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Body composition and physical capabilities of newly admitted police officers: changes during a training course

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ABSTRACT

Purpose. To investigate the changes that occur to body composition and physical fitness of newly admitted military police officers that undergo a training course involving a 24 weeks of physical training.

Methods. One-hundred and seven male police officers were evaluated before, after 12 weeks, and after 24 weeks of physical training. Body mass, fat mass, fat-free mass, fat percentage and body mass index were measured. Physical capabilities of strength (push-ups), muscle resistance (sit-ups), handgrip strength, and aerobic capacity (VO_2max) were also measured.

Results. An ANOVA with repeated measurements showed that after 24 weeks, there was a decrease ($p < 0.01$) of fat mass and fat percentage, and an increase ($p < 0.01$) in fat-free mass, number of push-ups, handgrip strength, and VO_2max. Most of the dependent variables already showed the best values in week 12.

Conclusions. Positive changes were observed in the body composition, aerobic capacity, and muscle strength of newly admitted military police officers at the end of 24 weeks of physical training, applied during the Soldier Training Course, compared to the beginning. However, the improvements occurred up to 12 weeks, with no new improvements after this, suggesting that modifications to the physical training are necessary.

Key words: physical exercise, conditioning, health, work performance, kinanthropometry

Introduction

In view of exposure to violence and crime, the work of police officers is considered a dangerous work activity [1, 2]. Physically, police work is mostly sedentary, however there are occasions when significant and suddenly physical effort is required [3–5], demanding quick physical adaptation to complete critical tasks [6]. These situations include, for example, pursuit of suspects (on foot), transport and arrest of detained individuals, rescue operations, direct confrontation, and crowd control [3, 6, 7].

In order to preserve their own safety and to meet the labour demands, police officers must be prepared [1, 2]. For optimum job performance, it is important to prioritise not only technical-legal knowledge but also health and physical fitness. Some physical demands may include running, jumping, pulling, pushing, holding, and carrying [1, 4]. Thus, satisfactory levels of strength, power, muscular endurance, speed, and cardiorespiratory fitness seem to be important for carrying out their work in the safest and most efficient way [1, 3–6, 8, 9]. Furthermore, low levels of body fat are suggested, not only to avoid the risk of metabolic and chronic-degenerative diseases [10], but for better work performance. Performance in specific military tasks correlates with lower levels of fat percentage and higher levels of lean mass [9]. In addition, weight gain can lead to a decrease in the cardiorespiratory capacity and police work performance [5, 7].

In general, based on the results of a recent systematic review, it seems that police officers presented physical fitness (e.g., cardiorespiratory fitness, strength) classified as 'average/good' or slightly above, in comparison with the general population [11]. In addition, the average fat percentage presented in the analysed studies was between 12 and 28.2% [11], which includes several classifications. As previously mentioned, these capa-

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bilities are important not just for health, but also for the police officer's job performance [3–10]. For example, excellent aerobic capacity can be used for pursuits on foot, while good muscle endurance is used for carrying the extra load of weapons or body armour [11]. Thus, it seems that monitoring the body composition and physical fitness of this population is relevant, independent of the career stage of the police officer.

In Brazil, after being approved in a public tender, the newly admitted military police officers undergo a Training Course for Soldiers. In this course, they are legally and physically prepared for their new duties and are exposed to general and specific physical activities of the daily work. One of the aims of this training course is to improve important physical capabilities for police officers, such as strength, muscle endurance and aerobic capacity, through a physical training. Some studies have investigated the effects of physical training on newly admitted police officers. Cocke et al. [1] verified that physical training applied for six months improved anthropometric measures and physical fitness variables in cadets, with differences in the improvements depending on whether the training was randomised or periodised. Čvorović et al. [12] verified improvements in the anthropometric and physical fitness of newly admitted police officers after 12 weeks of physical training. Finally, eight weeks of physical training were enough to promote improvements of some physical capabilities of cadets in a study by Crawley et al. [6]. However, no new improvements were seen in the remaining eight weeks of the exercise program [6].

As can be noticed, investigating the effectiveness of the physical trainings applied to newly admitted military police officers is clearly important, because it may improve their work performance, influencing their safety, and have implications for their health. It is expected that by the end of the training course, due to the physical training applied, the police officers will have better levels of physical fitness and a better body composition (i.e., low fat levels), thus being prepared to assume their duties. In addition, different training programs can be used, and investigating the results of each specific training program is also important.

Thus, the objective of this study was to investigate the changes in body composition and physical fitness of newly admitted military police officers that occur during the Soldier Training Couse, which involves 24 weeks of physical training. The main hypothesis is that the variables related to body fat will show a decrease, while the variables related to physical fitness will show an increase at the end of the course.

Material and methods

Design

This study has a longitudinal observational design, in which the body composition and physical fitness of newly admitted military police officers were evaluated before, after 12 weeks, and after 24 weeks of a physical training. The physical training was performed during an official formative course and conducted by military police officers qualified in physical education. The improvements of the dependent variables were tested through a mixed model analysis of variance with repeated measures, which compare the values for the three selected points in time.

Participants

The population was composed by two groups of 60 newly admitted police officers. Each group of police officers was admitted, trained, and assessed during the same semester of consecutive years, but the Soldier Training Course applied was the same for both groups. For this reason, the data was analysed together. After the exclusion criteria were applied, the study sample was composed of 107 male military police officers (age: 27.9 ± 2.2 years; height: 174.9 ± 5.5 cm). The participants had previous histories of physical activity (two to five times a week) and had no pathologies or injuries that precluded them from performing the tests with maximum performance. The police officers were newly admitted to the Military Police in Brazil, and after their recruitment, as part of their preparation, spent 24 weeks in the Soldier Training Course, which involved their physical training. After an explanation of the procedures, all the participants signed an informed consent form in which they were informed of the inherent risks and benefits, agreed to participate in the research, and had their rights and anonymity guaranteed. The exclusion criteria involved not carrying out the tests due to absence or injuries, and female police officers.

Physical training

Participants performed 24 weeks of physical training during the Soldier Training Course. The training program was composed of strength, localised muscular resistance, running, and stair climb exercises. In addition, functional training with specific military activities, such as carrying a partner and running with equipment, was also performed. It is important to mention that the type of exercises performed in each training session (i.e., running, strength, or functional) was alternated. That is, no more than one kind was applied in each session.

The trainings had aerobic and anaerobic characteristics, being non-periodised. The load of the exercises (weight, distance, or time) was increased every four weeks, and the intention was that the trainings were performed at moderate-to-maximum intensity. The frequency of the training was four sessions per week. Each session was executed for approximately one hour, divided into warm-up, main, and return to calm parts.

The training was applied in the morning or afternoon periods, depending on the day. For logistical reasons, each group of 60 police officers (of each year) were divided into two groups of 30 so the exercise trainings could be carried out. Thus, while one group was in theoretical classes or specialised practices, the other was performing the trainings, for example. The training was carried out at the headquarters of the military police (and in the street in the case of running and stairs climb trainings) and conducted by police officers qualified in physical education. The volunteers were evaluated at the beginning (baseline), in the middle (12 weeks) and at the end (24 weeks) of the Soldier Training Course. The interval between the last physical training session and the subsequent measurement session was between 24 and 48 h.

Procedures

The evaluations took place in a biomechanics and kinanthropometry laboratory, with the participants wearing appropriate clothes and without having previously carried out strenuous physical activities. The test battery was chosen to measure important components of physical fitness related to health (i.e., anthropometrics, muscle resistance, muscle strength, and cardiorespiratory fitness).

Anthropometric measurements

Anthropometric measurements were collected following the standardisation of the International Society for the Advancement of Kinanthropometry, by three trained, certified and experienced evaluators. Body mass was measured using a digital scale (Tanita, Illinois, United States), accurate to 100 g. Height was measured using a stadiometer (Gofeka, Santa Catarina, Brazil), with 0.1 mm precision. The skinfolds of the triceps, subscapular, suprailiac and calf were measured on the right side of the body, using a scientific adipometer (CESCORF, Porto Alegre, Brazil), with precision in the millimetres and a pressure of 10 g/cm^3. The body mass index (BMI) was calculated using the ratio between the body mass and squared height (m), using the World Health Organization (WHO) classification as a reference for assessment: < 18.0 underweight; 18.0–24.9 normal; 25.0–29.9 overweight; 30.0–39.9 obesity; and > 40 severe obesity [10]. Petroski's equation [13] was used to estimate body density, and after conversion by Siri's equation [14], the fat percentage was obtained. The body fractionation was computed in two components, where the fat mass was calculated through the product between the fat percentage and body mass, divided by 100; and the fat-free mass was obtained by subtracting the fat mass from the body mass.

Sit-up test

Abdominal muscles' localised resistance was measured through a sit-up test. The participant was in a supine position, with the knees flexed at 90° and the upper limbs crossed, with the hands positioned on the contralateral shoulders; the evaluator kept the feet of the participant stabilised. From this position, the participant touched his elbows to his knees and returned to the initial position as many times as possible in one minute [6].

Push-up test

Muscle strength was assessed using a push-up test. On the floor, in a prone position, with the elbows extended and the body supported on the hands and the feet, the participant performed an elbow flexion until the chest almost touched the ground, followed by a complete extension of the elbows. The arms were shoulder-width apart. Rest between flexions was not allowed. The largest number of completed movements was computed [15].

Handgrip strength test

Muscle strength was also assessed using a handgrip strength test. For this, a handgrip dynamometer (Takei, Tokyo, Japan), with an accuracy of 0.5 kg, was used. The dynamometer was adjusted according to the hand size of each individual, and the right hand was always evaluated. The volunteer remained seated, with the arm extended and the elbow flexed at 90°. At the evaluator's voice command, the participant performed maximum strength for three seconds [16]. The average of the maximum strength in two attempts was considered.

VO_2max test

Cardiorespiratory fitness was assessed using the Queens College Step Test [17], by estimating the maximum oxygen consumption (VO_2max). Using a metronome to set the pace at 96 steps per minute, the volunteers performed up and down from a 40.6 cm height step up for three minutes. The participant's heart rate was measured using a Polar heart rate monitor, model RS200. With the heart rate frequency results obtained after the test, it was possible to estimate the VO_2max using the equation:

$VO_2max = 111.33 - (0.42 \times \text{final heart rate})$ [17].

Statistical analysis

The data were analysed in the Statistical Package for the Social Sciences – SPSS (version 17.0), where initially the descriptive statistics of the data (mean and standard deviation) were calculated. The normality of the data's standardised residues was tested using the Shapiro-Wilk test. The data that did not show normality underwent logarithmic transformation, and after a new test, their normality was confirmed. To compare the variables between the evaluations (baseline, 12 weeks, and 24 weeks), a mixed model analysis of variance (ANOVA) with repeated measures was used, complemented with the Bonferroni post-hoc test. The level of significance adopted was $\alpha < 0.05$. Additionally, the magnitude of the variables' differences was quantified over time by calculating the effect size (Cohen's d) [(mean 1 – mean 2) / SD polled], always comparing two time periods (baseline – 12 weeks, 12 weeks – 24 weeks, baseline – 24 weeks). The results were interpreted as < 0.2 small, 0.21 – 0.5 medium, > 0.51 large [18].

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Regional University of Blumenau ethics committee (approval No.: 1.124.475).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Descriptive values (mean and standard deviation), as well as comparisons of body composition variables between the three assessments, can be seen in Table 1. The fat percentage and fat mass decreased at weeks 12 ($p < 0.01$) and 24 ($p < 0.01$) in comparison to the baseline values, while the fat-free mass increased at weeks 12 ($p < 0.01$) and 24 ($p < 0.01$) in comparison to the baseline values. Body mass and BMI did not change over time. The conventional statistics results were supported by the effect sizes results. The changes observed, especially between baseline and week 12, and between baseline and week 24, were classified as changes of medium magnitudes.

Table 2 shows the descriptive values and comparisons of the physical fitness variables over time. The number of push-ups, the handgrip strength and the VO_2max values increased at weeks 12 ($p < 0.01$) and 24 ($p < 0.01$; $p = 0.01$; $p < 0.01$), in comparison to the

Table 1. Comparison of body composition variables over 24 weeks of training

Variable	Baseline	12 weeks	24 weeks	*F*	*p*	0 vs 12 weeks ES (CI 95%)	12 vs 24 weeks ES (CI 95%)	0 vs 24 weeks ES (CI 95%)	% Change (0–24 weeks)
BM (kg)	77.4 ± 9.2	77.4 ± 8.4	77.0 ± 8.1	0.45	0.58	0.00 (–0.27 – 0.27)	–0.05 (–0.32 – 0.22)	–0.05 (–0.31 – 0.22)	0.5%
F%**	17.7 ± 4.6	16.2 ± 4.3*	15.7± 3.6*	29.6	< 0.01	–0.34 (–0.61 – –0.07)	–0.13 (–0.39 – 0.14)	–0.48 (–0.76 – –0.21)	11.3%
FM (kg)**	14.0 ± 4.9	12.7 ± 4.5*	12.3 ± 3.7*	21.4	< 0.01	–0.28 (–0.55 – –0.01)	–0.10 (–0.37 – 0.17)	–0.40 (–0.66 – –0.12)	12.1%
FFM (kg)	63.4 ± 6.2	64.7 ± 5.8*	64.7 ± 5.7*	32.7	< 0.01	0.22 (–0.05 – 0.49)	0.00 (–0.27 – 0.27)	0.22 (–0.05 – 0.49)	2.0%
BMI (kg/m^2)	25.3 ± 2.6	25.2 ± 2.2	25.1 ± 2.2	0.52	0.54	–0.04 (–0.31 – 0.23)	–0.04 (–0.31 – 0.23)	–0.08 (–0.35 – 0.19)	0.8%

BM – body mass, F% – fat percentage, FM – fat mass, FFM – fat-free mass, BMI – body mass index
** variables that underwent logarithmic transformation, * difference from baseline

Table 2. Comparison of physical fitness variables over 24 weeks of training

Variable	Baseline	12 weeks	24 weeks	F	p	0 vs 12 weeks ES (CI 95%)	12 vs 24 weeks ES (CI 95%)	0 vs 24 weeks ES (CI 95%)	Change (0–24 weeks)
Push-ups (n° rep)**	32.1 ± 11.2	40.6 ± 12.8*	36.0 ± 11.7*#	39.8	< 0.01	0.71 (0.43 – 0.98)	–0.38 (–0.65 – –0.10)	0.34 (0.07 – 0.61)	12.1%
Sit-ups (n° rep)	39.9 ± 8.8	46.7 ± 8.4*	40.8 ± 9.4	41.6	< 0.01	0.79 (0.51 – 1.07)	–0.66 (–0.94 – –0.39)	0.10 (–0.17 – 0.37)	2.3%
Handgrip strength (kg)	46.4 ± 6.4	48.5 ± 6.9*	47.6 ± 6.7*	9.66	< 0.01	0.32 (0.05 – 0.59)	–0.13 (–0.40 – 0.14)	0.18 (–0.09 – 0.45)	2.6%
VO_2max (ml · min^{-1} · kg^{-1})	40.1 ± 6.0	45.0 ± 5.1*	45.1 ± 5.3*	95.8	< 0.01	0.88 (0.60 – 1.16)	0.02 (–0.25 – 0.29)	0.88 (0.60 – 1.16)	12.5%

** variables that underwent logarithmic transformation, * difference from baseline, # difference from week 12

baseline week. Additionally, the number of push-ups decreased at week 24 compared to week 12 ($p < 0.01$) but remained above the baseline value. The number of modified sit-ups increased at week 12 compared to the baseline values ($p < 0.01$), but after 24 weeks of training, it returned to similar values of the training beginning. The physical fitness ANOVA results were also supported by the effect size results. The changes observed over time were classified as medium or large, according to the effects magnitude.

Discussion

The aim of the present study was to investigate the changes in body composition and physical fitness of newly admitted military police officers that occur during the Soldier Training Couse, which involves 24 weeks of physical training. The main hypothesis was that the variables related to body fat would decrease over time, while the physical fitness variables would increase. The findings showed a decrease in fat percentage and fat mass, while the fat-free mass, number of push-ups, handgrip strength, and VO_2max presented higher values after the 24 weeks of the training course, confirming the hypothesis.

Regarding body composition, the variables related to body fat – fat mass and fat percentage – presented decreases after 12 and 24 weeks of the training course in relation to the baseline. Since both variables are used to represent body fat, although on different scales, it is not surprising that they showed similar behaviours. As mentioned, high values of body fat are unfavourable to police work performance [9, 15], besides being harmful to health [10]. It is well-know that body fat represents an extra weight to be carried, in addition to possibly disturbing the functioning of some organs, thus overwhelming the cardiorespiratory and locomotor systems. During physical exercise, the adipose tissue (i.e., body fat) is mobilised and oxidated, being used as an energetic substrate [19]. The use of fat as a substrate is regulated by several factors, among them the mode, duration, and intensity of the exercise [20]. The fat contribution is higher especially during prolonged moderate-intensity exercises [21]. This, therefore, represents a possible mechanism to explain the decreases in the body fat seen in the police officers of the present study. Physical training was an important component of the training course and included exercises carried out for up to 60 min at moderate intensity. The police officers' diet could definitely have played a significant role in these results, but unfortunately, it was not controlled. At the end of the training, the participant's fat percentage was in the standardised average of 15% [22], which suggests an optimal value for health and physical fitness. This value was also in accordance with other studies involving the same population [1, 11, 15].

The fat-free mass also presented significant improvements throughout the Soldier Training Course, increasing after 12 and 24 weeks of the training in comparison to the baseline. A significant amount of fat-free mass (or lean mass) is important, because it is related to increases in muscle strength and resistance [23], in addition to be essential to health, preventing, for example, osteoporosis and insulin resistance [24, 25]. For police officers, good levels of muscle strength are important for the performance of their duties, as already mentioned. Thus, it can be suggested that this population will benefit from higher values of fat-free mass. Physical exercise is one of the main factors responsible for increasing muscle mass and, as a result, lean mass, through a process known as hypertrophy (i.e., increasing the volume of muscle cells). Specifically, strength and resistance training are pointed out as excellent exercises to achieve hypertrophy. That is because, if performed at an appropriate intensity and volume, it will cause micro-ruptures in the muscle's cells that, during the recovery process, together with proper protein availability, will increase the muscle volume [26, 27]. This mechanism helps to explain the results seen in the current study, where, after physical training involving strength and resistance exercises, the police officers presented an increase in their lean mass. Perhaps, even though the training program was not structured, and the intensity was not rigidly controlled, the sample training level produced the observed positive effects. The fat-free mass value found during the final assessment of the present study was slightly below to other studies with the same population [1, 8, 15].

Body mass and BMI did not present changes throughout the training course. The lack of changes in body mass can be explained by the recruits achieving a balance between decreasing their fat mass and increasing their fat-free mass, resulting in a stable body mass value. The BMI calculation takes into account body mass and height, so it is not surprising that it also remained constant. According to the WHO [10], the police officers of the present study had BMIs classified as 'overweight'. However, it must be highlighted that BMI is not considered a good health indicator for practitioners of physical exercise, since high values of lean mass might unfairly influence the interpretation of the values [28]. The body mass and BMI observed in the present study were lower [1, 6, 15] or similar [12, 29] to other studies with this population.

Regarding physical fitness, the muscular strength was measured through the maximal number of push-ups and handgrip strength. Compared to the beginning, at the end of the training course, the values presented were higher, although the number of push-ups significantly decreased in comparison to the middle (12 weeks) of the training. As mentioned, strength is considered an essential physical capability to the development of police officers' work; being necessary, for example, when performing arrests where there is resistance and rescues [11, 12]. Muscle strength can be improved through strength and resistance training, due to neural adaptations and hypertrophy [30]. Of course, it depends on the characteristics of the training program applied, in addition to respect the training principles, such as principles of overload and specificity [31, 32]. The increases in the strength values observed in the present study might be, at least partially, explained by the physical training applied during the Soldier Training Course. Other factors, such as specialised practices and extra physical exercises, might have also influenced the results, but these were not controlled. After the 24-week training course, the number of push-ups observed was classified as 'excellent' [33], and the handgrip strength was considered 'normal' [16]. The handgrip strength value of the present sample was lower in comparison to other studies [6, 11]. Due to the different methodologies involved, it was not a relevant metric to compare the number of push-ups in the present study to others from similar populations.

The muscle resistance, represented by the number of modified sit-ups performed in 1 min, increased after 12 weeks of the training course, but returned to baseline values after 24 weeks. This physical capability is considered relevant for police officers' work performance, being necessary, for example, in maintaining the correct posture while carrying the extra weight of the equipment belt and other body protection materials [11, 12]. It seems that the physical training applied during the Soldier Training Course was insufficient to induce long-term adaptation to this physical capability. It can be speculated that, even though the first part of the training course led to some improvements, the return to baseline of the values was due to the principle of reversibility, in which insufficient training load generates decreases in the performance [31]. After 24 weeks of the training course, the number of sit-ups observed was lower than those present in other studies with a similar population [1 ,6, 15].

The last physical capability evaluated was cardiorespiratory fitness, represented by estimating VO_2max. This variable presented an improvement after 12 weeks of the physical training applied during the training course, then remained stable at the end of the course. In addition to being important for the general health and quality of life [34], cardiorespiratory fitness is required in police officers' work, for on-foot pursuits of suspects, for example [11, 12]. Endurance trainings, such as running, when performed at an appropriate intensity, result in cardiorespiratory fitness adaptations. The maximum oxygen consumption can be improved through endurance exercises because they promote, among other things, physiological adaptations and increases in the cardiac output, which optimises oxygen transportation and utilisation [35, 36]. Taking into consideration that the physical training applied during the Soldier Training Course encompassed running and stair climb exercises of moderate intensity, it can be estimated that the improvements verified at the end of the training course are primarily a consequence of it. Corroborating, Lenart [37] observed that cadets that practiced sports activities more frequently, including mid- and long-distance running and swimming (aerobic exercises), possessed better respiratory abilities (based on spirometry), compared to cadets that practiced sport activities less frequently, suggesting some influence of the practice on cardiorespiratory system adaptations. However, like the strength improvements, other factors, such as extra physical exercises, also might have influenced the results, but these were not controlled. In the present study, the VO_2max value classifies the physical fitness of the military police officers as ‘good’ [33]. Considerable variation in the estimated values of VO_2max can be found in the literature, with studies presenting values above [29], below [38], or similar to [15] the present study. It must be borne in mind that different testing methodologies were used.

As can be noticed, all variables that showed improvements already presented the best values in week 12, without any subsequent significant improvement in week 24. A possible explanation for this comes from the principles of sports training. It seems that, initially, the military police officers were exposed to an unusual physical stimulus. Therefore, due to the principle of overload, their bodies underwent changes, which resulted in the improvements seen in week 12 [31, 32]. However, after this period, their bodies seem to have adapted (principle of adaptation), without new improvements [32]. Most likely, the non-structured format of the physical training applied does not provide accurate adjustments in the load/intensity of the training, especially at an individual level. Thus, it can be hypothesised that to avoid this, or to generate new performance improvements, varied stimuli and more progressive overload should be provided after the first half of the training period [12, 31, 32].

Other studies that evaluated the effects of physical trainings on the body composition and physical capabilities of police officers obtained results relatively similar to those of the present study [1, 12, 29]. Araújo et al. [29] found that after 54 weeks of physical training during the Soldier Training Course, body mass and BMI did not change, but there were improvements in neuromuscular and cardiorespiratory performance in newly admitted military police officers. Likewise, twelve weeks of training were also sufficient to improve the anthropometric and physical capacity variables in newly admitted military police officers [12]. Cocke et al. [1] verified that training protocols of randomised and periodised models, applied for six months, improved anthropometric measures and physical fitness variables in cadets, the most significant improvements being observed in randomised training. Finally, Crawley et al. [6] observed that some physical capacities increased in cadets after only eight weeks of training. However, similar to the present study, there were no subsequent increases over the remaining eight weeks of training – only maintenance of the improvements [6]. Together, the results of the aforementioned studies and those of the present study show that different physical training protocols might be beneficial in improving the body composition and physical fitness of police officers, but it is necessary to respect the training principles.

The present study has some limitations. First, the lack of details about the physical training performed. The training was applied by police officers qualified in physical education, and all the information provided by them about the application of the training is presented in the present manuscript. However, more details could have made it possible to better explain the findings and help other professionals in futures applications. Furthermore, as mentioned, the diet and the performance of extra physical exercises were not controlled and may have influenced the visualised results. The tests selected can also be considered a limitation. The use of more robust tests and equipment could have provided better or more detailed results. Finally, the lack of a re-test or a control group can also be considered a limitation of the current study. The use of a control group would make it possible to safely assign the results to the physical training applied. Nonetheless, it should be considered that the body composition and physical fitness variables were evaluated during a specific training course using a large sample of a population that is still lacking studies. This can be considered one of the strengths of the study. Future research on the topic should consider using a control group and a more robust test battery, as well as controlling the diet and extra exercises of the sample. In addition, future research could investigate the equivalent changes in a female sample.

Conclusions

Positive changes were observed in body composition, aerobic capacity, and muscle strength of newly admitted military police officers at the end of 24 weeks of physical training, applied during the Soldier Training Course, compared to the beginning. However, the improvements occurred up to 12 weeks, with no new improvements after this, suggesting that modifications to the physical training programme are necessary. The present results are important due to the need to emphasise the need for the responsible entities to encourage planned physical exercises and physical and anthropometric assessments in this population, not only at the beginning but also continuously throughout their careers.

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Conflict of interest
The authors state no conflict of interest.

Disclosure statement
No author has any financial interest or received any financial benefit from this research.

References

1. Cocke C, Dawes J, Orr RM. The use of 2 conditioning programs and the fitness characteristics of police academy cadets. J Athl Train. 2016;51(1):887–896; doi: 10.4085/1062-6050-51.8.06.
2. Plat MJ, Frings-Dresen MHW, Sluiter JK. A systematic review of job-specific workers' health surveillance activities for fire-fighting, ambulance, police and military personnel. Int Arch Occup Environ Health. 2011;84(8): 839–857; doi: 10.1007/s00420-011-0614-y.
3. Bonneau J, Brown J. Physical ability, fitness and police work. J Clin Forensic Med. 1995;2(3):157–164; doi: 10.1016/1353-1131(95)90085-3.
4. Orr R, Dawes JJ, Pope R, Terry J. Assessing differences in anthropometric and fitness characteristics between police academy cadets and incumbent officers. J Strength Cond Res. 2018;32(9):2632–2641; doi: 10.1519/JSC.0000000000002328.
5. Sörensen L, Smolander J, Louhevaara V, Korhonen O, Oja P. Physical activity, fitness and body composition of finnish police officers: a 15-year follow-up study. Occup Med. 2000;50(1):3–10; doi: 10.1093/occmed/50.1.3.
6. Crawley AA, Sherman RA, Crawley WR, Cosio-Lima LM. Physical fitness of police academy cadets: baseline characteristics and changes during a 16-week academy. J Strength Cond Res. 2016;30(5):1416–1424; doi: 10.1519/JSC.0000000000001229.
7. Rossomanno CI, Herrick JE, Kirk SM, Kirk EP. A 6-month supervised employer-based minimal exercise program for police officers improves fitness. J Strength Cond Res. 2012;26(9):2338–2344; doi: 10.1519/JSC.0b013e31823f2b64.
8. Boyce RW, Jones GR, Schendt KE, Lloyd CL, Boone EL. Longitudinal changes in strength of police officers with gender comparisons. J Strength Cond Res. 2009;23(8): 2411–2418; doi: 10.1519/JSC.0b013e3181bac2ab.
9. Pihlainen K, Santtila M, Häkkinen K, Kyröläinen H. Associations of physical fitness and body composition characteristics with simulated military task performance. J Strength Cond Res. 2018;32(4):1089–1098; doi: 10.1519/JSC.0000000000001921.
10. World Health Organization. Global report on diabetes. Geneva: World Health Organization; 2016.
11. Marins EF, David GB, Del Vecchio FB. Characterization of the physical fitness of police officers: a systematic review. J Strength Cond Res. 2019;33(10):2860–2874; doi: 10.1519/JSC.0000000000003177.
12. Čvorović A, Kukić F, Orr RM, Dawes JJ, Jeknić V, Stojković M. Impact of a 12-week postgraduate training course on the body composition and physical abilities of police trainees. J Strength Cond Res. 2021;35(3): 826–832; doi: 10.1519/JSC.0000000000002834.
13. Petroski EL. Development and validation of generalized equations for estimating body density in adults [in Portuguese]. Thesis [PhD in Human Movement Science] – Santa Maria, Federal University of Santa Maria; 1995.
14. Siri WE. Body Composition from Fluid Spaces and Density: Analysis of Methods. In: Brozek J, Henschel A (eds). Techniques for Measuring Body Compositions. Washington DC: National Academy of Sciences; 1961.
15. Dawes JJ, Orr RM, Siekaniec CL, Vanderwoude AA, Pope R. Associations between anthropometric characteristics and physical performance in male law enforcement officers: a retrospective cohort study. Ann Occup Environ Med. 2016;28:1–7; doi: 10.1186/s40557-016-0112-5.
16. Fukuda DH. Assessments for sport and athletic performance. Champaign: Human Kinetics; 2019.
17. McArdle WD, Katch FI, Pechar GS, Jacobson L, Ruck S. Reliability and interrelationships between maximal oxygen intake, physical work capacity and step-test scores in college women. Med Sci Sports. 1972;4(4): 182–186.
18. Lee DK. Alternatives to P value: confidence interval and effect size. Korean J Anesthesiol. 2016;69(6):555–562; doi: 10.4097/kjae.2016.69.6.555.
19. Thompson D, Karpe F, Lafontan M, Frayn K. Physical activity and exercise in the regulation of human adipose tissue physiology. Physiol Rev. 2012;92(1):157–191; doi: 10.1152/physrev.00012.2011.
20. Ranallo RF, Rhodes EC. Lipid metabolism during exercise. Sports Med. 1998;26(1):29–42; doi: 10.2165/00007256-199826010-00003.
21. Spriet LL. Metabolic regulation of fat use during exercise and in recovery. In: Maughan RJ, Burke LM (eds). Sports Nutrition: More Than Just Calories – Triggers for Adaptation. 2012;69:39–58; doi: 10.1159/000329281.
22. Lohman TG. Advances in body composition assessment. Champaign: Human Kinetics; 1992.
23. Charlton K, Batterham M, Langford K, Lateo J, Brock E, Walton K, et al. Lean body mass associated with upper body strength in healthy older adults while higher body fat limits lower extremity performance and endurance. Nutrients. 2015;7(9):7126–7142; doi: 10.3390/nu7095327.
24. Ho-Pham LT, Nguyen ND, Lai TQ, Nguyen TV. Contributions of lean mass and fat mass to bone mineral density: a study in postmenopausal women. BMC Musculoskelet Disord. 2010;11(59):1–9; doi: 10.1186/1471-2474-11-59.

25. Haines MS, Dichtel LE, Santoso K, Torriani M, Miller KK, Bredella MA. Association between muscle mass and insulin sensitivity independent of detrimental adipose depots in young adults with overweight/obesity. Int J Obes (Lond). 2020;44(9):1851–1858; doi: 10.1038/s41366-020-0590-y.
26. Schoenfeld BJ. The mechanisms of muscle hypertrophy and their application to resistance training. J Strength Cond Res. 2010;24(10):2857–2872. doi: 10.1519/JSC.0b013e3181e840f3.
27. Damas F, Libardi CA, Ugrinowitsch C. The development of skeletal muscle hypertrophy through resistance training: the role of muscle damage and muscle protein synthesis. Eur J Appl Physiol. 2018;118(3):485–500; doi: 10.1007/s00421-017-3792-9.
28. Rothman KJ. BMI-related errors in the measurement of obesity. Int J Obes. 2008;32(Suppl 3):56–59; doi: 10.1038/ijo.2008.87.
29. Araújo LGM, Sanches M, Turi BC, Monteiro HL. Physical fitness and injuries: 54 weeks of physical training among military police officers. Rev Bras Med Esporte. 2017;23(2):98–102; doi: 10.1590/1517-8692 20172302158877.
30. Taber CB, Vigotsky A, Nuckols G, Haun CT. Exercise-induced myofibrillar hypertrophy is a contributory cause of gains in muscle strength. Sports Med. 2019; 49(7):993–997; doi: 10.1007/s40279-019-01107-8.
31. Kasper K. Sports training principles. Curr Sports Med Rep. 2019;18(4):95–96; doi: 10.1249/JSR.000000000 0000576.
32. Stone M, Plisk S, Collins D. Strength and conditioning: training principles. Sports Biomech. 2002;1:79–103; doi: 10.1080/14763140208522788.
33. Pollock ML, Wilmore JH. Exercises in Health and Illness: Assessment and Prescription for Rehabilitation [in Portuguese]. Rio de Janeiro: MEDSI; 1993.
34. Sloan RA, Sawada SS, Martin CK, Church T, Blair SN. Associations between cardiorespiratory fitness and health-related quality of life. Health Qual Life Outcomes. 2009;28(7):1–5; doi: 10.1186/1477-7525-7-47.
35. Murias JM, Kowalchuk JM, Paterson DH. Mechanisms for increases in VO_2max with endurance training in older and young women. Med Sci Sports Exerc. 2010;42(10):1891–1898; doi: 10.1249/MSS.0b013e31 81dd0bba.
36. Lundby C, Montero D, Joyner M. Biology of VO_2max: looking under the physiology lamp. Acta Physiol. 2017; 220(2):218–228; doi: 10.1111/apha.12827.
37. Lenart D. Sports activity as a factor differentiating the level of somatic constitution and physical fitness of officer cadets at the Military Academy of Land Forces. Hum Mov. 2015;16(4):195–199; doi: 10.1515/humo-2015-0048.
38. Myers J, Kokkinos P, Nyelin E. Physical activity, cardiorespiratory fitness, and the metabolic syndrome. Nutrients. 2019;11(7):1652; doi: 10.3390/nu11071652.