements to be observed, the training program should be longer than 8-weeks (3 times/week).

Specific physical training programs for police officers have numerous advantages, having a proven impact on morphology and fitness [7, 13, 14, 23].

Similarly, to the studies conducted by Crawley et al. [7], after 8 weeks of the program, and Chizewski et al. [5], after 7 weeks, no significant differences were observed in flexibility (sit and reach). However, after 12 weeks of the physical training program, in contrast to the study by Pawlak et al. [19], significant differences were observed.

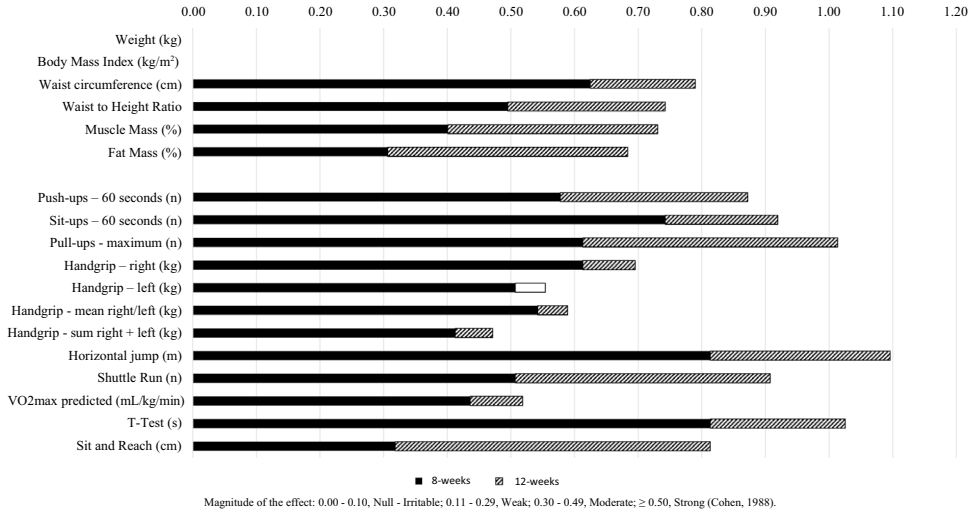

Fig. 3 Graphical representation of the dimensions of the effect of the training program at 8 (T1) and 12 (T2) weeks on the morphological and fitness attributes of police officers

To develop flexibility, we used proprioceptive neuromuscular facilitation (PNF) work and static stretching. Sokoloski et al. [25] also observed improvements in flexibility ($P < 0.05$) in their program. However, it is important to note that they used a longer program (24 weeks). This information allows us to speculate that the flexibility may require more extensive training programs (more than 8-weeks) or, possibly, weekly sessions (in the same period) superior to three, since here we performed weekly programming of 3×/week (8-weeks), proving to be insufficient.

Regarding muscular endurance, assessed through the tests of arm extensions on the ground (push-ups), sit-ups, and barbell lifts (pull-ups), we observed that there were significant differences both in the first 8 weeks and in the complete program (12 weeks). The results are similar to those of the studies conducted by: (i) Wood and Krüger [29], who observed significant improvements after 6 and 12 weeks of application of the program, in the sit-ups and push-ups tests; (ii) Crawley et al. [7], who observed differences in the sit-ups test (after 8 weeks), and in the push-ups test; and (iii) Reau et al. [22] and Lan et al. [13] who observed differences in the pull-ups test, albeit relative to a slightly longer training program (16 weeks).

The tests assessing muscle power (handgrip strength and horizontal jump) showed significant improvements after 8 and 12 weeks. Similar results were obtained by Kudryavtsev et al. [12] regarding handgrip strength (5 weeks) and, contrary to the study of Stone et al. [27] (no significant differences were observed after 11 weeks of their training program). However, as mentioned by the authors, the sample presented high values in this test at the initial assessment (right hand, 55.8 ± 6.8 kg; left hand, 54.3 ± 6.7 kg), which may have conditioned the existence of significant changes. These values are indeed high, and we can prove it by comparing these values with our study, since not even after the training program these results were reached (T2) (right hand, 49.25 ± 10.53 kg; left hand, 45.90 ± 9.3 kg).

Aerobic capacity (assessed using the shuttle test) showed significant improvements at both time points (8 and 12 weeks). These results are in line with those obtained by Kilen et al. [11] at 9 weeks and Lockie et al. [14] at 14 weeks.

Agility was assessed using the *t*-test and, like the studies by Crawley et al. [7] and Stojković et al. [26], showed significant improvements after both 8 and 12 weeks.

Analysing the magnitude of the effects (Table 4 and Fig. 3), we observed that in the first 8 weeks (T1), the significant variables presented a magnitude between 0.49 (moderate; observed in the waist-to-height ratio) and 0.81 (strong; observed in the horizontal jump and *t*-test variables), presenting an average magnitude, in the variables with significance, of 0.62. In turn, at week-12 (T2), the significant variables presented a magnitude between 0.47 (moderate; observed in the handgrip—sum of both hands) and 1.1 (strong; in the horizontal jump variables), presenting an average magnitude, in the variables with a significance of 0.77. It should also be noted that the only variable that decreases in effect between T1 and T2 was the left handgrip (T1, 0.55; T2, 0.51; Delta, − 0.04).

The implementation of a physical training program lasting at least 8 weeks, with a frequency of three training sessions per week (60 min each) seems to allow the development of the physical fitness of police officers. However, we believe that it would be important to follow up on the sample to understand the impact of detraining, because, as observed by Rossomanno et al. [23] and Lan et al. [13], after the end of the training program, when they reapplied the battery of tests sometime later, they observed a regression in the results obtained, both in terms of physical fitness.

The major limitation of the study was the lack of female participants. However, it is important to mention that there was only one female police officer in the police station where the study took place, which made it impossible to integrate them. In accordance, future studies (i) should replicate the intervention program both for female police officers and observe the differences between gender adaptation of the program; and (ii) could also look at the different adaptations to an intervention program at different stages of the police career. Future interventions, in addition to determining the volume and specificity of training, should also determine nutritional aspects (as they may bias the morphological parameters) as well as specify the different circadian cycles of the participants, which, as they vary, may influence the predisposition to physical activity, thus influencing the results.

Conclusion

Although 8 weeks of training allowed us to observe improvements in most of the physical fitness attributes, all of them improved significantly in the 12-week physical training program. In accordance, prolonging the duration of the training program from 8 to 12 weeks results in strong improvement in the physical fitness of police officers.

This tool can be applied by (tactical) security institutions, with the necessary adaptations, to their personnel, either to promote their employees' health and physical fitness or to "recover" eventual elements that present physical fitness attributes below the desired by the institution. In addition, it seems that the battery of tests applied is sensitive to the adaptations resulting from the application of a training plan, so it can be considered a useful tool to monitor or certify the physical fitness of police officers.

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Data Availability The data supporting this study's findings are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Ethics Approval The research, conducted from January to April 2023, met the conditions of the Declaration of Helsinki: Recommendations Guiding Physicians in Biomedical Research Involving Human Subjects, and had the approval of the Public Security Police and Higher Institute of Police Sciences and Internal Security (1300-352 Lisbon, Portugal; reference number 261/SECDE/2022).

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