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# Differences in Aerobic and Anaerobic Capacity between Special Police Force Members and Elite Basketball Players

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**Abstract**

The goal of this research is to evaluate and compare the functional abilities of the special anti-terrorist unit from Serbia and professional basketball players. The idea is to determine whether members of the special unit police have high functional abilities and at what level are they compared to professional athletes. The sample of participants, for the purposes of this research, consisted of 162 respondents with an average age of 29.75±8.12 years who were classified into two groups. One group consisted of members of the SAF (special anti-terrorist force) (n=101) of average age 33.74±6.19 years and in other group were elite level professional basketball players from Serbia (n=57), of average age 22.39±4.25 from three Serbian clubs. To measure cardiorespiratory fitness, a cardiopulmonary exercises test (CPET) was performed on a treadmill (HP-COSMOS®). Maximal oxygen consumption (VO2max), as a measure of aerobic capacity, was determined using the Quark CPET system (Cosmed®) by direct monitoring of gas exchange (oxygen and carbon dioxide). Aerobic ability of members of the Serbian SAF (special anti-teroristic force) can be considered excellent and almost close to the professional athletes, but statisticly lower ($p<0.05$). Anaerobic capacity is also high and there is no difference in relation to basketball players ($p>0.05$). These results can be explained by the selection of people who are chosen for this unit, which can be called very rigorous and equated with sports selection. The results of our study point to the fact that a high level of cardiorespiratory fitness is not only required by professional sports, but also by certain professions such as SAF..

***Keywords:*** *V02 max, pulmonary ventilation, cardiopulmonary testing, anaerobic treshlod*

## Introduction

The work of professional police officers, members of the special anti-terrorist unit is one of the most physically demanding jobs that require good functional abilities. High value of these abilities stands for a base for developing and perfecting both motor and technical-tactical abilities for special anti-terrorist police unit because their job requires performing complex and high-risk physically demanding tasks for the security and protection of the Republic of Serbia and its citizens (Radovanović, 2020). That is why the training of elite force is more demanding than the training of members of the ordinary police (Ricciardi, Deuster, & Talbot, 2007). At the same time, members of the police must be highly aware of maintaining their level of health and physical ability in order to be able to perform tasks at a high level of effort during their careers (Poncio, 2020). A high level of aerobic capacity is considered more important than strength and power in elite police officers (Robinson et al., 2018). Furthermore, a high level of functional and cardiorespiratory capacity has a large the potential of protecting the physical and mental health of police officers in their daily work (Schilling et al., 2020). At the same time, better functional capacity and cardiorespiratory response to exercise are associated with reduced cardiometabolic risk (Schilling et al., 2019). The selection process itself for mem-

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bers of the elite unit is quite competitive and requires people with good cardiorespiratory abilities (Poirier et al., 2022).

For assessment of functional abilities (aerobic and anaerobic), as well as long endurance parameters, generally are evaluated maximum oxygen consumption (VO2max), pulmonary ventilation (VE max), aerobic and anaerobic thresholds (Westra et al., 2020). Maximal oxygen consumption is defined as the largest amount of oxygen consumed per unit time during progressively increasing work intensity involving large muscle groups that continues despite exhaustion (Kohozuki et al., 2018). On the other hand, pulmonary ventilation is important because stands for the process of renewing oxygen in the lungs, which is used for muscle work, and is conducted through the processes of inhalation (inspirium) and exhalation (expirium) and is expressed in liters per minute (Đorđević Saranović et al., 2019).

In regular police officers, the average value of VO2max is 38.7 ml/kg/min (Marins, David, & Del Vecchio, 2019). At the same time, in elite units, maximum oxygen consumption was recorded between 45 and 57.4±4.3 ml/kg/min. Professional basketball players must have a high level of aerobic capacity due to recovery from anaerobic activities during the game itself. Maximum oxygen consumption in basketball players is in the range of 45 to 65 ml/kg/min (Midgley, McNaughton, & Marchant, 2007). These values, of course, also depend on the level at which senior basketball players compete. In addition to aerobic abilities, functional abilities include anaerobic abilities, which take place in conditions when there is no oxygen available. When we say anaerobic capacity, it primarily refers to the ability to tolerate the accumulated products of anaerobic work (Živković, 2016). When the concentration of lactate reaches a level at which the body cannot remove them, the aerobic threshold is reached. In the literature, the level of around 2 mmol/l is most often mentioned (Kenney, Willmore & Costill, 2012), and the terms are different compared to different authors such as "lactate threshold", "first ventilatory threshold" or "anaerobic threshold" (Binder et al., 2008).

This implies that the level of physical activity is so high that aerobic and anaerobic metabolism intermix. When the body uses up its buffer reserves, a period of unstable lactate state occurs, or in sports literature, the anaerobic threshold is often mentioned. The lactate concentration at this threshold is about 4 mmol/L. Above the anaerobic threshold, the organism creates energy in anaerobic conditions without the presence of oxygen, and physical activity is highly intense and leads to fatigue and cessation of exercise (Wasserman, Cox, & Sietsema, 2014). The organism uses the respiratory system to try to eliminate the accumulated carbon dioxide (CO2) and thereby compensates for the resulting acidity of the organism. In functional diagnostics, this moment is called the respiratory exchange ratio (respiratory exchange ratio = CO2/O2 – RER) or anaerobic threshold. At the maximum effort, the RER values are 1.10 and above, which represent a realistic measure of the achieved metabolic fatigue and the ability of the body to tolerate elevated levels of lactate in muscles and blood, as well as exercise in exclusively anaerobic conditions, which stands for a highly trained person.

Previous research comparing the functional abilities of police officers and athletes is very limited. The authors searched the literature and found a similar study that showed that aerobic and anaerobic capacity is significantly less developed in police officers compared to elite athletes from most Olympic disciplines. But, compared to basketball players in the same study, it was significantly higher (VO2max - 52.4 ml/kg/min vs 46.5 ml/kg/min) (Zwingman et al., 2021). At the same time, Vuckovic and Koropanovski (2007) compared the motor skills of members of the police academy and elite karate fighters and concluded that they differ statistically significantly.

The lack of research in the existing literature indicates that more similar studies are needed to conduct in order to contribute to a better understanding of the functional capacity and design of standards in the training program of elite police forces, in order to meet the demands of the profession. Given all the above, the aim of this research is to evaluate the functional abilities of elite police officers and compares their level in relation to professional athletes.

## Methods

### *Procedures*

Pre-participation medical examination was a prerequisite for taking part in the study before performing cardiopulmonary exercise test (CPET) on a treadmill. The aim of the sports medical examination was to determine the general health ability of police officers and basketball athletes for their profession/sport. CPET was performed to evaluate VO2max of participants. Prior to being conducted, the ethics committee of University Singidunum of Serbia approved this study. University Ethics Committee (no. 36-2 decision made on January 24th, 2022). Each participant voluntarily supplied written informed consent before taking part in the study. The conducted research does not violate the rights of the examined players, according to the ethical standards of the Helsinki Declaration of the Committee on Human Rights (WMA Declaration of Helsinki, 2013).

### *Participants*

The sample of respondents, for the purposes of this research, consisted of 162 participants with an average age of 29.75±8.12 years. Study participants were classified into two groups. One group consisted of members of the special anti-terrorist unit of the police (n=104) of average age 33.74±6.19 years. The second group was made by elite professional basketball players from Serbia (n=58) of average age 22.39±4.25 from three top rank Serbian teams. The cardiopulmonary exercise test was performed by trained medical doctors in the outpatinet sporst medicine clinic "Vita Maxima" and all subjects gave their written consent to perform the test. In addition, the CPET was conducted in order to check the health status of members of the police and elite basketball players.

### *Data collection*

A sample of variables for research purposes presented the parameters of the functional abilities of members of the special anti-terrorist unit and professional basketball players. Heart rate after maximum effort (HR max), heart rate at the second anaerobic threshold, heart rate recovery during first three minutes after CPET, maximal pulmonary ventilation (VE), VO2max and respiratory exchange ratio (RER) were evaluated during CPET.

### *Test protocol*

Electrocardiogram of the heart at rest was performed using a 12-channel ECG (Fukuda). CPET was performed on a treadmill (HP-COSMOS®) and VO2max, as a measure of aerobic ability, was determined by using the Quark CPET system (Cosmed®) by direct monitoring of gas exchange (oxygen and carbon dioxide). A modified Nowacki protocol (Novacki

& Preuhs, 2003) was used to conduct the test, with an initial speed of 5 km/h and an elevation of 0°. After the introductory part of the test, which serves as a warm-up, the speed of the treadmill increased to 9 km/h and did not change during the test, but the elevation of the treadmill was raised by 2° every one minute to achieve the maximum load. Subjects had a face mask and a mobile ECG device (Quarck® T 12x, Wireless 12-lead ECG) on their back to directly monitor gas exchange and heart rate during exertion. Test was maximal if at least three of four below mentioned criteria were achieved: the value of the achieved heart rate of 90% or more of the predicted theoretical maximum heart rate for gender and age, which is calculated based on the formula: 220 - number of years; respiratory exchange ratio (RER) >1.10; plateau in maximal oxygen consumption despite increasing load (differences in VO2max values less than 150 mL/min near the end of CPET); subjective feeling of exhaustion.

Before CPET tests the calibration according to the so-called STPD criteria (ST - standard temperature/standard gas temperature: 0°; P - pressure/pressure: 760 mmHg; D - dry equivalent/dry air) of the Quark CPET system (Cosmed®) was performed after every fifth test to adequately determination of measured parameters.

*Statistical analysis*

To describe parameters of importance, depending on their nature, the following were used: frequency, percentages, mean value, median, standard deviation, rank and 95% confidence intervals. To test the normality of the distribution, the Kolmogorov Smirnov test was used and the graphics: histogram and normal QQ plot. To test the differences in the functional characteristics of police officers and basketball players, the T Test of independent samples and the Mann Withney U test were used. Statistical data processing was performed in the statistical package SPSS 20.0 for Windows. Differences were considered significant when the p value was less than 0.05.

## Results

Descriptive statistics of anthropometric characteristics, body composition and functional abilities of all participants in the study are presented in Table 1.

Comparative statistics of maximum oxygen consumption between members of the special police unit and basketball players in different positions are given in Tables 2, 3, 4.

**Table 1.** Descriptive statistic of antropometric varibales and functional ability of all participants in study

| | Basketaball | SAF | T value | p value |
|---|---|---|---|---|
| Variables | X±SD | X±SD | / | / |
| N (number) | 57 | 105 | / | / |
| Age | 22.39±4.25 | 33.791±6.80 | -11.42 | p<0.001 |
| Height (cm) | 200.65±7.79 | 179.61±4.63 | 17.42 | p<0.001 |
| Weight (kg) | 97.37±9.59 | 87.39±11.45 | 5.69 | p<0.001 |
| BMI (kg/m2) | 24.18±1.84 | 26.87±2.87 | -7.27 | p<0.001 |
| FFM kg | 88.9±7.92 | 74.17±7.034 | 12,24 | p<0.001 |
| Fat % | 10.65±4.63 | 15.85±4.85 | -6.65 | p<0.001 |
| VO2max ml/kg/min | 55.40±5.45 | 51.40±7.26 | 3.64 | p<0.001 |
| RER | 1.10±0.18 | 1.10±0.89 | 2.60 | p>0.05 |
| Ve Max | 165.5±28.02 | 142.4±21.37 | 5.88 | p<0.001 |
| HR rest | 60.04 ±10.35 | 64.10±12.45 | -2.26 | p<0.05 |
| HR VT2 | 176.54±8.73 | 173.15±6.73 | 0.88 | p=0.377 |
| HR max | 186.05±7.87 | 185.21±10.04 | 0.45 | p=0.651 |
| HR recovery 1. min | 159.42±11.52 | 155.86±13.95 | 1.56 | p=0.119 |
| HR recovery 2. min | 134.04±14.43 | 130.86±15.73 | 1.17 | p=0.243 |
| HR recovery 3. min | 121.56±14.03 | 119.57±15.73 | 0.71 | p=0.479 |

Abbervations: BMI (body mass index), FFM (free fat mass), VO2 max (maximal oxygen consumption), RER (respiratory excange ratio), VE max (maximal ventilation), HR at VT2 (heart rate at the second ventilatory threshold), HR max (maximal heart rate), HR recovery (heart rate recovery in first, second, and third minute after test).

**Table 2.** Comparative statistics V02 max and RER of the special police unit and centers

| Variable | SAF | Centers | T value | P value |
|---|---|---|---|---|
| VO2 max mil/kg/min | 51.41±7.23 | 52.05±5.51 | 2.385 | p=0.65 |
| RER | 1.07±0.39 | 1.09±0.55 | 0.375 | p=0.69 |

**Table 3.** Comparative statistics V02 max and RER of the special police unit and forwards

| Variable | SAF | Forwards | T value | P value |
|---|---|---|---|---|
| VO2 max mil/kg/min | 51.41±7.23 | 57.40 ±4.08 | 3.588 | p<0.001 |
| RER | 1.07±0.39 | 1.08±0.03 | 1.630 | p=0.112 |

**Table 4.** Comparative statistics V02 max and RER of the special police unit and guards

| Variable | SAF | Guards | T value | P value |
|---|---|---|---|---|
| VO2max mil/kg/min | 51.41±7.23 | 57.00±5.16 | 3.891 | p<0.001 |
| RER | 1.07±0.39 | 1.08±0.23 | 1.916 | p=0.064 |

In general, a statistically significant difference between the two groups was found in the parameters of maximum oxygen consumption and parameters of maximum pulmonary ventilation (p<0.05) (Figure 1 and Figure 2).

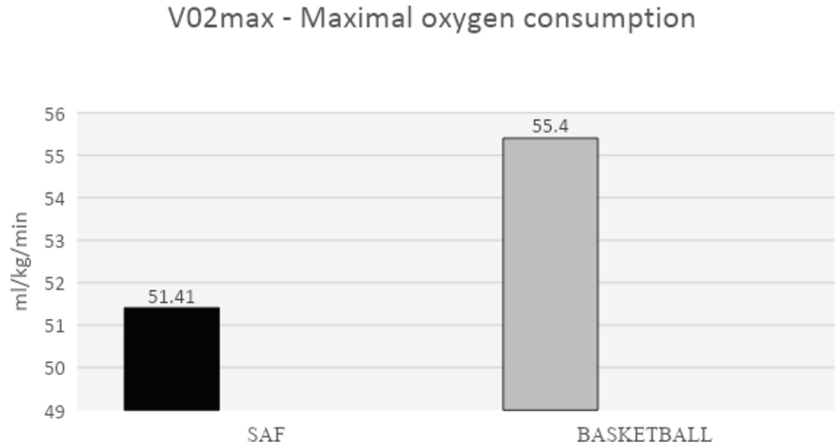


FIGURE 1. Results of maximum oxygen consumption (VO2max) for policemen and basketball players; *A statistically significant difference between the groups was found in the parameters of maximum oxygen consumption (p<0.05). Abbreviation: SAF- special anti-terrorist force

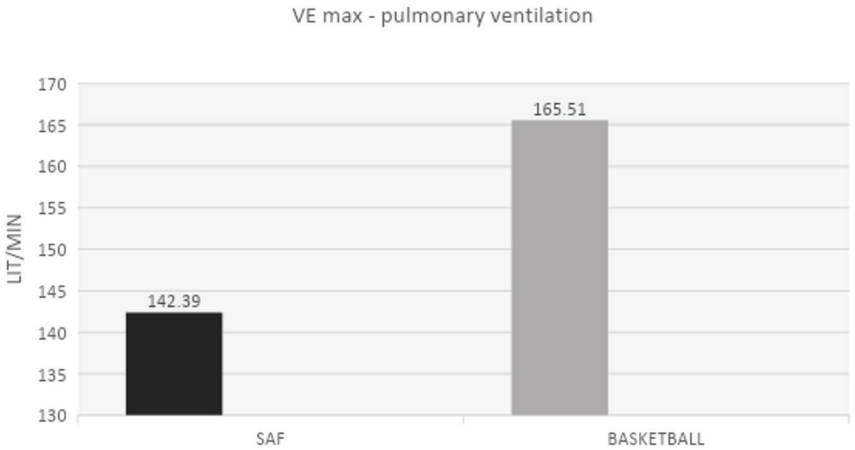


FIGURE 2. Results of maximal pulmonary ventilation for police officers and basketball players; *A statistically significant difference between the groups was found in the parameters of maximal pulmonary ventilation (P<0.05).

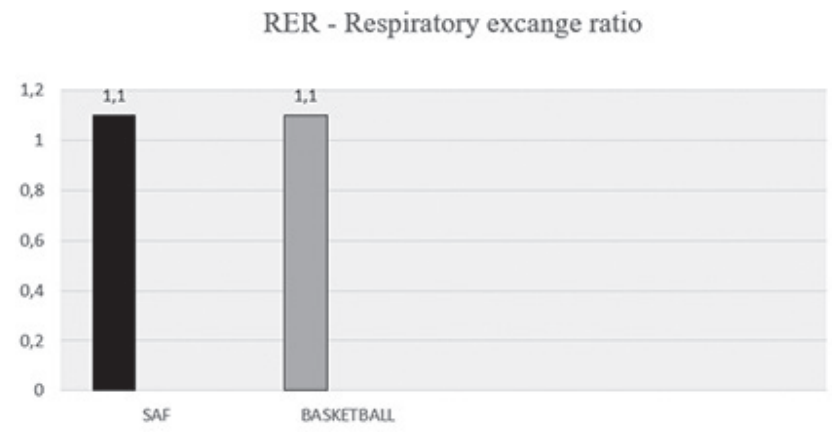


FIGURE 3. Results of anaerobic ability and respiratory gas exchange in police officers and basketball players; Abbreviation: SAF - special antiterrorist force

In the anaerobic capacity shown through the RER (respiratory exchange ratio), i.e. the capacity of the body to tolerate lactate in the anaerobic mode, no difference was found between police officers and professional basketball players (p>0.05) (Figure 3).

There was no statistically significant difference in the heart rate at rest or in the maximum heart rate, and there was also no difference in the heart rate at the second anaerobic threshold (Figure 4). There was no difference in the heart rate during recovery in both groups in the first three minutes after the intensive physical activities (Figure 5).

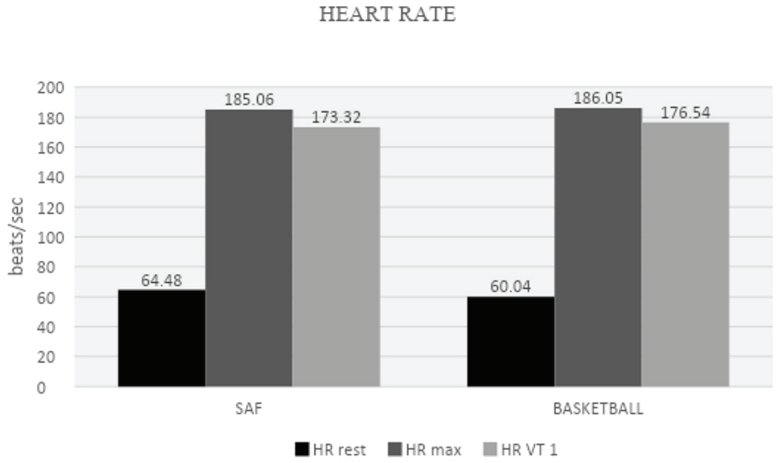


FIGURE 4. Results of heart rate frequency in police officers and basketball players

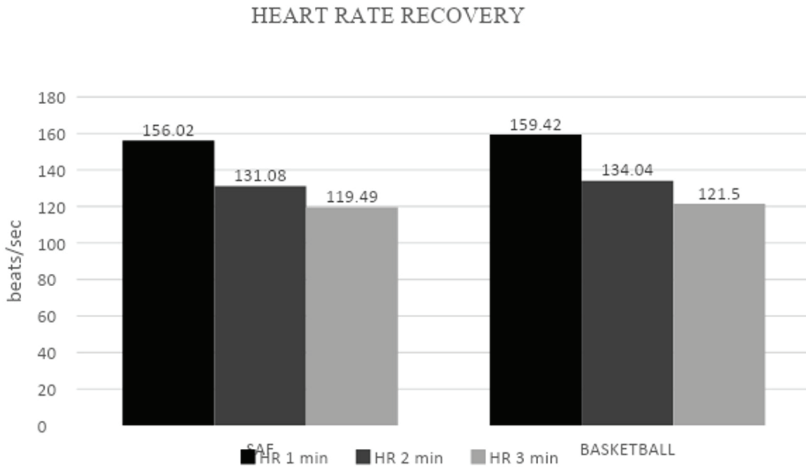


FIGURE 5. Results of heart rate recovery during three minutes after intense physical activity; Abbreviation: SAF - special antiterrorist force

## Discussion

The results of this study aimed to determine the functional status of the special police unit and evaluate is there differences in relative to elite basketball players. In general, the purpose was to determine whether regular training of members of the special anti-terrorist unit affects the level of aerobic abilities and at what level they are compared to elite athletes. In both groups, functional abilities and body composition represent an important aspect of the work they do. The results of this research support the fact that there is a statistically significant difference in functional abilities between the two groups, but only in maximum oxygen consumption and pulmonary ventilation (VE max) for the benefit of elite athletes. Basketball players, especially of the elite level due to the nature of the sport and professionalism, have a greater volume and intensity of training, as well as intense matches 2 times a week, compared to members of the police, who train once a day 5 times a week, and do also strenght training. In terms of aerobic capacity, the elite basketball players from this study had a maximum oxygen consumption (55.04 ml/kg/min), which is within the range of results described in earlier research on elite basketball players (Midgley et.al., 2007). It should be noted that the research was conducted in the post-season, that is, before the start of preparations for the new season, so the slightly lower results of the elite basketball players from Serbia are in support of this. At the same time, members of the special anti-terrorist unit showed a high level of aerobic capacity (VO2max - 51.41 ml/kg/min), which is above the reference values for gender and age.people from the general population (Maupin et al., 2018). However, in basketball there are different positions in the team in relation to height and motor characteristics, so the fact that guards and forwards had better results than centers is in favor of better oxygen consumption in basketball players (Stojmenović, Trunić, & Stojmenović, 2022). But, if we compared VO2max values of policemen and players in the center position it can be established that policemen have a better aerobic capacity then centers, acording to previos study (Stojmenovic et al., 2022). But, in this reasearch police officers have slight lower aerobic capacity according to center (51.41 vs 52.04 ml/kg/min) with no statistic meanings.

At the same time, SAF members in this study had statistically significantly lower values of VO2max compared to forwards and guards, but not RER values (respiratory exchange ratio). Besides aerobic capacity special police unit are above the ability of the regular police (Marins et al., 2019) who perform regular daily duties on the field. At the same time, members of the Serbian elite police unit had better results compared to police officers from Montenegro (Spalevic et al., 2021). Furthermore, Koropanovski and Janković (2007) showed that students of the Police Academy, at the beginning of their education, had a lower level of motor skills from the aspect of maximum isometric force, as well as dynamic and repetitive strength of the whole body, in relation to well-trained persons of the same age type of strength training. At the same time, it was shown that the motor skills of police academy students differ from elite karate players (Vuckovic, & Koropanovski, 2007). Serbian members of special forces have a good aerobic capacity, which is within the limits of the values of members of special units from other countries, which were described in earlier studies (Sperlich et al., 2011; Maupin et al., 2018; Araújo et al., 2019,). Also, it was shown that Serbian special forces have a higher level of aerobic fitness than members of the American SWAT team, but also lower values than their colleagues from Slovenia (Šimenko et al., 2014). Compared to members of the fire department, where high levels of functional ability are also required, this study showed that elite police officers from Serbia have better aerobic capacity than firefighters (Donovan et al., 2009). Police work also requires good recruitment of personnel, who will become elite police officers, so this is one of the conditions for selecting candidates. Police officers from Serbia have good aerobic abilities, which are little lower than the criteria for filling police personnel in Canada (Poirier et al., 2022). In the area of anaerobic capabilities, statistic difference between groups it is not observed in the RER variable (Respiratory exchange ratio), which explains lactate tolerance in anaerobic conditions. Basketball players had a slightly higher RER, but no statistically significant compared to members of the SAF, which indicates that the job belong to the special unit of the police often practiced anaerobic work zone. In the pulmonary ventilation variable, we found statistically significant difference ($p<0.05$) which proves that police officers have a good lung volume of breathing, but lower acording to basketball players. Furthermore, there was no difference between the groups in heart rate parameters, first of all in the values of the maximum heart rate as well as the heart rate at the second anaerobic (ventilatory) threshold, which indicates that police officers have a good tolerance to lactate and that they later enter total anaerobes. The sametime, there was no difference between the groups in the recovery heart rate in the first, second and third minutes, after maximum work, which also indicates a good level of recovery from maximal efforts. The limitations of this study are that there was an unequal number of respondents in these two research groups (105 vs 57), as well as different ages and morphological characteristics. Namely, members of the SAF were statistically significantly older than professional basketball players (33.74 vs 22.39), significantly shorter, and they also had a higher percentage of fat, and body mass index, which can be a limiting factor in functional abilities. At the same time, professional basketball players have a greater number of training sessions on a weekly basis, as well as competitive matches, which contributes a lot to the improvement of functional abilities.

Nevertheless, despite the limitations, this study is important because it provides insight into the aerobic and anaerobic abilities of SAF as well as professional basketball players and contributes to a better understanding of determining the direction and important parameters of the training process in both groups. At the same time, the study provides guidelines in which direction they could be improved.

## Conclusion

Functional abilities are an important factor for the performance of the tasks of the members of the special anti-terrorist unit. Their profession demands performing complex and high-risk physically demanding tasks for the security of the state and citizens. The level of aerobic and anaerobic capacity of members of the Serbian SAF can be considered excellent and almost approximate to professional athletes. A big role in all parameters is played by the selection of people who are chosen for this unit, which can be called very rigorous and equated with sports selection. The assumption is that the level of aerobic capacity of police officers would be much higher if the volume of training during the week were increased. However, their training requires other types as technical-tactical trainings that are also important, which takes time.

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**Conflict of Interest**
The authors declare that there are no conflicts of interest.

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