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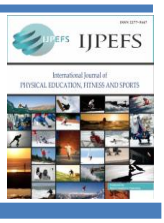

Invited Article

A brief review of body composition in police workforce

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Filip Kukic [a,*], Milivoj Dopsaj [b], Aleksandar Cvorovic [a], Milos Stojkovic [c], Velimir Jeknic [c]

[a] Police Sports Education Center, Abu Dhabi Police, UAE
[b] Faculty of Sport and Physical Activity, Belgrade, Serbia
[c] Police College, Abu Dhabi, UAE
[*]Corresponding Author: Ph: +971- 056 4805956: Email: filip.kukic@gmail.com

Abstract: It is evident that success in performing certain police duties undoubtedly depends on the level of certain physical abilities, while good health status is necessary for each employee in police workforce. Tasks performed by police officers can involve chasing fleeing suspects on foot, grappling, wrestling and handling uncooperative belligerents, and carrying injured or unconscious people. Next to the "foot soldiers", logistics and administration jobs are less physically but mentally very demanding and stressful. In both cases, body composition has twofold importance in physical fitness: performance-related and health-related. Therefore, the purpose of this study was to gather the studies that dealt with body composition in police workforce using various approaches with the aim to make a clearer insight into what has been done so far, and what might be done in the future.

Key Words: policing, testing, performance, body fat, muscle mass, tactical athlete

Filip Kukic *is a Ph.D. candidate at the University of Sport and Physical Education, University of Belgrade, Serbia. Filip was a professional flat-water kayak and rowing athlete, competing for the both national teams. He studies at Faculty of Sport and Physical Education, University of Belgrade (2008) where he gained Bachelor (2012) and Master's degree (2014) at the Biomechanics and Motor control. Currently he is employed in Abu Dhabi police on developing and implementing strategies of physical fitness improvement of police employees. His current research is related to associations between body composition and physical fitness and physical performance. Some of his longitudinal studies are on the effect of planned exercise programs on changes in body composition and physical abilities in male and female police officers. He has been author and co-author of different posters and communications in international conferences. He has also been collaborating in research projects with the members of Faculty of Sport and Physical Education, Belgrade; Academy of Criminalistic studies in Belgrade, Serbia; Tactical research unit of Bond University, Australia; and with a member of Health Department of Colorado Springs, University of Colorado Springs.*

Milivoj Dopsaj *was the national swim team member, and national swim record holder in former Yugoslavia from 1978 to 1989. He studied at the Faculty of Sport and Physical Education University of Belgrade (1990), where he completed his M.Sc. (1998) and Ph.D. (2005) in Department of Swimming and Water polo. For the past 20 years his research interests have combined technology in science of sports training, competitive swimming and water polo, metrology in sports, physical fitness testing, morphology and body structure, performance analysis etc. His papers have been published in a number of international journals, including: the*

International Journal of Sports Medicine, the European Journal of Applied Physiology, the Scandinavian Journal of Sports Medicine and Science, Clinical Biochemistry, International Journal of Morphology, International Journal of Performance Analysis in Sport etc.

Aleksandar Cvorovic *holds a Ph.D. in Sport and Physical Education and currently employed at the Abu Dhabi Police on developing and implementing strategies for physical fitness improvement for police employees. Also, he is visiting lecturer at the Higher College for education of trainers and managers in sport "Belgrade Football Academy" on the subject Methodology of strength training and conditioning. He has collaborated with many teams and national teams, as well as with athletes of national and international level. His professional and research interests are related to tactical strength and conditioning, high-performance strength and conditioning, bilateral asymmetries in sport and performance, basketball skill development and body composition. He regularly participates in scientific conferences as well he is an author and co-author of research articles in peer-reviewed international scientific journals. He has also been collaborating in research projects with the members of Faculty of Sport and Physical Education, Belgrade; Academy of Criminalistic studies in Belgrade, Serbia; Tactical research unit of Bond University, Australia; and with a member of Health department of Colorado Springs University of Colorado Springs*

Milos Stojkovic *is currently enrolled in a PhD studies as a full time student, on a Faculty of Sport and Physical Education in Belgrade, Serbia. Holding a Master's degree from 2015. and Bachelor's degree from 2012. at a Faculty of Sport and Physical Education from Novi Sad, Serbia. He is a former professional athlete and a national team member in karate and a certified black belt master – 1st dan. Currently, he's working as a physical culture trainer at Abu Dhabi Police College. His field of expertise are strength and conditioning and martial arts. Research interests are: strength and conditioning, tactial athlete, martial arts, recreation.*

Velimir (Lazar) Jeknić *(born 1988. in Kranj, Slovenia) has completed his graduation from Faculty of Sport and Physical Education in Belgrade, Serbia (2012). He remained at the University of Belgrade and completed his Master's degree in Criminalistics Science on Academy of Criminalistics and Police Studies in 2016. He is a former member of Serbian National Karate team, from 2015. working as strength and conditioning trainer at Abu Dhabi Police College.*

1 Introduction

Physical fitness represents the ability of the optimal functioning of the cardio-vascular, respiratory, and muscular system. In other words, physical fitness is ability for conducting prolonged physical work effectively by joined actions of cardio-respiratory endurance, strength, flexibility, and coordination [1]. World health organization defined physical fitness as the muscle ability to perform work at certain level [2]. Physical fitness implies abilities and skills necessary for performing ongoing tasks in real social, cultural, and psychological environment. Since the level of physical fitness is usually defined by successfulness of the task performance or by the health status it could be concluded that physical fitness depends on the development of various physical abilities and good body composition. Consequently, it can be altered because of the adaptation process of those abilities and body composition to a different stressor. In that regard, physical fitness is in a tight relationship with the amount and intensity of both, daily-needs-related physical activity and planed exercise programs [2,3]. From the angle of health-related physical fitness various jobs differently affect human body. But when it comes to police jobs due to its diversity, the permanent follow-up of the physical fitness and general health is necessary [4-8].

Many studies have shown that effectiveness in police jobs requires personal contact through communication and if necessary using general and specific physical abilities and skills [9-11]. Implementing rules and laws among people requires an enormous amount of analytical thinking and emotional control. These are important to consider because they all could affect the levels of stress that each in the task force is exposed to [12, 13]. Police

officers may be involved in various tasks such as fighting fire, chasing suspect, controlling riots or carrying people, which suggests that the importance of the physical fitness is clearly evident [4-6, 12, 14]. On the other side, many administrative employees from every police department are officers as well and their job requirements are less physically but more mentally demanding and stressful. In this regard, long sitting hours together with increased stress level have been reported to increase the risk of metabolic syndrome and cardiovascular disease [13, 15, 16]. Thus, physical abilities and body composition as a part of the physical fitness should be considered seriously when recruiting for the policing jobs and as a regular follow up process.

In recent history, numerous studies with different approaches to body composition in policing jobs have been conducted but to our knowledge, there have been no studies to gather such references at one place. Only 2 review studies were found [17, 6] but neither of them dealt with body composition as part of the physical fitness. Da Silva et al. [17] wrote about anthropometric indicators of obesity, while most recently Petersen et al. [6] conducted review study with the aim to explain best practice in physical and physiological employment standards. Thus, the aim of this study is to deepen the knowledge and understandings of importance of body composition for law enforcement officers.

2 Discussion

2.1 Importance of body composition assessment

Body composition has been frequently investigated over the years because of its biological meaning [18-20]. Human body is consisted of different tissues which are further consisted of cells and those cells are consisted of atoms. Moreover, human body is alive organism because all those compartments connects and contact between each other. That means that those compartments also influence each other, and the origin of the relationship and constancy of that relationship are fundamental in body composition research. It allows better insight in biology of the human body composition and indirectly better control of human health. Wang et al. [20] stated 'Nutritional status, physical activity level, and disease state alter body cell mass, which in turn serves as a biomarker of these processes'. In that regard, body composition assessment and monitoring is necessary because human body structure is at the same time very important but biologically very inconsistent category. It has been widely known that body composition is the result of various factors such as diet, stress, the amount of physical activity and other factors that are parts of daily habits. Thus, the body composition could be considered as a reliable indicator of the current health status. Research has shown that skeletal muscle mass in men decreases with age [21] which is led by decrease of the strength for about 5% overall [22]. Contrary, an increase in body fat mass over the criterion levels brings up the risk of cardio-vascular diseases, high blood pressure, diabetes and according to some researches mortality [23, 24]. Although police officers, in their early career, are considered more physically active than the general population, studies indicate that they are more prone to being obese or having diseases related to obesity. Aforementioned changes usually happen during the police career as a result of physical and psychological work requirements which are often in conflict with maintenance of physical fitness [11, 25-28]. Since body composition components are shown to be closely related to health and changes can occur by time spent in the service, regular body composition assessment in police workforce is of great importance.

2.2 Body fat changes during the career

In study of Sorensen et al.[11], the assessment of changes in physical activity, physical fitness and body composition of 103 Finnish police officers during 15 years of follow-up indicated that the overweight proportion (BMI>27 kg/m^2) was considerably lower in 1981 than in 1996 (29% vs. 51%, respectively). Almost 2/3 of the officers (64%) had a waist circumference above 94 cm, and more than 1/3 (38%) had a waist circumference above 102 cm. Similarly, in the Boyce et al. [25] cohort study of the Charlotte Police Department in Mecklenburg County, the time spent on working as a police officer contributed to an increase in body composition values after the 1st decade, including a significant increase in body mass, fat percentage and fat mass. Recent results of Lagestat and Tillar [28] showed significant decrease in frequency of physical activity during the 3 years of service. During the same period the proportion of high-level active officers decreased while the proportion of low-level active officers doubled. Demling and DeSanti [29] showed that both, controlled diet and controlled exercise programs can have very significant influence on body composition, because all three applied methods significantly influenced body composition in obese police officers, just the size of the effect was different relative to the method applied (Table 1). Aforementioned studies showed that body composition is negatively altered by the time spent working in police, and conversely that amount of exercise and type of diet can positively affect the body composition. These findings suggest

Table 1 Longitudial studies that dealt with changes in body composition during years spent working in police.

#	Name	Sample	Type of study	Variables	Results
1	Demling and DeSanti [21]	N=38	Longitudinal 3 groups: 1) Non-lipogenic, hypocaloric diet (10), 2) Hypocaloric diet plus resistance exercise plus a casein hydro isolate intake (14), 3) Hypocaloric diet plus resistance exercise plus a whey hydro isolate intake (14).	Weight, Fat mass (FM), Lean mass (LM), Chest strength, Shoulder strength, Leg strength.	Body weight decreased 2.5 kg in all three groups. PBF decreased in all 3 groups: 1) 27 vs 25% - mean change 2.5kg, 2) 26 vs 18% - mean change 7kg, 3) 27 vs 23% - mean change 4.2 kg.
2	Sorensen et al. [17]	Male Female N=103	Longitudinal 1) Changes in body composition and physical fitness from starting work as a police officer and after 15 years of service.	BW, BMI, Triceps skinfold, Biceps skinfold, Subscapular skinfold, Suprailiac skinfold, VO2max, Sit-ups and Push-ups in 30 seconds, Max no of Pull-ups.	Significant changes occurred in BW=7.2kg, BMI=2.1kg/m^2, Biceps skinfold=2.3kg, Subscapular skinfold=4.7mm, Suprailiac skinfold=1.7mm, VO2max= -0,1 L/min, VO2max= -4.4 milL/min, Push-ups= - 6.9, Sit-ups= -3.4, Pull-ups= -1.9.
3	Boyce et al. [44]	Male Female N=327	Longitudinal 1) Changes in body composition from initial-recruit to after 12 years of service. 2) Compare differences between genders and races, and among low to high body composition groups.	Body weight (BW), Percent body fat (PBF), Fat mass (FM), Lean mas (LM).	Average change in BW was 12.28kg, Obesity prevalence averagely increased from 6-20.25% with the range of 7-23%, PBF averagely increased for 4.8%, depending on initial PBF. Highest increase occurred in group lowest initial PBF (7-14%), and lowest increase in highest PBF (23-26%), LM increased for 2.5kg in female and 5.7kg in males.

that police employees should be included and motivated for permanent involvement in planned exercise programs and correct diet habits.

2.3 Obesity prevalence in police worldwide

Cross-sectional studies (Table 2) involving police officers from other countries have also shown a high prevalence of obesity among police officers [9, 10, 13, 27, 30]. When Dopsaj and Dimitrijevic [10] investigated morphological models of 19 years old female students of police academy, they found that 12% of them were already pre-obese or obese. Furthermore, Dimitrijevic et al. [9] conducted the study on female employees of communal police and found that 20% overweight (5% pre-obese, 10% lightly obese, 2.5% obese, 2.5% very obese).

On a big sample of 511 police officers, Dopsaj and Vukovic [30] found that 81.6% of the sample were pre-obese or obese (61.84% pre-obese, with BMI=25-29.99 kg/m^2 and 19.77% obese, with BMI≥30 kg/m^2). Moreover, 29.35 out of 61.84% were having BMI of 27.50-29.99 kg/m^2, which means in total 49.12%, had BMI above 27.50 kg/m^2. Practically, every second police officer from the sample was obese. In comparison to Abu Dhabi police Kukic and Dopsaj [[41]] showed similar results where 59.1% of the sample were obese with BMI>25 and body fat percentage greater above 25%.

2.4 Factors influencing body composition of police officers

In a 5-year follow-up study on Italian police, Garbarino and Mangavita [13] investigated the influence of work stress on metabolic syndrome. Five main indicators of metabolic syndrome were followed: obesity, high blood pressure, hypertriglyceridemia, low HDL-cholesterol, and high fasting glucose, and after 5 years of service, all five variables increased 20-30%, respectively [13]. Shift work was also found to be a risk factor for obesity in policing jobs [26, 15]. In the cross-sectional study of Gu et al. [26], male police officers from a metropolitan region of the United States of America who worked during the night shift had significantly higher values of waist circumferences and body mass index (BMI).

In the study of Violanti et al. [15], the prevalence of each metabolic syndrome component (waist circumference, low HDL cholesterol, hypertension) and composite metabolic syndrome tended to be highest for mid-night shift officers. The explanation for this association could be nutritionally inadequate food intake, as the officers who work at night only have access to convenience stores or fast food; in other words, they opt for calories and high-fat foods [26]. Other possible explanations given by Violanti et al. and Gu et al. [26] could be related to changes in the sleep-wake pattern, changes in the circadian rhythm as well as restricted opportunities to practice physical exercise. Table 3 shows short summary of studies that explain various influences of police work on body composition and health.

2.5 Importance of skeletal muscle mass

Skeletal muscle as a live tissue has a crucial role in metabolic health, strength and athletic performance and more importantly, skeletal tissue is capable of remarkable plasticity [31]. Skeletal muscle mass (SMM) plasticity is a result of the adaptation process that leads to increase or decrease of SMM [31-33]. Sarcopenia is a well-known term utilized to define the phenomenon of loss of SMM and strength that occurs with aging [32, 33]. On the other side, many studies have shown the influence of the training on fat-free mass (FFM) and SMM [34-36]. Rabelo et al. [34] showed a significant increase in knee extensor peak torque (15.6%) and appendicular FFM (2%) in women after 24 weeks of resistance training. Even though effect of the resistance training was higher on peak torque than on FFM, in comparison with other studies authors proposed the idea that increase in FFM could be due to the muscle hypertrophy. Additionally, study of Schoenfeld et al. [36] showed increase in muscle thickness after 8 weeks of Low and High load training in elite athletes. Also, Candow et al. [36] conducted the study on older population and found that 22 weeks of heavy resistance training significantly improved lean tissue mass and strength in 60-71 years old participants. Authors discussed that possible mechanism for these changes could be protein retention and muscle hypertrophy related to the resistance training 4. According to Frontera et al. [37] urinary based 3-MeH amino acid can be used to detect the turnover of muscle proteins. After they applied 12 weeks of strength training in older sedentary men (60-72), authors detected the change in 3-MeH which they explained by increase in skeletal muscle mass and/or increased turnover of actomyosin, most likely in the muscles that showed evidence of hypertrophy [38].

2.6 Skeletal muscle mass and police work

In the most recent study of Pihlaynen et al. [38] it has been reported that among the other variables the amount of skeletal muscle mass (SMM) was a significant predictor of the military specific task performance. In the same study, SMM correlated with the military specific task as well as with counter movement jump, suggesting that higher SMM improve military specific anaerobic performance. Similarly, Dawes et al. [39] showed that lean mass correlates with the performance in push-ups, bench

press, estimated peak power and vertical jump height in law enforcement officers.

Table 2 Cross-sectional studies that were investigating body composition in police workforce.

#	Name	Sample	Type of study	Variables	Results	
1	**Dimitrijevic et al. [40]**	Female N=144	**Cross-section** InBody body composition analysis	BW, BMI, BF, PBF, VFA, Trunk Fat (TF)	BW=61.3±6.9kg, (46-84.6kg), BMI=21.4±2 (17.2-28.8kg/m^2), BF=15.2±4kg (7.9-29.9kg), PBF=24.6±4.6% (16.8-40.4%), VFA=40±16.3cm^2 (6.3-99.2cm^2), TF=7.5±2.2kg (3.1-15.4kg).	
2	**Dopsaj and Dimitrijevic [10]**	Female N=144	**Cross-section** Cluster analysis	BMI, Intracellular fluid, Extracellular fluid, Protein mass (PM), Mineral mass (MM), Bone mineral mass (BMM), BFM, SMM, Visceral fat area (VFA), Body cell mass (BCM)	**5 clusters have been extracted:** 1) Obese-short (H=166cm; W=72kg), 2) Skinny-average (H=169cm; W=56kg), 3) Average-average (H=168cm; W=62kg), 4) Average-tall (H=170cm; W=60kg), 5) Obese-tall (W=175cm; W=75kg). **Tissue proportions (%) in each cluster:** 1) Fat=25.9; PM=9.3; MM=3.3; Water=34.2, 2) Fat=11.4; PM=8.7; MM=3.1; Water=32.6, 3) Fat=17; PM=9; MM=3.3; Water=33.5, 4) Fat=14.3; PM=9.1; MM=3.2; Water=33.8, 5) Fat=22.2; PM=10.3; MM=3.8; Water=38.5.	
3	**Dimitrijevic et al. [9]**	Female N=40	**Cross-section** InBody body composition analysis	BW, BMI, ICW, ECW, PM, MM, BMM, BFM, PBF, VFA, BCM, Basal metabolic rate (BMR)	BW=63.61±9.81kg, BMI=22.97±3.73kg/m^2, ICW=21.14±2.08L, ECW=13.01±1.30L, PM=9.13±0.91kg, MM=3.20±0.35kg, BMM=2.67±0.26kg, BFM=17.10±6.43kg, PBF=26.24±5.99%, VFA=57.07±25.67cm^2, BCM=30.27±3.09kg, BMR=1372.0±100.0kcal.	
4	**Kukić and Dopsaj [27]**	Male N=59	**Cross-section** InBody body composition analysis	BW, BMI, BFM, PBF, Skeletal muscle mass (SMM), Percent of skeletal muscle mass (PSMM).	BW=80.10±11.1 kg, BMI=26.76±3.74 kg/m2, PBF=24.35±7.57%, SMM=34.47±4.78kg and PSMM=43.31±4.49%.	
5	**Kukic and Dopsaj [41]**	Male N=120	**Cross-section** Factorial analysis was conducted on 11 variables	BW, BMI, PBF, Percent of skeletal muscle mass (PSMM), Percent of protein mass (PPM), VFA/kg, Body fat mass index (BFMI), Skeletal muscle mass index (SMMI), Protein mass index (PMI), Fat-free mass index (FFMI), Visceral fat index (VFAI), Protein-fat index (PFI), Index of hypokinezia (IH).	BW=80.55±11.36kg, BMI=26.76±3.60kg/m^2, 1. PBF=25.31±7.40%, 2. PSMM=42.20±4.53%, 3. PPM=14.87±1.51%, 4.VFA/kg=1.31±0.36cm^2/kg, 5. FMI=6.95±2.75kg/m^2, 6. SMMI=11.19±1.25kg/m^2, 7. PMI=3.94±0.41kg/m^2, 8. FFMI=19.80±1.98kg/m^2, 9. VFAI=0.36±0.12cm^2/m^2, 10. PFI=0.67±0.31kg, 11. IH=0.94±0.21%/(kg/m^2).	3 factors were extracted: 1) Physical inactivity and nutrition, 2) Physical activity and exercise 3) Sedentary lifestyle

Table 3 Cohort studies that were investigating body composition in Police workforce.

#	Name	Sample	Type of study	Variables	Results
1	**Boyce et al. [25]**	Male Female N=2330	**Cohort study** Difference between regular police and firefighter's unit	Body weight (BW), PBF, Fat mass (FM), Lean mass (LM), Bench press strength, Bench press/lean mass, Bench press/Body mass, Prevalence of obesity.	**Male firefighters and police:** BM (91.5 vs. 93.2 kg), PBF (17.8% vs.18.5%), FM (16.9 vs. 18.0 kg), Obesity prevalence (10% vs.17%), **Female firefighters and police:** BM (77.5 vs. 71.8 kg), LM (54.4 vs. 51.2 kg).
2	**Violanti et al. [16]**	Male Female N=98	**Cohort study** Association of shift work with the metabolic syndrome	Waist circumference (WC), Triglycerides, HDL cholesterol, Glucose intolerance (GI), Hypertension.	**Elevated prevalence of metabolic syndrome components for midnight shift:** WC (≥102 in M, ≥88 in F) = 30.6%, Triglycerides (≥150mg/dL) = 15.3%, HDL (<40mg/DL in M, <50mg/dL in W) = 38.8%, GI (fasting glucose≥100ml/dL, or diabetic mediation use) = 21.4%, Hypertension (≥130 mm Hg/85 mm hg, or medication use) =15.3%.
3	**Garbarino and Mangavita [13]**	N=207	**Cohort study 5-year follow-up** Influence of work stress on metabolic syndrome	Body mass index (BMI), Waist circumference (WC), High blood pressure, Hypertriglyceridemia, Low HDL-cholesterol, High fasting glucose.	Obesity increased from 110 officers at the baseline to 186 at the end of the study. All indicators of metabolic syndrome increased for 20-30%.
4	**Gu et al. [26]**	Male Female N=408	**Cohort study** Long work hours and adiposity in policemen	WC=94.3±13.7cm Men=99.3 ± 10.5cm Women=80.3 ± 12.0cm BMI=29.1±4.4kg/m^2 Men=30.2 ± 3.7 kg/m^2, Women=26.1±4.8 kg/m^2 PBF=25.8±6.2% Men=24.0 ± 5.1% Women=30.9 ± 6.0%	40% of the sample had BMI>30kg/m2 – 48% of males and 16.7% of females. Night shift and shift length significantly influenced WC and BMI (p=0.006 for WC and p=0.001 for BMI.

On the sample of Abu Dhabi police, 37.29% of the sample had insufficient percent of skeletal muscle mass (PSMM<41.07%), 28.81% had below average (PSMM=41.08-45.41%), 27.12% were averagely muscular (PSMM=45.42-49.75%), 6.78% had above average PSMM (49.76-54.10%) and nobody was with excellent muscular mass with PSMM>54.10% [27]. Subramaniam et al. [42] conducted the study on Malaysian firefighters and they found that better initial emergency response had the firefighters with higher weight and better cardiorespiratory fitness. One might argue that body weight should be in negative correlation with the performance but it should be noted that the average weight of the participants was 75.30 kg with the range of 63.67-88.93 kg and the average height was 168.40 cm with the range 162.13-173.32 cm. Thus, it could be concluded the sample consisted of relatively fit subjects which authors explained with daily duty requirements of the firefighters [42]. When it comes to pistol shooting proficiency, Kayihan et al.[43] showed that hand-grip strength, biceps circumference, femur diameter, and waist circumference significantly correlated with the pistol shooting efficiency.

More precise explanation of the relationship between SMM and Performance can be found in athletes. Studies on elite athletes found 3-5% higher fat-free mass (FFM) in elite wrestlers compared to amateur and 11% higher FFM in elite handball players comparing to amateur and accordingly higher maximal strength and maximal power output [44, 45]. Dopsaj et al. [18] compared 3 different martial art athletes, wrestlers, judo athletes, and karate athletes and they found that according to the nature and needs of the sport these athletes are different in SMM and FFMI. On a big sample of collegiate American football players, it has been shown that players from

the division I have a higher FFMI values than the division II [46].

3 Conclusions

Wrapped up all together, numerous studies have been found in various study designs and it could be said there are certain common things for most of the studies:

- Longitudinal studies showed that length of service had a negative effect on body composition which manifests in increasing pattern of obesity, increased prevalence of metabolic syndrome, which leads to increased risk of cardiovascular disease,
- Policing can be classified as very stressful with various sources of stress as crime scene, physical effort, and difficult work schedule,
- Performance in physically demanding duties depends on good skeletal mass and aerobic fitness, and lower fat mass.
- It seems that the space for further research might be investigating possibility of developing body composition standards that could be used during recruitment process and as a regular follow-up process. The logic behind it lies in the relationship between job-related task performance and body composition as well as health – body composition relationship.

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Competing Interests:

The authors declare that they have no competing interests.