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Original empirical article

THE DIFFERENCES IN AEROBIC CAPACITY OF PHYSICALLY ACTIVE FEMALES IN RELATION TO THEIR AGE

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Abstract. *The aim of this research was to establish whether there are statistically significant differences among three groups of individuals that exercise actively, concerning the indicators of aerobic capacities, and in relation to their age. The sample of individuals consisted of 72 women in total (aged 20-49) who exercised actively in the World Class fitness club, Novi Sad. The individuals were grouped into three sub-samples according to their age. The first sub-sample consisted of individuals aged 20-29 (N=22), the second sub-sample of individuals aged 30-39 (N=28) and the third one of individuals aged 40-49 (N=22). The application of a multivariate and univariate analysis, as well as the t-test for independent samples, established statistically significant differences of the indicators of aerobic capacities on the quantitative level among all three groups of females and in favor of the younger women. The application of a univariate and multivariate analysis of variance, followed by the t-test for independent samples, which showed that there are statistically significant differences between aerobic capacity indicators at the quantitative level among the three groups of women and that they are in favor of the younger women. Those differences can be noted in the variables of peak heart rate, heart rate at peak oxygen uptake, relative oxygen uptake, duration, and speed test runs at peak oxygen uptake. Based on these results it can be concluded that there are significant differences in the aerobic capacity of women belonging to different age groups on the quantitative level. The women belonging to the group aged 20-29 showed better aerobic performance than the other two analyzed groups, aged 30-39 and 40-49.*

Key words: *aerobic capacity, individuals, age, aging.*

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INTRODUCTION

Aging represents an unstoppable and irreversible process which starts in the embryonic stage of development of organisms (Nešić et al., 2004). Starting with puberty, women go through a number of different phases which are, to a great extent, biologically conditioned. In the period of so-called late adolescence, there is a process of adjustment of the morphological, motor and functional status of women (Korovljev, Mikalački and Čokorilo, 2010). Physiological aging, in comparison to chronological aging, can be defined as an individual ability of organisms to adapt to the living conditions which are most often conditioned by the working capacity. Peak oxygen uptake is the indicator of aerobic capacity and most often it is the indicator which is used to estimate the physiological age and the efficiency of adult organisms. It is considered that 50% of the changes in the population of the developed world which are claimed to be the consequence of aging are actually caused by atrophy due to inactivity (Heath, Hagberg, Ehsani, and Holloszy, 1981; Kasch, Boyer, Champ, Verity and Wallace, 1990). Aerobic capacity usually reaches its maximum between the ages of 15 and 20. After the age of 20 and 30, healthy sedentary adults of both sexes start to suffer from a decline in aerobic capacity at a rate of 10% per decade (Buskirk and Hodgson, 1987; Fitzgerald, Tanaka, Tran and Seals 1997; Eskurza, Donato, Moreou, Seals and Tanaka, 2002; Pimentel, Gentike, Tanaka, Seals and Gates, 2003). A very influential factor which affects the aerobic capacity of women is physical activity. Doing recreational exercises is one of the key factors for fitness of a strong healthy woman. A big expansion of fitness and wellness and numerous other recreational centers supports this fact. When taking the population of women into account, it can be concluded that more and more women are becoming physically active in order to achieve better psycho-physical performances. The contemporary approach to programmed recreational exercises includes being active 4, or even 5 times a week with the tendency of combining different programs during the week. That system of doing physical exercise most often consists of group programs which are aimed at developing and improving aerobic endurance, coordination, strength and flexibility. The aerobic capacity characteristics of physically active women are one of the questions which are discussed in this paper. Taking into account that the sample consisted of women who do physical exercises intensively, it was interesting to establish what their functional status is, considering the fact that they differ from the usual pattern of doing physical exercise, at least in Novi Sad, where women usually do exercises two or three times a week following a uniform program (unlike the World Class program which offers various programs of exercises).

THE METHOD

The sample consisted of 72 women, aged 20-49, who exercised actively in the World Class fitness center in Novi Sad. The women were divided into three sub-samples in relation to their age. The first sub-sample consisted of individuals aged 20-29 (N=22) and 30-39 (N=28) and the second sub-sample consisted of individuals aged 40-49 (N=22). The division was made based on past surveys (Nasis and Gledas, 2003; Heyward, 2006). All of them did exercises according to the standard program of the World Class fitness centre. The sample consisted of women who had exercised for one year and belonged to the population of urban women of higher socio-economic status. The program which was used consisted of a combination of various group fitness programs, according to the following schedule:

For the purpose of estimating aerobic capacity, the DIF1 spiroergometric test was used. The spiroergometric test on a treadmill is a test which is used on healthy individuals

in the diagnostic department of the Faculty of Sport and Physical Education in Novi Sad and is referred to as DIF1. The test is made for all categories of individuals, from pre-school children to elderly people, and it has been applied in accordance with the protocol which has been successfully implemented in the Sports Diagnostic Centre of the Faculty of Sports at the University of Zagreb for the last ten years (Vučetić and Šentija, 2004, according to Vučetić, 2007). In order to adapt to the treadmill, the participants who had never run or walked on it practiced running and walking for several minutes before the measurement started. The apparatus which is connected to the computer enabled the monitoring and the numeric and graphic display of the data obtained during the process, as well as the automatic storage in the memory of the computer in order to be analyzed subsequently. During the test, the participants used breathing masks for their noses and mouths. After the phase of standing still which lasted for one minute, the test started with the participant walking at a speed of 3 km/h which lasted for 2 minutes. After that the speed of the treadmill increased every 30 seconds by 1 km/h. The incline of the treadmill was constantly 1.5%. Each individual walked during the first four levels of resistance (up to 6 km/h) and then started running at a speed of 7 km/h. The top speed and the end of the test were determined by the last level of the resistance at which an individual managed to run completely. Spirometry was also used to estimate the Forced Vital Capacity (FVC), together with a program package COSMED PFT Suite.

The obtained data included the following:

1) VO_2max (ml/min/kg) – the peak uptake of oxygen, which can be defined as the maximal amount of oxygen which a person can take from the air and use in their peripheral tissue,
2) FVC (l) – Forced Vital Capacity, representing the maximal amount of air which can be exhaled after maximal inhaling,
3) VE (l/min) – Ventilation per minute or the Volume of breathing per minute – the amount of air during breathing expressed as VE = DV (breathing volume) x f (frequency of breathing),
4) HRmax (bpm) – heart rate during peak oxygen uptake (VO_2max),
5) Hrmax (bpm) – peak heart rate,
6) The total time of the resistance test on a treadmill (min) and
7) The top speed achieved during running on a treadmill (km/min).

In order to establish the basic statistics of the groups, basic descriptive statistics were calculated. The testing of the significant differences in the indicators of aerobic capacities for the groups of women who belonged to different age groups required the application of multivariate and univariate analyses, as well as the t-test for independent samples. The data processing included the use of the statistical package SPSS 16.0.

RESULTS

With the purpose of establishing the significance of the differences on the quantitative level, the results obtained by the application of multivariate and univariate analyses (Table 2) are shown, as well as the results of the t-test for the independent samples for all three sub-samples. The application of the t-test for the independent samples (Table 3) established the statistically significant differences among the analyzed groups. For most of the indicators of aerobic capacity, high and statistically significant differences are present.

Table 1. Exercise program.

Group fitness programs			
training 1	training 2	training 3	training 4
pump 60'	step express 30'	pump 60'	pilates 60'
spinning express 30'	core express 30'	spinning express 30'	

Table 2. Testing the significance of differences in the indicators of aerobic capacity by applying a univariate and multivariate analysis of the variable.

Variable	Group	AM	S	f	P
Peak heart rate (bpm)	20-29	195,04	2,75	47,48	0,00
	30-39	186,35	4,46		
	40-49	178,52	8,60		
Heart rate at peak oxygen uptake (bpm)	20-29	183,43	5,28	31,82	0,00
	30-39	175,57	6,60		
	40-49	166,14	9,40		
The length of the test (min)	20-29	14,60	1,26	20,31	0,00
	30-39	13,77	0,98		
	40-49	12,05	1,79		
The speed of running at the peak oxygen uptake (km/min·10)	20-29	120,43	9,64	13,33	0,00
	30-39	113,58	12,30		
	40-49	96,26	23,91		
Relative oxygen uptake (ml/kg/min)	20-29	43,18	6,00	13,10	0,00
	30-39	37,51	7,83		
	40-49	32,46	6,65		
Peak ventilation of lungs per minute (l/min)	20-29	78,06	15,82	1,86	0,16
	30-39	74,98	12,40		
	40-49	70,17	12,50		
Forced vital capacity (l/min)	20-29	4,04	0,45	0,72	0,48
	30-39	3,94	0,44		
	40-49	3,85	0,63		

F= 6.21 P=0.00

Legend: AM – arithmetic mean, S - standard deviation, f - value of the f-test, p - significance of the f-test

DISCUSSION

The analysis of the basic descriptive statistics for the sub-samples of different age groups obtained in this research led us to new conclusions. If the results of the indicators of aerobic capacities were compared to referential values (which, unfortunately, are not present in Serbia in such a form that they are obtained by using the same protocol and on the same sample), it could be concluded that the women belonging to all three age groups have above average results for aerobic capacities, according to the criteria of the World Health Organization (WHO) and the research done by Heyward (2006). The analysis of the arithmetic means of the variable Relative oxygen uptake and the comparison of those with referential values in relation to sex and age, showed that the two groups of younger women (aged 20-29 and 30-39) are above average when oxygen uptake is taken into account. The

third group of women aged 40-49, based on the same criteria, belong to the group of excellent performers, which implies that their results are also better than average, which is connected to good functional capacities. The multivariate analysis of the variable showed that there is a statistically significant difference in the total space of the variables between the groups of women, where the value F= 6,21 is at the p=0,00 level of significance.

Table 3. Testing the significance of the differences in the aerobic capacities between the pairs of groups by applying the t-test on different variables.

Variable	AM	S	Pairs	T	p
Peak heart rate (bpm)	195,04	2,75	20-29 - 30-39	8,14	0,00
	186,36	4,46	20-29 - 40-49	8,74	0,00
	178,52	8,60	30-39 - 40-49	4,14	0,00
Heart rate at peak oxygen uptake (bpm)	183,43	5,28	20-29 - 30-39	4,62	0,00
	175,57	6,60	20-29 - 40-49	7,60	0,00
	166,14	9,40	30-39 - 40-49	4,12	0,00
The length of the test (min)	14,61	1,26	20-29 - 30-39	2,63	0,01
	13,78	0,98	20-29 - 40-49	5,49	0,00
	12,05	1,79	30-39 - 40-49	4,29	0,00
The speed of running at the peak oxygen uptake (km/min·10)	120,43	9,64	20-29 - 30-39	2,17	0,03
	113,59	12,30	20-29 - 40-49	5,67	0,00
	96,26	23,91	30-39 - 40-49	3,53	0,01
Relative oxygen uptake (ml/kg/ min)	43,18	6,00	20-29 - 30-39	2,85	0,05
	37,51	7,83	20-29 - 40-49	5,61	0,00
	32,46	6,65	30-39 - 40-49	2,38	0,02
Peak lung ventilation per minute (l/min)	78,06	15,82	20-29 - 30-39	0,78	0,44
	74,98	12,40	20-29 - 40-49	1,82	0,76
	70,17	12,50	30-39 - 40-49	1,34	1,88
Forced vital capacity (l/min)	4,04	0,45	20-29 - 30-39	0,74	0,46
	3,95	0,44	20-29 - 40-49	1,11	0,27
	3,85	0,63	30-39 - 40-49	5,91	0,56

Legend: AM – arithmetic mean, t – value of the t-test, p – the level of significance of the t-test

The analysis of the quantitative differences of the indicators of aerobic capacities, made by using the univariate analysis of the variable (Table 2), showed that for most of the analyzed indicators there is a statistically significant difference among the groups of women and it is at the $p<0,01$ level of significance. Only the variable Forced Vital Capacity and Peak Ventilation of Lungs per Minute showed no statistically significant difference among the groups of women. The results of the t-test for independent samples (Table 3) also showed a statistically significant difference of the indicators of aerobic capacity at the $p<0,01$ level of significance and confirmed the results obtained by the multivariate and univariate analysis of the variable.

The results obtained by comparing the pairs of groups of women indicated the existence of statistically significant differences among the indicators of aerobic capacity for women who exercise actively in relation to their age. Physically active women have a lower decreasing rate of the Peak heart frequency as they get older, but it necessarily decreases to some extent, in spite of their doing exercises regularly. This fact can be ex-

plained by the attenuated heart volume and arteriovenous differences in the oxygen uptake during the process of aging (Earnest, Blair and Church, 2010). The reason for that, as the past surveys have shown, is the decreased elasticity of arteries and attenuated function of the left ventricle (Tanaka, Monahan, and Seals, 2001; Ehsani et al., 2003), the increased amount of connective tissue, attenuated elasticity, increased total periphery resistance and higher blood pressure, which all together make the reason why a heart has to work harder in order to pump out the same amount of blood. The differences in the peak heart rate among the groups of women of different age groups have also been proved by other surveys (Tanaka et al., 2001; Fleg et al., 2005; Zoller, 2008). When younger and older groups of women are compared, it can be concluded that older women (40-49 years old) have weaker aerobic efficiency. Doing spiroergometric tests of resistance on a treadmill indicated some deficiencies which can be ascribed to weaker results of older women in comparison to younger ones. Older women had less experience of running on a treadmill and at the same time that lacked a certain routine during running. If we pay attention to the absence of statistically significant differences of the variables Forced Vital Capacity and Maximum Ventilation of Lungs per Minute among the women of different ages, it can be concluded that the older women (aged 40-49) have good efficiency and a good respiratory system, which can also be ascribed to their long-term exercise, or their long-term use of breathing organs. In the variable Maximal Oxygen Uptake, expressed in ml/kg/min, there is a statistically significant difference at the quantitative level. Statistically significant differences in the oxygen uptake are connected to the attenuation of heart rate, peak heart volume, the level of the difference between arterial and vein blood oxygen saturation ($A - VO_2$), as well as the level of the capacity of muscular tissue for the extraction and further utilization of oxygen (according to the theory of utilization and the theory of presentation - Wilmore and Costil, 2005). As women get older, the volume of their capillaries and the activity of mitochondrial enzymes in muscles and, at the same time, the capacity for the uptake of oxygen in muscular tissues decrease (Coggan et al., 1992). Some authors claim that there is no clear connection between the decrease of peak heart rate and aerobic capacity on the one hand, and age on the other, especially in the case of physically active women. The results of a transversal study (Fitzgerald et al., 1997) support the hypothesis that, unlike the widespread opinion, the differences between peak aerobic capacities over age are bigger, not smaller; nevertheless, this applies only for women who do physical exercise on a regular basis, as opposed to those who are inactive. More significant differences among the values of peak oxygen uptake (VO_2max) for the groups who do physical exercise on a regular basis can be connected to their higher values during the women's youth (basic effect), or doing less exercises at a later date (Fitzgerald et al., 1997; Zoller, 2008). A significant factor which explains the decrease of aerobic capacity, in addition to peak heart rate and peak oxygen uptake, are the changes in body composition during aging, especially the reduction of muscular mass, and the increase of the subcutaneous fatty tissue. According to the above mentioned, it can be concluded that there are significant differences in the aerobic capacities of women in different age groups on the quantitative level. The women who belong to the group aged 20-29 showed better aerobic efficiency in comparison to the other two analyzed groups. A part of the obtained results can, probably, be ascribed to the different lifestyles of those two categories of women, including how often they are active, their regular diet, marital status, genetic and other factors which influence the functional capacities as established by Nelson et al. (2007) and Earnest, Blair and Church (2010).

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RAZLIKE U AEROBNOJ SPOSOBNOSTI KOD FIZIČKI AKTIVNIH ŽENA U ODNOSU NA STAROSNU DOB

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Cilj ovog istraživanja bio je utvrditi da li postoje statistički značajne razlike između tri grupe fizički aktivnih žena u pogledu indikatora aerobnih sposobnosti u odnosu na starosnu dob. Za uzorak ispitanika odabrane su 72 ispitanice, stare 20-49 godina, koje su aktivno vežbale u fitnes klubu "World Class" u Novom Sadu. Ispitanice su bile podeljene u tri poduzorka u odnosu na starosnu dob. Prvi poduzorak činile su ispitanice starosne dobi 20-29 (N=23), drugi 30-39 godina (N=28) i treći ispitanice starosti 40-49 (N=21) godina. Primenom univarijatne i multivarijatne analize varijanse a potom t testa za nezavisne uzorke ustanovljene su statistički značajne razlike na kvantitativnom nivou u indikatorima aerobne sposobnosti, između sve tri posmatrane grupe ispitanica, a u korist mlađih ispitanica u varijablama Maksimalna srčana frekvenca, Srčana frekvenca pri maksimalnoj potrošnji kiseonika, Relativna potrošnja kiseonika, Dužina trajanja testa i Brzina trčanja pri maksimalnoj potrošnji kiseonika. Na osnovu dobijenih rezultata može se reći da postoje značajne razlike u aerobnim sposobnostima žena različite starosne dobi na kvantitativnom nivou. Ispitanice koje pripadaju grupi 20-29 godina starosti pokazale su bolju aerobnu efikasnost u odnosu na druge dve analizirane grupe (30-39 i 40-49 godina starosti).

Ključne reči: *aerobne sposobnosti, ispitanice, starenje.*