

Age-related influences on somatic and physical fitness of elite police agents Influencias de la edad en la aptitud física y somática de los agentes de policía de élite

*,** Alfredo O. Araujo, ***Jose M. Cancela, *, ****Pedro Bezerra, *, ****Cesar Chaves, *, ****Luis P. Rodrigues

*Instituto Politécnico de Viana do Castelo (Portugal), **Detached Force of Special Police Unit in Oporto (Portugal), ***Universidad de Vigo (España), ****Research Center in Sports Sciences Health Sciences and Human Development (Portugal)

Abstract. Background: Elite police officers must be physically fit to perform their job occupational demands but information on the effect of age in their physical fitness and somatic composition is scarce. Our aim is to describe the effect of age on somatic and physical fitness of a Special Police Unit (SPU); and to understand age-related changes. Methods: 117 SPU elements of a total of 218, aged 42.6 ± 4.2 years, were assessed on their somatic (height, weight, circumferences, skinfolds); body composition (BMI, body fat); and physical fitness (maximal, power and endurance strength, aerobic power, and flexibility). T-tests were used for comparing results to other police studies. Regression analysis was used to detect the effect of age for somatic and fitness variable. Results: SPU elements showed a homogeneous and suitable fitness condition. No somatic differences were found along age, but annual age losses were found for physical fitness, namely for strength: left handgrip strength (95%CI -0.70 to -0.12), bench press (95%CI -2.34 to -0.89), squat jump (95%CI -0.70 to -0.12), medicinal ball throw (95%CI -0.62 to -0.25), push-ups (95%CI -1.64 to -0.66), pull-ups (95%CI -0.53 to -0.11), sit-ups (95%CI -1.33 to -0.27), but also on the VO₂max (-0.535 to -0.115). Conclusions: Portuguese SPU elements showed a good somatic and physical fitness condition according to the requirements of their profession. Regardless the effect of age they were able to maintain a good somatic fitness and a very good aerobic power along the years. The loss of strength was the most associated with age.

Keywords: law enforcement, physical endurance, morphology, strength, aging

Resumen. Introducción: Los agentes de policía de élite deben estar en buena forma física para cumplir con las demandas ocupacionales de su trabajo, pero la información sobre el efecto de la edad en su condición física y composición somática es escasa. Nuestro objetivo es describir el efecto de la edad sobre la aptitud física y somática de una Unidad Especial de Policía (SPU); y comprender los cambios relacionados con la edad. Métodos: Se evaluaron 117 elementos SPU de un total de 218, con edad de $42,6 \pm 4,2$ años, en su morfología (altura, peso, circunferencias, pliegues cutáneos); composición corporal (IMC, grasa corporal); y aptitud física (fuerza máxima, potencia y resistencia, potencia aeróbica y flexibilidad). Se utilizaron pruebas t-Student para comparar los resultados con otros estudios policiales. Se utilizó el análisis de regresión para detectar el efecto de la edad para la variable somática y de aptitud. Resultados: Los elementos SPU mostraron una condición física adecuada y homogénea. No se encontraron diferencias somáticas a lo largo de la edad, pero se encontraron pérdidas de edad anuales para la condición física, es decir, para la fuerza: fuerza de prensión (IC 95%: -0,70 a -0,12), bench press (IC del 95%: -2,34 a -0,89), squat jump (IC 95%: -0,70 a -0,12), lanzamiento de pelota medicinal (IC 95%: -0,62 a -0,25), extensiones de brazo (IC 95%: -1,64 a -0,66), flexiones de brazo (IC 95%: -0,53 a -0,11), abdominales (IC 95%: -1,33 a -0,27), pero también sobre el VO₂ máx. (-0,535 a -0,115). Conclusiones: Los elementos SPU portugueses mostraron una buena condición física y somática de acuerdo con los requisitos de su profesión. Independientemente del efecto de la edad lograron mantener una buena condición somática y una muy buena potencia aeróbica a lo largo de los años. La pérdida de fuerza fue la más asociada con la edad.

Palabras clave: cuerpos policiales, resistencia física, morfología, fuerza, envejecimiento.

Introduction

Police officers must be physically fit to cope with their job occupational demands (Marins, David, & Del

Vecchio, 2019). Several studies have pointed out that police work requires performing multiple physical efforts, like lifting, transporting, pushing, dragging, pulling, fighting, hitting, jumping, crawling, running, and arresting suspects (Dillern, Jenssen, Lagedstad, Nygård, & Ingebrigtsen, 2014; Lockie, Dawes, Kornhauser, & Holmes, 2019; Rhea, 2015). The work

and efficiency of movements performed by police officers seems to be largely determined by the somatic characteristics of their bodies (Araujo, Cancela, Rocha-Rodrigues, & Rodrigues, 2018). It is easier to attack and injure a police officer whose morphological structure is compromised (by obesity or muscular atrophy) due to an unhealthy lifestyle (J. V. D. C. Esteves, Andrade, Gealh, Andreato, & Franzói de Moraes, 2014). Police officers showing a combination of a fit body composition and physical condition are also less prone to injuries and disease conditions (Magnavita & Garbarino, 2013; Zimmerman, 2012); relate better with their peers and improve police public image (Violanti, Ma, et al., 2017). They are also more productive at work, cope better with stressful situations (Gerber et al., 2014), and show a lower tendency for the excessive use of force (Zorec, 2009). Furthermore, active and fit agents are less likely to early retire from duty, or to be prone to occupational diseases (Violanti, Fekedulegn, et al., 2017).

Although a great age range is to be expected within the different Police forces, job-specific physical demands are usually not changing with advancing age (Lockie et al., 2019). Furthermore, reports are showing that police officers are not getting younger all over the world (e.g. The police foundation (Hale, 2017)). In Portugal, a recent report shows that nearly half of police officers are 45 years old or older, and this percentage tends to increase in the next decades (MAI, 2017). Giving the physical demands of the job, the age-related decline on physical and physiological characteristics can have a huge impact on the officers' ability to successfully perform their job tasks, while keeping them safe and healthy.

In Portugal, within the police forces, the Special Police Unit (SPU) created at August 31, by the Law 53/2007 of the Portuguese Government (Lei Orgânica da Polícia de Segurança Pública, 2007), includes the Special Intervention Forces, must be prepared to countless risk missions. The Portuguese SPU is a unit dedicated to operations for the maintenance and restoration of public order, resolution and management of critical incidents, tactical intervention in particularly violent, dangerous, complex and risky situations, security of sensitive installations and major events, personal security of members of the government and official institutions, deactivation of explosives, underground security, and international missions. They need to use heavy protective and armored equipment daily, making their physical and somatic fitness an important job requirement, regardless of their age. Aging, and its associated loss of functional health and fitness, can

compromise the job accomplishment of all police officers, but more so on this specific group of police agents. Admission to SPU is conditional upon inspection, medical examinations and physical testing, and all operational personnel are subject to annual physical, technical and firearm certification tests. Despite their need to maintain physical and somatic fitness, no specific exercise or nutritional program is currently implemented at SPU. Officers can use the existing fitness facilities, and they are recommended to do so, during their work time but always depending on the schedule that usually includes travelling away from the SPU base. Given these constraints (lack of time, program, and supervision), SPU agents involvement in physical exercise or nutritional programs depends almost entirely on the agent will power and spare time.

Information on age-related effects on this specific population is still scarce (J. J. Dawes, Orr, Siekaniec, Vanderwoude, & Pope, 2016; Lockie et al., 2019; Teixeira, Monteiro, Silvestre, Beckert, & Massuca, 2019) and, to the best of our knowledge, no studies have looked for the effect of age in the physical fitness and somatic composition of special force's officers.

Thus, the goals of this study are: (1) to describe the effect of age on the somatic and physical fitness of the elements of a Special Police Unit, part of the Portuguese Public Security Police; and (2) to understand how detrimental can the age-related changes be, relative to the occupational demands of this professional class.

Material and methods

Sample

A convenience sample of 117 male agents from the Oporto Special Police Unity (SPU) of the Portuguese Public Security Police, took part of this study. The sample represented 54% of all the SPU population, with an age range from 28 to 55 years of age, and an average age of 42.5 ± 4.4 years. All included agents had several years of active duty in the SPU (ranging from 7 to 34 years with an average of 20.5 years), and the absence of personal or physical impediments to participate in the program.

The study was approved by the Scientific Council of the Polytechnic Institute of Viana do Castelo and authorized by the Portuguese Nacional Board of the Public Security Police. After being informed of the study conditions, all participants volunteered for participating and signed a consent form. All procedures were in accordance with the ethical principles for medical

research involving human subjects of the WMA Declaration of Helsinki 2013.

Methods

The SPU police force uses a specific physical fitness assessment protocol (Araujo et al., 2018) to assess every agent at every active duty year. To fully take into account the daily physical demands of this special unit elements (e.g. the need to use heavy protective equipment and weaponry), we used in our study, not only the SPU physical fitness assessment protocol (aerobic power and endurance strength), but also the tests for maximum strength, explosive strength, and flexibility, along with somatic measures. These additional tests are usually performed in similar studies, thus allowing the comparison between police force's elements (Beck et al., 2015). All measures were taken by the same trained observer and this paper first author. All participants were tested on a morning period on groups of 2 to 5 persons, during the autumn season (October and November). The testing sequence was somatic measures (height, weight, skinfolds, and muscle circumference), flexibility (sit-and-reach), maximal strength (handgrip, bench test), power strength (squat jump, medicine ball throw), endurance strength (push-ups, pull-ups, sit-ups), and aerobic power (cooper test) along an average period of two hours including individual resting time between the tests.

Somatic measurements included: height; weight; tricipital, subscapular, suprailiac and calf skinfolds; mid-arm circumference, and calf circumference. All measurements were taken according to the International Society for the Advancement of Kinanthropometry standardized protocol (ISAK, 2001).

Body composition assessments included the body mass index (BMI) and the percentage of body fat (%FAT). BMI was estimated using bodyweight in kilograms divided by height square in meters. Percentage of body fat was quantified using a TANITA scale (Body Composition Analyzer, model BC-418 MA, Arlington Heights, USA) according to the Tanita protocol (Tanita, 2016).

Flexibility was tested by the best of three attempts on the sit-and-reach test, according to the ACSM protocol (ACSM, 2014a).

Maximal strength included assessments of isometric maximal strength, and concentric maximal strength. The first was tested with the handgrip dynamometer (SAEHAN, model SH5001, Changwon, South Korea) according to the American Society of Hand Therapists

(Fess, 1992), and the second was assessed with 1RM bench press test protocol (ACSM, 2014a) using a Gym80 bench, and a 15 kg Olympic iron barbell (220 cm long, 10 cm handle area) equipped with Air Machine rubber discs of 2.5, 5, and 10 kg.

Power strength of the upper and lower limbs was assessed respectively by throwing for distance a 3 kg medicine ball (Johnson & Nelson, 1979); and by the squat jump test without countermovement, performed on the Globus Ergojump (Byomedic, Barcelona, Spain) (Bosco, 1994). The best of three attempts was recorded.

Endurance strength was evaluated by the maximum number of push-ups, and pull-ups in 1 min, and by 2 min sit-ups. All three tests were performed according to standardized established protocols (Farinatti, 2000).

Aerobic power was assessed by the maximum distance covered in 12 min according to the Cooper protocol (Cooper, 1968), and the derived calculation of VO_{2max} . The test took place in a 400 m tartan track with marks at every 25 m.

Statistical analyses

All variables were considered as being normally distributed when the ratio of skewness to its standard error was between -2 +2 (Marôco, 2018). Descriptive statistics (mean and standard deviation) were used to characterize all normal distributed variables.

The mean, standard deviation and number of participants reported in previously published police studies with similar age scope were used to conduct independent Student t-tests to test for differences with our results. To understand the contribution of age for the measured variables, a linear regression was run to each variable using age as predictor. Residuals distribution were inspected for normality. Results of each variable according to the increment of one year of age in the participants' sample were expressed by the non-standardized Beta coefficient, and its 95% confidence interval whenever the coefficient was statistically significant. The amount of variance explained by the age of participants in each variable was also reported (R^2).

All statistical analyses were conducted in IBM SPSS Statistics version 25 for Windows (SPSS Inc., Chicago, IL, USA). The statistical significance level was set at $p < 0.05$.

Results

Table 1 presents the descriptive values (number of

participants, mean, standard deviation, minimum and maximum values) for all tested variables and the regression coefficients for the effect of age on each variable tested along with their 95% confidence intervals. The magnitude of the average change per year for each variable is represented by the Beta coefficient and respective 95% confidence interval (Table 1).

Table 1
Descriptive values, regression coefficients and 95% confidence intervals for the effect of age on each variable tested (N = 17).

	Mean	SD	Min	Max	R ²	B	Beta	95% CI	Sig.
Somatic measures									
Height (cm)	175,9	4,7	165	188					
Weight (kg)	82,3	9,8	66	120	.005	-0.12	-	--	.569
Tricipital skf (mm)	9,1	3,1	4,1	18,0	.001	0,02	-	--	.785
Subscapular skf (mm)	14,1	5,2	6,5	38,0	.010	0,12	-	--	.276
Suprailiac skf (mm)	17,9	5,9	6,0	32,2	.010	-0,13	-	--	.288
Calf skf (mm)	6,1	2,2	3,0	12,1	.000	-0,01	-	--	.897
Midarm circumf. (cm)	36,1	2,9	30,2	44,7	.069	-0,17	-0,26	[-0,29 to 0,06]	.004
Calf circumference (cm)	38,6	2,4	34,0	46,0	.007	0,04	-	--	.337
Body composition									
BMI (kg/m ²)	26,6	2,8	22	37	.002	0,03	-	--	.639
%FAT	21,6	4,3	12	34	.000	0,00	-	--	.983
Maximal strength									
Handgrip right (kgf)	53,9	7,6	38	70	.029	-0,298	-	--	.064
Handgrip left (kgf)	51,7	7,1	31	68	.063	-0,407	-0,25	[-0,69 to -0,12]	.006
Bench test (kgf)	93,0	18,6	55	145	.145	-1,616	-0,38	[-2,34 to -0,89]	.000
Power strength									
Squat jump (cm)	31,0	4,8	17,7	45,6	.155	-0,435	-0,39	[-0,70 to -0,12]	.000
Medicinal ball throw (m)	5,4	0,72	3,3	7,8	.163	-0,067	-0,40	[-0,62 to -0,25]	.000
Endurance strength									
1 min Push-ups (n)	49,3	12,2	24	90	.164	-1,151	-0,41	[-1,64 to -0,66]	.000
1 min Pull-ups (n)	10,7	4,9	2	30	.080	-0,325	-0,28	[-0,54 to -0,12]	.003
2 min Sit-ups (n)	62,8	12,5	28	86	.075	-0,799	-0,27	[-1,33 to -0,27]	.004
Aerobic power									
Cooper test (m)	2747,5	254,5	2175	3250	.046	-12,70	-0,22	[-23,7 to -1,74]	.024
VO2máx. (ml/kg/min)	50,1	5,7	37	61	.046	-0,283	-0,21	[-0,54 to -0,12]	.024
Flexibility									
Sit-and-Reach (cm)	30,7	7,6	12	45	.001	0,040	-	--	.806

Note: B= unstandardized regression coefficient; BETA= standardized regression coefficient.

Regarding the results related to the somatic constitution and body composition of the police agents, only for arm circumference an average loss of 0.174 cm by year of age was found. For all other somatic variables, the regression coefficients were all statistically non-significant, meaning that no changes can be attributed to an age effect.

However, within the fitness related variables only the right-hand maximal strength (handgrip right) and the flexibility (sit-and-reach) did not statistically significant losses associated with age. For all other fitness variables, a loss of performance was detected associated with increasing age.

Discussion

Special police officers are required to have a strong, muscular, and robust body (Araujo et al., 2018; J. J. Dawes et al., 2016; Dillern et al., 2014; J. Esteves, Andrade, Andreato, & Morais, 2014; Lockie et al., 2019). In fact, the average member of the SPU is taller (175,9 vs 172.9) (Nobre, Jorge, Macedo, & Castro, 2004), and less obese (12.0% vs 22.9%) than the average Portuguese men of

identical age (Gaio et al., 2018). They also present a significantly lower average tricipital (9.13 vs 15.1; $p < .001$) and subscapular skinfold thickness (14.1 vs 20.9; $p < .001$); and a higher midarm circumference (36.1 vs 34.9; $p < .05$) than the general population of the same age (Fryar, Gu, & Ogden, 2012). In addition, when BMI was used in the comparison with other police forces with similar average age, we concluded that the SPU men are significantly fitter than Police elements of similar age from the USA (26.6 vs 29.4; $p < .01$) (Can & Hendy, 2014; Fekedulegn et al., 2017), similar to Slovenian police agents (26.0) (Zorec, 2009), and only less fit than the Japanese agents (26.6 vs 24.3; $p < .01$) (Izawa, Tsutsumi, & Ogawa, 2016). Also on the fat mass, our SPU men showed to be leaner than their USA peers with identical age (23.8%, and 29.6%; $p < .01$) (Alasagheirin, Clark, Ramey, & Grueskin, 2011) (Charles et al., 2015).

Regarding the effect of age on the somatic and body composition variables, our results indicate that only the midarm circumference shows a statistically significant loss associated with the increasing age of the agents (-0.174 cm per year). Given the average values presented by our sample when compared to other police agents across the world, these results are encouraging because they show that SPU elements remain morphologically fit, independent of age. Maybe the specific physical activity that elite SPU agents are engaged on their daily police work life, but also their commitment to keep in shape as a professional duty, can explain these differences. This supposition is supported by the results presented by non-elite Portuguese police officers that show a clear age detrimental effect on this same somatic variables (Teixeira et al., 2019), namely a strong increase of relative fat mass ($\eta^2 = 0.357$), and a small augmentation of their BMI ($\eta^2 = 0.153$).

In general, research shows that newly graduate Police agents are physically fit, but their physical fitness tends to decrease after graduation (Sorensen, Smolander, Louhevaara, Korhonen, & Oja, 2000). That can represent a problem to their success for the everyday police work, particularly if the physical fitness profession demands remain the same. Information on how physical fitness and the specific job demands actually change through elite police officer's careers remains unanswered (Hoffman & Collingwood, 2015; Sluiter, 2006).

Relative to maximal strength, both right and left handgrip mean values of our sample were classified as

above average from the general population ($p50=50$ kgf) (Dodds et al., 2014), but similar to the Portuguese non-elite Police officers (105.6 vs 106.6 kgf for the sum of both hands) (Teixeira et al., 2019). The bench press average value was close to the 90th percentile of the general population reference values (ACSM, 2014a), and significantly better than the average Portuguese police officer within the same age range (93.0 vs 84.7; $p<.001$) (Teixeira et al., 2019).

Power strength mean values for the squat jump were higher than the same age average Portuguese Police officer (31.0 vs 24.1; $p<.001$), and in fact were very similar to the performance of the 20-29 years old group (32.0) (Teixeira et al., 2019). The medicine ball throw performance was classified as average, according to the reference values (Bosco, 1994; Johnson & Nelson, 1979).

On the endurance strength, the push-up mean value was significantly better than their regular Portuguese (49.3 vs 31.3; $p<.001$) and USA police peers (49.3 vs 43.9; $p=.001$) (J. Dawes, Orr, Brandt, Conroy, & Pope, 2016).

On the sit-up test, the SPU elements mean values are considered excellent by the ACSM age-reference values, and the pull-up's average is at the 80th percentile (ACSM, 2014a, 2014c).

Relative to the aerobic power assessment, participants revealed an excellent average VO_{2max} , close to the 90th percentile of the similar age general population (ACSM, 2014b), and significantly better than the Portuguese regular Police (50.1 vs 37.1; $pd>.001$) (Teixeira et al., 2019), the Brazilian Military Police (J. V. D. C. Esteves et al., 2014) (50.1 vs 42.1; $pd>.001$) and Highway Patrol (Junior, Medeiros, Oliveira, Ferreira, & Sousa, 2009) (50.1 vs 34.8 $pd>.001$) although being younger, and the USA University Police (Beck et al., 2015) (50.1 vs 42.7 $pd>.001$). Only the Special Operations Battalion from Rio de Janeiro, Brazil (Berria, Daronco, & Bevilacqua, 2011) (50.1 vs 55.1; $p<.001$), and the police officers from Turkey (Ali et al., 2012) (50.1 vs 52.4; $p<.001$) showed a better aerobic power.

Finally, concerning the flexibility component, the SPU elements showed a mean considered as high by the general population reference values (ACSM, 2014b). Our SPU sample showed significantly better results in the sit-and-reach test than the Military Police from Minas Gerais (30.7 vs 13.2; $p<.001$) (Filho et al., 2012), and the Special Police Operations Battalion from Bauru-São Paulo (30.7 vs 22.7; $p<.001$) (Berria et al., 2011) both from Brazil; but worse than the regular agents of the Portuguese Public Security Police (30.7 vs 40.1;

$pd>.001$) (Frias, 1999; Monteiro, 1998). No differences were found with the US University Police (Beck et al., 2015).

All the strength measures - maximal, power, and endurance strength - except for the right handgrip, showed to be negatively affected by age. This means we can expect older agents to be less strong, less powerful, and less resistant to strength fatigue, each year. This tendency, the amount of loss per year is represented by an average expected value (beta coefficient) that can vary along the represented 95% confidence interval (see Table 1). For instance, in the squat jump performance our results indicate that, as each year goes by, a detriment ranging from -0.697 to -0.117 cm (-0.435 on average) can be expected. In a decade, about 4.35 cm are lost in vertical jump height.

For SPU agents to have a long career in active duty it is important to keep fit, regardless of the biological age-related changes. Our research shows that agents were generally able to maintain the same level of somatic fitness and body composition, but their physical fitness performance decreased as they were older. Age associated losses were more evident on strength related fitness, which was expected given the natural loss of muscle mass related to age, or sarcopenia (Picoli, Figueiredo, & Patrizzi, 2011). Power strength was the fitness component with the greater annual standardized effect (-0.403 for medicine ball throw, and -0.393 for squat jump), followed by the endurance strength tests (-0.405 for push-ups; -0.282 for pull-ups, and -0.274 for sit-ups), and maximal strength (-0.381 for bench press, and -0.251 for left handgrip). Teixeira and colleagues (Teixeira et al., 2019), when comparing Portuguese police officers' age decade groups from 20's to 40's years of age, also found a very large to large effect size for age relative to endurance strength ($\eta^2=0.564$ for sit-ups, and 0.436 for push-ups), a large effect size relative to power strength ($\eta^2=0.345$ for vertical jump), and a small effect size for maximal strength ($\eta^2=0.188$ for bench press, and 0.133 for handgrip).

Relative to the aerobic power of our SPU subjects only a small although significant effect was found along the years ($\alpha=-0.215$), which, given the high VO_{2max} values found, show that these elite officers maintained a high aerobic power independent of age. The same cannot be said of their regular counterpart agents that showed a very strong detrimental effect on VO_{2max} capacity ($\eta^2=0.632$) (Teixeira et al., 2019).

Some limitations on this work must be acknowledged. Although the sample was large (54% of

the population), participants were not randomly selected, which can drive a possible bias towards better performance values. Since the design was cross sectional caution should be exerted as to fully expect that the found effects represent real age changes. All comparisons were exclusively made with studies on male policeman that used the same or similar variables testing, but in some cases, there were small differences on the protocols used that could influence the results. Also, the type of police units compared were not always elite forces as the SPU. Some were constituted of regular police agents, some were special units of some kind (SWAT, Military Police, etc.), and these differences can contribute for the reported results on somatic and physical fitness. Furthermore, living conditions and professional conditions, social economic status, age, cultural environment, lifestyle (nutrition and exercise), and even genetics were not controlled in this study or in any other of the aforementioned, and could have interfered with the overall results and conclusions.

On the positive side, this study is the first to address the issue of somatic and physical fitness in Portuguese elite police units, and a large sample was used. Most of the published research on the theme, and all the studies cited for comparison, only used a small, limited sample. This fact makes this the most comprehensive study to address the issue of physical and somatic fitness on elite police units.

Conclusion

A police agent profession demands him to be fit across his active life, and more so if he belongs to a special police force. That is why addressing changes in somatic characteristics and physical fitness levels of actual agents across a broad age spectrum might give us an insightful picture on the situation, enabling us to act against deleterious changes that would otherwise negatively impact their job function, personal safety and health.

The Portuguese SPU elements showed a homogeneous and suitable somatic and physical fitness condition, according to the requirements of their professional practice, when compared with other police forces all over the world.

Portuguese elite polices showed to keep a good somatic fitness and did show to maintain a very good aerobic power along the years. The loss of strength was the most associated with age, but even so and comparing to other studies, SPU agents were able to keep fit. Overall and by the comparison with other international

police forces, Portuguese SPU elements showed to be quite fit for the job, but further studies and comparisons are warranted to understand how the real (longitudinal) changes occur, and how fit to duty really are these police officers while aging.

The results further suggest that prescription of a training program aimed to maintaining and reinforcing the best results, as well as reversing the most adverse outcomes, might be necessary. Police officers who perform their duties in this type of elite units should exhibit high levels of aerobic power, core, muscular and power strength, and flexibility, to adequately meet the needs of the job.

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