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ORIGINAL ARTICLE

PHYSICAL, MOTORIC AND CARDIOVASCULAR STATUS IN SELECTED GROUPS OF FIREFIGHTERS IN THE CZECH REPUBLIC - CASE STUDY

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Summary

The aim of this study is to evaluate and compare the physical, motoric and cardiovascular status of selected Czech professional and volunteer firefighters aged 25 to 35 years. Firefighters (especially professionals) were chosen as a template for Czech male population because they are considered the most physically fit among the adult population. Moreover, physical training is a part of the job description for professionals, their motoric performance is regularly checked, and a decline in fitness is grounds for termination of employment. Since volunteer firefighters assist professionals in emergencies, they tend to be under the same physical and mental stress and their motivation to maintain excellent physical condition is considerable. The somatic characteristics, body composition, motoric performance tests as an indicator of the level of speed, power and endurance abilities, blood pressure and heart rate measurements and the Ruffier test as an information about the status of the cardiovascular system were performed. This study used hand-grip dynamometry to determine muscle strength as well. The results of our investigation showed that professional and volunteer firefighters have good physical, motoric and cardiovascular status and do not differ significantly in body height and adiposity, in body composition, in motoric performance, in cardiovascular characteristics, but do differ significantly only in hand-grip dynamometry (higher mean values in professionals).

Key words: Firefighter; Motoric Performance; Body Fat; Hand-Grip Dynamometry; Blood Pressure

Introduction

The issue of physical performance and physical fitness is presented in many international studies. As a rule, these researches are related to cardiovascular problems, sedentary problems, sports performance in amateur or professional athletes, issues of overweight, high blood pressure and obesity, volumes of sports training to prevent diseases or diseases of the back and spine (1, 2, 3, 4, 5). Research into motoric performance and physical fitness in Czech professional and volunteer firefighters brings a new expanding view and additional knowledge on the topic.

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The Integrated Rescue System of the Czech Republic (6) is a generally reputable union (7, 8, 9). The IRS CR consists of the Fire Rescue Service of the Czech Republic (professional firefighters), fire units (volunteer firefighters), the Police of the Czech Republic and Medical Rescue Service and others. These components are synergistic and enable rapid and effective intervention in both standard and extraordinary risk events (10, 11, 12).

Medical admission is required for admission to individual groups of firefighters - medical fitness to work in a fire protection unit. Medical fitness is verified at the initial examination and subsequently at regular interval checks (30). The assessment of medical fitness for members of the Fire and Rescue Service of the Czech Republic is governed by Decree No. 226/2019 Coll., On medical fitness for service in the security forces. Assessment of medical fitness of members of units of the voluntary fire brigade of municipalities is regulated by Act No. 373/2011 Coll., On specific health services and Government Regulation No. 352/2003 Coll., On assessment of medical fitness of members of units of the voluntary fire brigade of municipalities or companies.

Care of human resources varies across the Fire Rescue Service and fire units. Professional firefighters undergo a full medical evaluation every year (including physiotherapy care), and also they must pass tests of motoric performance (13, 14). At the same time, professional firefighters are generally reflected as the most physically fit among the adult population (15, 16, 17). Although volunteer firefighters are urgently summoned to assist in rather extensive interventions, they are subjected to limited medical checks only once every two years (18) and receive no physiotherapy care. Concurrently, their motoric performance or anthropometric characteristics are not registered. Firefighter units are principally considered to be organisations with laudable social aspects (19), but the physical fitness of volunteer firefighters is slightly fuzzy.

This study aims to obtain data on (a) the physical characteristics including the estimate of the body composition, (b) the tests of motoric performance and muscle strength and (c) cardiovascular fitness in professional and volunteer firefighters to assess and compare their physical status.

Materials and methods

For each proband aged 25 to 35 years, randomly selected from the South Bohemian Region, the investigation consisted of anthropometric measurements, estimation of body fat and fat-free mass, sets of motoric tests, muscle testing using a hand-grip dynamometry and blood pressure and heart-rate measurements. The research included healthy probands without signs of acute illness.

The research sample was selected with a focus on a group of respondents aged 25 to 35 as a group that is not expected to occur and be affected by diseases of civilization of the general population. Due to the scope and complexity of the survey, the actual measurement of capacity was limited during the elaboration of the research. In terms of the number of probands, this is a low number, however, it is a unique research of the target group in the Czech Republic.

A group of professional firefighters (PROF) consisted of men employed as professional firefighters. The mean age of the group of professional firefighters was 31.58 years, with a standard deviation of 2.74. For professional firefighters, two hours are set aside during working hours for any form of physical activity. What sport the firefighter will do is up to him. The usual part of fire stations is a gym or a football field. The profession requires practically one hundred percent health (physical or cardiovascular), but also the absence of chronic or autoimmune diseases, because only then can a firefighter help one hundred percent and be a valid member of the team. If a firefighter is to be valid during an intervention, he should be physically fit as a top athlete. However, sport has become not only a duty for many firefighters, but also a necessity of life, as it helps firefighters cope with often harsh experiences after demanding interventions.

A group of volunteer firefighters (VLNT) consisted of men who did Czech fire sport and were not employed as professional firefighters. The disciplines of fire sport include running 100 meters with obstacles, a relay 4 x 100 meters with obstacles, ascent to the fourth floor of a training tower and fire attack. Fire-sport training usually takes place once a week for one hour. The duration of training, the course of training, as well as other sports activities of individuals, are completely voluntary and based on inner motivation. The mean value of physical activity (PA)

reported by men was 4.42 hours per week, standard deviation 4.05 (20). The rather higher standard deviation indicates a high variability in the distribution of the PA data in our sample. Volunteer firefighters in fire sport compete among themselves, the teams consist of motivated members of volunteer fire brigades, thus employing professional firefighters, who are often members of a volunteer fire brigade in their region. Participation in competitions is voluntary, in the week before the competition, training is usually more intensive and focuses on competition disciplines. The mean age of the group of volunteer firefighters was 28.02 years, standard deviation 3.41.

Anthropometric characteristics were ascertained using the standard method (21) in 2013 and 2018. Anthropologists measured the data assessed for all the reliability coefficients over 0.94. The accuracy of the measurement was verified before each data collection. The fundamental somatic characteristics of the file were body height, body weight and weight-height ratio – Body Mass Index (BMI; [kg/m2]). Not only circumferences (waist circumference, gluteal circumference and Waist-to-Hip Ratio (WHR)) but also skinfolds (skin fold on the right arm over the triceps, subscapular skin fold, suprailiacal skin fold, abdominal skin fold and the skin fold on the right thigh over the quadriceps) were collected. A skinfold is a fold of skin formed by compressing the skin and subcutaneous layers. The anthropometric equipment used for the measurement was an anthropometric measuring device (e.g. anthropometer, cephalometer, pelvimeter, a Harpenden skinfold calliper and a Luxa brand personal mechanical scale).

The estimate of the body composition of probands was determined via a bioelectrical impedance analysis (BIA) using the Bodystat®1500Touch tetra polar device (22). The principle of the method is based on the different electrical properties of tissues, fat and fat-free mass. The current passes through the fat-free mass, and the resulting resistance is directly proportional to its volume. Measurements using this device are widespread in medical and scientific practice with the knowledge that BIA significantly overestimates fat-free mass (FFM) and underestimated fat mass (FM) by 1–3 kg on average compared with dual-energy X-ray absorptiometry (23). Measurements were carried out according to standard methods (22). The body fat mass (BFM), fat-free mass (FFM) and the body water content (Water) were obtained. The body fat mass index (BFMI = BFM (kg)/ height (m)²) and the fat-free mass index (FFMI = FFM (kg) / height (m)²) were calculated.

Motoric tests indicate the level of speed, power and endurance abilities (motoric performance). Tests were always carried out using probands on one day and in the same order: sit-ups with rotation of the torso for 2 minutes, long jump with legs together, throwing a 2 kg ball with both hands in an upper arch, a 50 m run with fixed start and running for 12 minutes (Cooper test). All probands were encouraged to give a maximum effort and were given about 15 minutes to rest between all the tests. The tests were carried out under standard conditions (24, 25).

Muscle strength testing using a hand-grip dynamometry was also carried out using Collins dynamometer. The proband holds the dynamometer in the hand to be tested, with the extended arm by the side of the body. The handle of the dynamometer is adjusted if required - the base should rest on heel of palm, while the handle should rest on middle of the four fingers. When ready the subject squeezes the dynamometer with maximum isometric effort, no other body movement is allowed.

Blood pressure (BP) and heart rate (HR) measurements were performed on the right arm using a digital arm tonometer OMRON®M6 (26). The instrument was regularly digitally calibrated, and the accuracy of the measurement was verified before each data collection. The reaction of the cardiovascular system to strain was assessed via the frequently used Ruffier test. This functional test is based on monitoring the response of the cardiovascular system to 30 deep squats done using the standard method in 45 seconds (27, 28). The values of resting heart rate (HR1), the heart rate immediately after exercise (HR2) and the heart rate 1 minute from the end of the strain (HR3) were measured. A Ruffier test index (RTI)=((HR1+HR2+HR3)-200)/10) was calculated from the obtained values. For adults at values less than zero, the indicative rating scale shows excellent adaptation to strain (or outstanding fitness of the circulatory system), from 0.1 to 5 as good, from 5.1 to 10 as average, from 10.1 to 15 as inadequate, and above 15 as poor adaptation to strain. The values of resting heart rate were ascertained in a calm atmosphere, after sitting in a chair for approx. 15 minutes. The values of the index differ according to gender, age, physical condition and, importantly, strict compliance with the methodology (29).

Fundamental statistical values (numbers of probands – N, mean values – Mean and standard deviations – SD) can be found in the tables. The data on professional and volunteer firefighters were compared in view of Shapiro-Wilk

test' results using parametric Student's t-test: $\alpha = 0.05$ (*$p<0.05$) and $\alpha = 0.01$ (**$p<0.01$), respectively and non-parametric Mann-Whitney U test: $\alpha = 0.05$ (*$p<0.05$) and $\alpha = 0.01$ (**$p<0.01$), respectively.

Results and discussion

Our results of 36 professional firefighters (PROF) consisted of men employed as professional firefighters (the mean age was 31.58 years, with a standard deviation of 2.74) and our results of 36 volunteer firefighters (VLNT) consisted of men who did Czech fire sport and were not employed as professional firefighters (the mean age was 28.02 years, standard deviation 3.41) are in all the tables (Table 1, 2, 3 and 4) and all the figures (Figure 1, 2, 3 and 4).

Physical characteristics in professional firefighters (PROF) and volunteer (VLNT) firefighters

Comparison of the body weight, BMI, waist circumference and WHR (*Table 1*) showed higher mean values in professional firefighters. The difference of the mean values of BMI was statistically significant only rated by the Mann-Whitney U test, but the *p*-value is close to the significance limit. The mean value of the gluteal circumference in volunteer firefighters is higher than in professional firefighters. The differences of the mean values of the body weight, BMI, waist circumference, gluteal circumference and WHR were statistically significant by Student's t-test and/or Mann-Whitney U test.

Comparison of the body height and all the skinfolds in both groups showed approximately the same mean values. The differences of the mean values were statistically insignificant by Student's t-test or Mann-Whitney U test.

Thus, professional and volunteer firefighters do not differ significantly in adiposity.

Table 1. Comparison of physical characteristics in professional (PROF) and volunteer (VLNT) firefighters.

	PROF			VLNT			t-test	U-test	
	N	Mean	SD	N	Mean	SD	*p*	*p*	
Height (cm)	36	184.0	6.50	36	181.8	7.98	0.205	0.255	
Weight (kg)	36	86.7	9.12	36	82.6	12.51	0.121	**0.033**	*
BMI (kg/m^2)	36	25.5	1.50	36	25.0	3.49	0.395	**0.040**	*
WTC (cm)	36	93.4	7.18	36	90.1	11.2	0.140	**0.040**	*
GLC (cm)	36	98.1	6.45	36	102.8	6.48	**0.003**	**0.003**	**
WHR (i.u.)	36	95.2	4.44	36	87.5	7.62	**0.000**	**0.000**	**
SF triceps (mm)	36	10.7	3.11	36	10.4	3.59	0.688	0.844	
SF subscapular (mm)	36	14.8	4.69	36	15.8	7.25	0.493	0.774	
SF suprailiac (mm)	36	12.7	4.41	36	14.4	6.72	0.209	0.525	
SF abdominal (mm)	36	20.1	4.96	36	22.8	10.83	0.184	0.270	
SF quadriceps (mm)	36	17.4	5.32	36	16.9	7.09	0.750	0.640	

Note: Body Mass Index (BMI), waist circumference (WTC), gluteal circumference (GLC), Waist-to-Hip Ratio (WHR), skin fold on the right arm over the triceps (SF triceps), subscapular skin fold (SF subscapular), suprailiacal skin fold (SF suprailiac), abdominal skin fold (SF abdominal) and skin fold on the right thigh over the quadriceps (SF quadriceps).
Source: own research

The estimate of the body composition in professional firefighters (PROF) and volunteer (VLNT) firefighters

The mean values of the body fat mass, fat-free mass, total body water, body fat mass index and fat-free mass index are presented in *Table 2*. The differences of the mean values in professional and volunteer firefighters were statistically insignificant by Student's t-test or the Mann-Whitney U-test. The difference of the mean values of BFMI

was statistically significant when rated by the Mann-Whitney U-test, but the *p*-value is close to the significance limit. There is no significant difference in the mean values between professional and volunteer firefighters in the mean values of the body fat mass, fat-free body mass, total body water and FFMI (Fat-Free Mass Index).

Professional and volunteer firefighters do not differ significantly in body composition.

Table 2. Comparison of the estimate of the body composition via Bodystat®1500Touch in professional (PROF) and volunteer firefighters (VLNT)

	PROF			VLNT			t-test	U-test	
	N	Mean	SD	N	Mean	SD	*p*	*p*	
BFM (%)	36	17.2	5.34	36	18.0	3.27	0.434	0.253	
BFM (kg)	36	14.5	7.06	36	15.5	3.52	0.473	0.097	
FFM (%)	36	83.0	5.44	36	82.0	3.57	0.388	0.235	
FFM (kg)	36	67.8	8.10	36	70.9	7.62	0.102	0.102	
Water (%)	36	56.9	4.52	36	57.0	2.68	0.865	0.955	
Water (lt)	36	46.7	5.53	36	49.0	5.05	0.070	0.055	
BFMI (i.u.)	36	4.4	2.21	36	5.7	6.01	0.239	**0.043**	*
FFMI (i.u.)	36	20.8	2.36	36	21.3	1.88	0.423	0.175	

Note: the body fat mass (BFM), the fat free mass (FFM), the total body water (Water), the body fat mass index (BFMI), the fat free mass index (FFMI).
Source: own research

Motoric tests and hand-grip dynamometry of professional firefighters (PROF) and volunteer (VLNT) firefighters

The mean values of the motoric tests do not show statistically significant differences. The results of the motoric tests showed the same motoric performance in both professional and volunteer firefighters. The results are presented in *Table 3*, *Figures 1* and *2*.

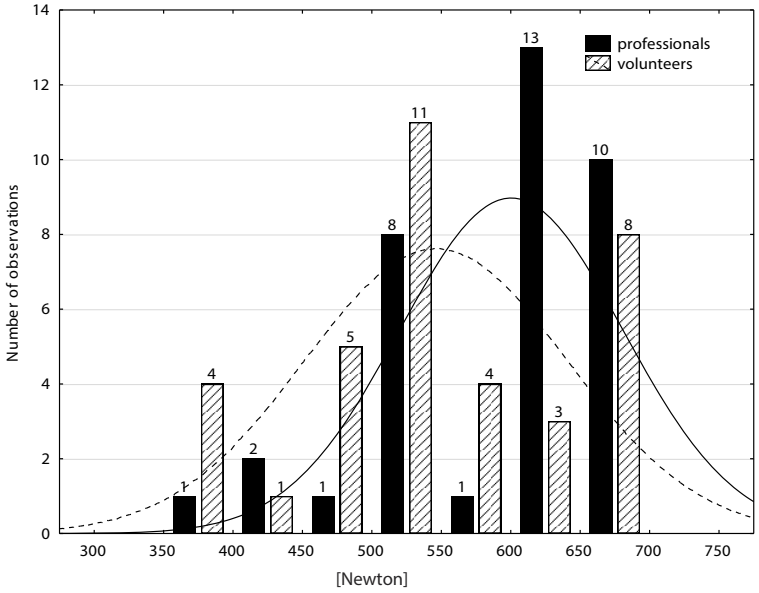
Table 3. Comparison of the results of motoric tests and hand-grip dynamometry in professional (PROF) and volunteer (VLNT) firefighters.

	PROF			VLNT			t-test	U-test	
	N	Mean	SD	N	Mean	SD	*p*	*p*	
sit-ups (sum)	36	55.6	12.92	36	55.3	8.61	0.923	0.624	
long jump (cm)	36	200.6	17.48	36	202.5	20.47	0.666	0.942	
throwing a ball (cm)	36	966.4	150.02	36	964.7	153.56	0.962	0.946	
50 m run (s)	36	8.6	0.96	36	8.5	0.91	0.796	0.892	
running for 12 min (m)	36	2146.4	308.48	36	2170.8	331.64	0.747	0.969	
dynamometry RH (N)	36	610.6	81.62	36	555.6	96.20	**0.011**	**0.013**	*
dynamometry LH (N)	36	578.1	90.67	36	506.1	123.23	**0.006**	**0.010**	**

Note: hand-grip dynamometry of the right hand (dynamometry RH) and hand-grip dynamometry of the left hand (dynamometry LH).
Source: own research

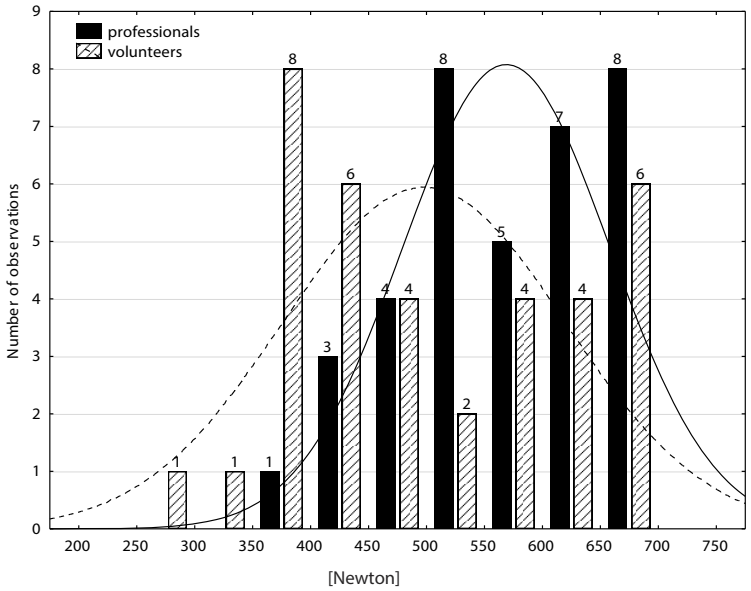
On the contrary, the mean values of the muscle strength testing (hand-grip dynamometry) of the right and the left upper extremity were higher in professional firefighters (*Table 3*). The differences of the mean values were rated as statistically significant by Student's t-test and the Mann-Whitney U-test. *Figures 1* and *2* noticeably show higher dynamometry values in professional firefighters, it could indicate strength training preferences in professionals.

Figure 1. Hand-grip dynamometry values [Newton] of the right hand (dynRH) in professional and volunteer firefighters.



Source: own research

Figure 2. Hand-grip dynamometry values [Newton] of the left hand (dynLH) in professional and volunteer firefighters.



Source: own research

Blood pressure and heart rate measurements in professional firefighters (PROF) and volunteer firefighters (VLNT) and the Ruffier test index

The mean values of the resting blood pressure systolic (BP1s), resting blood pressure diastolic (BP1d), blood pressure immediately after exercise systolic (BP2s) and blood pressure immediately after exercise diastolic (BP2d), blood pressure 1 minute from the end of the strain systolic (BP3s), blood pressure 1 minute from the end of the strain diastolic (BP3d), resting heart rate (HR1), heart rate immediately after exercise (HR2), heart rate 1 minute from the end of the strain (HR3) and the Ruffier test index (RTI) are presented in *Table 4*.

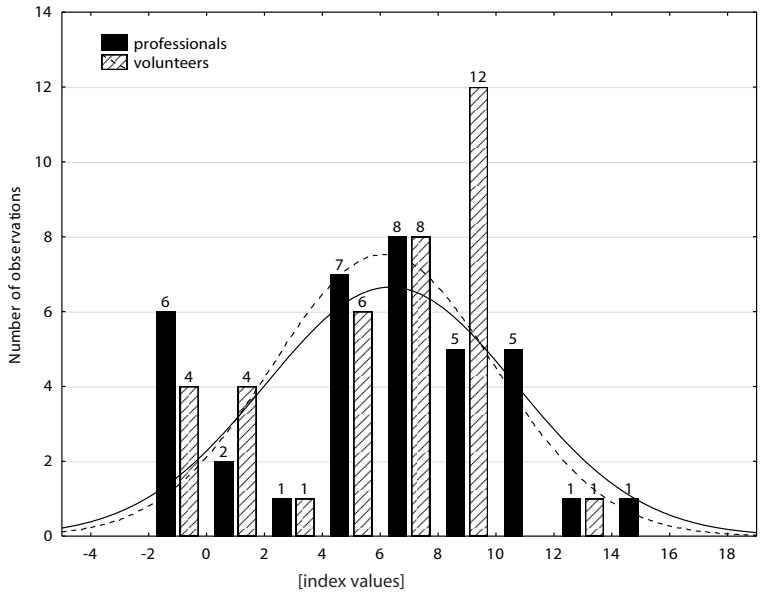
Table 4. CComparison of blood pressure, heart rate measurements and the Ruffier test index in professional (PROF) and volunteer (VLNT) firefighters.

	PROF			VLNT			t-test	U-test
	N	Mean	SD	N	Mean	SD	*p*	*p*
BP1s (Torr)	36	143.6	11.17	36	144.0	8.75	0.861	0.888
BP1d (Torr)	36	81.0	8.87	36	82.4	9.20	0.508	0.517
BP2s (Torr)	36	156.9	14.18	36	157.6	7.97	0.799	0.478
BP2d (Torr)	36	77.6	10.76	36	74.4	10.35	0.215	0.151
BP3s (Torr)	36	152.0	10.42	36	148.0	13.79	0.169	0.239
BP3d (Torr)	36	81.9	10.35	36	81.2	10.11	0.757	0.735
HR1 (bpm)	36	75.1	12.68	36	74.2	8.67	0.738	0.866
HR2 (bpm)	36	104.2	19.52	36	103.8	19.80	0.933	0.915
HR3 (bpm)	36	83.7	17.19	36	82.6	16.71	0.777	0.910
RTI (i.u.)	36	6.3	4.32	36	6.1	3.82	0.804	0.770

Note: resting blood pressure systolic (BP1s), resting blood pressure diastolic (BP1d), blood pressure immediately after exercise systolic (BP2s), blood pressure immediately after exercise diastolic (BP2d), blood pressure 1 minute from the end of the strain systolic (BP3s), blood pressure 1 minute from the end of the strain diastolic (BP3d), resting heart rate (HR1), heart rate immediately after exercise (HR2), heart rate 1 minute from the end of the strain (HR3) and the Ruffier test index (RTI).
Source: own research

No statistically significant difference in the mean (rather higher) values of blood pressure, heart rate and the Ruffier test index was rated in professional and volunteer firefighters by Student's t-test or Mann-Whitney U-test; the values are presented in *Figure 3*. Unexpectedly, the mean values of the Ruffier test index in both professional and volunteer firefighters showed average adaptation to strain, it could be functional to focus more on the internal factors of stress that could influenced resting blood pressures and resting heart rate. Also, it could be appropriate to add the shuttle run test in further research. The effect of strain is in the shuttle run test prolonged and the test might provide more accurate results of the cardiovascular adaptation of strain.

Figure 3. The Ruffier test index (RTI) in professional and volunteer firefighters.

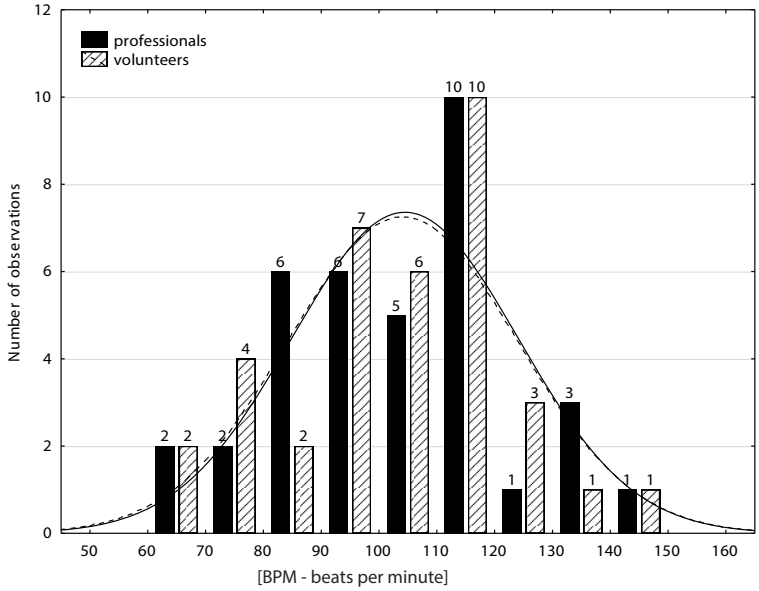


Source: own research

The mean values of the heart rate immediately after exercise (HR2; the response of the cardiovascular system to 30 deep squats done using the standard method in 45 seconds) do not differ among professional and volunteer firefighters. The values of the HR2 in our file are presented in *Figure 4*.

The fitness of the circulatory system (the reaction of the cardiovascular system to standardised strain) is equal in both professional and volunteer firefighters.

Figure 4. The heart rate immediately after exercise (HR2) in professional and volunteer firefighters.



Source: own research

Conclusion

Czech professional firefighters (36 probands) and Czech volunteer firefighters (36 probands) aged 25 to 35 years were examined to evaluate and compare their physical, motoric and cardiovascular status. Firefighters as a population sample were chosen because they are considered the most physically fit among the adult population, but the physical, motoric and cardiovascular status of this sample is slightly fuzzy (mainly in volunteer firefighters).

The difference of the mean values of the body height (184.0 cm and 181.8 cm, respectively) was statistically insignificant by Student's t-test or Mann-Whitney U test, the difference of the mean values of the Body mass index (25.5 kg/m^2 and 25.0 kg/m^2, respectively) was statistically significant only by Mann-Whitney U test, but the *p*-value is close to the significance limit. Also, the skinfolds measurement and the estimate of the body composition showed that professional and volunteer firefighters do not differ significantly in adiposity. The results of the motoric tests showed the same motoric performance in both professional and volunteer firefighters. On the contrary, the mean values of the muscle strength testing (hand-grip dynamometry) of the right and the left upper extremity were statistically significantly higher in professional firefighters, it could indicate strength training preferences in professionals. The cardiovascular status is equal in both professional and volunteer firefighters, no statistically significant difference in the mean (rather higher) values of blood pressure, heart rate and the Ruffier test index was rated in professional and volunteer firefighters. Unexpectedly, the mean values of the Ruffier test index in both professional and volunteer firefighters showed average adaptation to strain, it could be functional to add the shuttle run test in further research. The effect of strain is in the shuttle run test prolonged and the test might provide more accurate results of the cardiovascular adaptation of strain.

In general, the results of the investigation showed that professional and volunteer firefighters have a good physical, motoric and cardiovascular status and do not vary considerably.

Health care is the primary task of every member of the fire protection unit in order to be able to carry out their normal activities, but also to be able to carry out rescue work (31). Good health is a prerequisite for effective help to others and not endangering yourself or colleagues. The founders of fire protection units also have a certain co-responsibility for the health of intervening firefighters, who must create adequate safe conditions for the training of members of fire protection units. In particular, however, they must provide appropriate protective equipment to ensure that firefighters are protected during hazardous work and that the health or lives of firefighters are not endangered.

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Conflict of interest

The authors declare that they have no conflicts of interest regarding the publication of this article. The authors alone are responsible for the content and writing of the paper.

Adherence to ethical standards

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. The authors thank the probands for their helpfulness and willingness.

References

1. Demirkan E, Can S, Ozkadi T, et al. Fifty-meter swimming performance in young swimmers: the effect of anthropometric and motoric values on performance. Medicina dello Sport. 2019;72(4):488–497. doi: 10.23736/S0025-7826.18.03386-0.
2. Theis N, Le Warne M, Morrison S C, et al. Absolute and Allometrically Scaled Lower-Limb Strength Differences Between Children With Overweight/Obesity and Typical Weight Children. J. Strength Cond. Res. 2019;33(12):3276–3283. doi: 10.1519/JSC.0000000000003382.
3. Nunez F J, Munguia-Izquierdo D, Petri C, et al. Field Methods to Estimate Fat-free Mass in International Soccer Players. Int. J. Sports Med. 2019;40(10):619–624. doi: 10.1055/a-0969-8591.
4. Rowlands AV, Fairclough SJ, Yates T, et al. Activity Intensity, Volume, and Norms: Utility and Interpretation of Accelerometer Metrics. Med. Sci. Sports Exerc. 2019;51(11):2410–2422. doi: 10.1249/MSS.0000000000002047.
5. Zölzer F, Havránková R, Freitinger Skalická Z, et al. Analysis of Genetic Damage in Lymphocytes of Former Uranium Processing Workers. Cytogenetic and Genome Research. 2016;147(1):17-23. doi: 10.1159/000441889.
6. IRS CR. Integrated Rescue System of the Czech Republic. [Online]. Available from: https://www.hzscr.cz/hasicien/article/about-us-scope-of-activities-integrated-rescue-system.aspx [accessed: July 15, 2020].
7. Zelnicek P, Neklapilova V. Integrated rescue system in the Czech Republic. International Journal of Disaster Medicine. 2003;1(2):132–133. doi: 10.1080/15031430310029936.
8. Brehovská L, Charvátová M, Zölzer F, et al. Approach of social institutions to preparedness for emergency. Kontakt. 2017;19(1):e57–e66. doi: 10.1016/j.kontakt.2017.01.001.
9. Zegzulková V M, Špiláčková M. Cooperation of social workers of non-state non-profit organisations with the Integrated Rescue System staff during critical incident situations. Kontakt. 2018;21(1):98–105. doi: 10.32725/kont.2018.009.
10. Malachova H, Bednar K. Providing Security in Objects of Critical Infrastructure. In: Vision 2020: Sustainable economic development, innovation management, and global growth. Norristown: IBIMA. 2017;pp. 3178–3188.
11. Brumar J, Brumarova L, Pokorny J. Airport integrated operational center [online]. In: 2018 XIII International Scientific Conference - New Trends in Aviation Development (NTAD). Kosice: IEEE, 2018, s. 25–29. doi: 10.1109/NTAD.2018.8551671.
12. Kavan S. Výsluhové nároky příslušníků bezpečnostních sborů v České republice. International Scientific Conference „Safety and Security Society. 2020, s. 52-60. doi: 10.36682/ssc_2020.
13. MI CR. Ministry of the Interior of the Czech Republic. Vyhláška 407/2008 Sb. Decree No. 407/2008 Coll. (in Czech). [Online]. Available from: https://www.zakonyprolidi.cz/cs/2008-407 [accessed: July 15, 2020].
14. MI CR. Ministry of the Interior of the Czech Republic. Sbírka interních aktů řízení generálního ředitele HZS ČR - částka 70/2008. Collection of internal documents of the director general of Fire Rescue Service

of the Czech Republic – No. 70/2008 (in Czech). [Online]. Available from: https://www.hzscr.cz/soubor/pokyn58-08-pdf.aspx [accessed: July 15, 2020].
15. CT. Hasiči. Czech Television. Firefighters (in Czech). [Online]. Available from: https://www.ceskatelevize.cz/porady/11721706812-hasici/ [accessed: July 15, 2020].
16. Doležel J, Jarošová D. Analysis of clinical practice guidelines for cardiovascular disease prevention. Kontakt. 2015;17(2):e96–e102. doi: 10.1016/j.kontakt.2015.05.001.
17. Kavan S. Selected social impacts and measures resulting from the Covid-19 epidemic in the Czech Republic on the specific example of the South Bohemian Region. Health & Social Care in the Community. 2021. doi.org/10.1111/hsc.13272.
18. MI CR. Ministry of the Interior of the Czech Republic. Metodika pro zřizování jednotek sborů dobrovolných hasičů obcí (č.j. MV-52763-6/PO-2008). Methodology for establishment voluntary fire units of municipalities No. MV-52763-6/PO-2008 (in Czech). [Online]. Available from: http://www.hzscr.cz/soubor/metodika-zrizovani-jsdho-2009.aspx [accessed: July 15, 2020].
19. Brunet A, DeBoer L, McNamara K T. Community Choice Between Volunteer and Professional Fire Departments. Nonprof Volunt Sec Q. 2001;30(1):26–50. doi: 10.1177/0899764001301002.
20. Hruskova M, Mrackova P. Somatotype and Futher Characteristics of Volunteer Firefighters. Studia Kinanthropologica . 2019;20(3):231–241. ISSN 1213-2101.
21. Knussmann R. Anthropologie. Handbuch der vergleichenden Biologie des Menschen (4. Auflage des Lehrbuchs der Anthropologie begründet von Rudolf Martin), Band I und II. Anthropology. Handbook of Comparative Biology of Man (4th Edition of the Textbook of Anthropology by Rudolf Martin), Volumes I and II. (in German). Stuttgart: Gustav Fischer Verlag. 1988, 742 p.
22. Bodystat. Bodystat 1500 Touch. [Online]. Available from: https://www.bodystat.com/products/ [accessed: July 15, 2020].
23. Verdich C, Barbe P, Petersen M, et al. Changes in body composition during weight loss in obese subjects in the NUGENOB study: Comparison of bioelectrical impedance vs. dual-energy X-ray absorptiometry. Diabetes Metab. 2011;37(3):222–229. doi: 10.1016/j.diabet.2010.10.007.
24. Měkota K; Blahuš P. Motorické testy v tělesné výchově. Motoric performance in physical education (in Czech). Prague: SPN, 1983, 355 p.
25. Měkota K, Kovář R. (1995). UNIFITTEST: Tests and Norms of Motor Performance and Physical Fitness in Youth and in Adult Age. Olomouc: Univerzita Palackého. 1995, 108 p.
26. Omron. Blood pressure monitor Omron M6. [Online]. Available from: https://www.omron-healthcare.com/eu/category/blood-pressure-monitors [accessed: July 15, 2020].
27. Dickson J. L'utilisation de l'indice cardiaque du Ruffier dans le contrôle médico-sportif. Use of Ruffier's cardiac index in sports medical testing (in French). Médecine, Éducation Physique et Sport 2. 1950, 65–80. ISSN 0246-098X.
28. Nsenga L A, Shephard R J, Ahmaidi S. A brief history of exercise clearance and prescription: 1. The Era of Heart Rate Recovery Curves. Health & Fitness Journal of Canada. 2014;7(1):26–35. doi: 10.14288/hfjc.v7i1.155.
29. Bacquaert P. Test de Ruffier-Dickson. Institut de Recherche du Bien-être, de la Médecine et du Sport Santé. [Online]. Available from: https://www.irbms.com/test-de-ruffier-dickson/ [accessed: July 15, 2020].
30. Kavan Š, Kročová Š, Pokorný J. Assessment of the Readiness and Resilience of Czech Society against Water-Related Crises. Hydrology 2021, 8, 14. https://doi.org/10.3390/hydrology8010014.
31. Malerova L, Pokorny J. Transport of Dangerous Substance in Territory. In: Proceedings of the 21th International Scientific Conference Transport Means 2017. Lithuania: Kaunas Univ Technology Press, 2017. s. 607–610. ISSN 1822-296 X (print). ISSN 2351-7034 (on-line).