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DIFFERENCES IN PULMONARY VENTILATION FUNCTION PARAMETERS IN YOUNG VOLLEYBALL PLAYERS ACCORDING TO COMPETITIVE SUCCESS CRITERION

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(Original scientific paper)

Sanja Vitaić, Marko Erceg, Mirjana Milić
Faculty of Kinesiology, University of Split, Croatia

Abstract
Spirometry is a very acceptable method of sports diagnostics; due to its simple application, it is used in measuring lung capacity and speed of air flow through the airways. The aim of this research was to determine the sizes of lung function indicators in 56 young female volleyball players from Split-Dalmatia County, whose mean chronological age was 14.1 years, as well as the differences according to the criterion of competitive success. The application of Student's independent samples t-test indicated a significant difference in the defined subgroups of successful (n=32) and less successful (n=24) players, regarding the indicators of absolute value of maximum expiratory flow at 50% and maximum expiratory flow at 25%.The obtained results indicate the importance of dynamic lung indicators in the differentiation of successful and less successful young female volleyball players. .

Key words: *spirometry, vital capacity, volleyball, t-test*

Introduction

Good work capacity is a precondition of good athletic performance and in sports practice it is evaluated based on functionality of energy systems (Foretić et al., 2013). The energy systems are closely related to oxygen uptake and metabolism, processes that begin with breathing in the lungs. Breathing as a complex process includes ventilation, which rhythmically and constantly renews the air in the lungs, diffusion of oxygen and carbon-dioxide through alveolar membrane and adequate blood flow in lung capillaries (Guyton, 1985).

Pulmonary ventilation function which denotes the mechanism of breathing in and out, i.e. movement of air between the atmosphere and lung alveoli is tested by the *spirometry* method which measures static volumes and capacities and dynamic lung volumes. Spirometry is a very acceptable diagnostic method in sports due to its simple application. Two tests that are most commonly used to define the ventilation function of the lungs in athletes and general population are the *forced vital capacity* and *maximum voluntary ventilation*.

Pulmonary ventilation represents a measure of athlete's health status which determines the athlete's possibility for quality, optimal and successful training. Although Willmore (1990) points out that, in general, lung volumes and capacities are insignificantly changed under the influence of training, i.e. that vital capacity is slightly increased but the total lung capacities remain unchanged, different sports have different effects on development of the breathing function. Prakash et al. (2007) noticed more efficient ventilation in people who were better adapted to physical exertion through systematic exercise. However, aerobic stimuli have the greatest impact on the increase of vital capacity, whereas anaerobic stimuli have the greatest impact on the increase of air flow speed (Jeličić, 2000).

Pulmonary function testing is an important diagnostic procedure in sport. The lack of literature on this theme can partially be explained by a common belief that analysis of ventilation in sport is not very important, which is further explained by the existence of great capacities in athletes and its small influence on oxygen consumption (Jeličić, 2000).

In other words, it was believed that, in terms of ventilation, athletes were ready to do any type of work. Such investigations have been carried out among rowers, sailors, swimmers, water polo players, and partly among basketball, football, handball and volleyball players in laboratory and field conditions.

By comparing the results of forced vital capacity, forced expiratory volume and maximum expiratory flow between football players, hockey players, volleyball players, swimmers, basketball players and the control group, Mehrotra et al. (1998) determined that the results in the listed parameters showed significant differences in favour of all groups of athletes and the best results of pulmonary ventilation function were the swimmers' results.

Ventilation values in childhood and puberty change in parallel with changes of anthropometric characteristics. At this age, development of pulmonary ventilation values can be influenced by exercise and training (Cuurteix et al., 1997; Lakhera, 1994; Marinović & Tocigl, 1999; Tocigl et al., 1999).

In their research, Hraste et al. (2008) determined significant effects of increase of pulmonary ventilation function value in young athletes playing water polo for three, five and seven years, which were caused by programmed training and time spent training. However, there have been few investigations on subjects at the age of growth and development related to cardiovascular and respiratory system of male/female volleyball players.

In accordance with the aforementioned, the aim of this research is to determine the parameter sizes of ventilation function of young female volleyball players and their differences according to the criterion of competitive success.

Methods

The subject sample included 56 youth female volleyball players of Split-Dalmatia County. Mean chronological age of subjects was 14.09 years, mean body height was 168.66±6.68, mean body mass was 58.34±9.07 and mean Body Mass Index (BMI) was 20.48±2.80. All subjects participated in the 2015 Youth National Volleyball Championship in Rovinj.

Competitive success of female players was determined on a five-point Likert scale. Each player was assigned a score from 1 to 5 following two criteria: *Team placement at the competition* and *Player quality within her team (according to the coach's evaluation)*. All players who were assigned a score from 1 to 3 represented the group of less successful players, whereas all players who were assigned scores 4 and 5 represented the group of more successful according to Grgantov (2005) and Milić (2014).

Based on the aforementioned, the subject sample was divided into two groups according to the criterion of competitive success – more successful (n=32) and less successful (n=24) young female volleyball players. All participants had a membership card of the Croatian volleyball federation certified by an authorized sports doctor.

A battery of tests of predictor variables consisted of six ventilation indicators and two morphological measures. Static and dynamic volumes and the flow-volume curve were also measured by spirometry procedure. Of the static capacities, the *forced vital capacity* (FVC) was measured, and of the dynamic capacities, the *forced expiratory volume in 1 second* (FEV1) and *Tiffeneau index* (FEV1/%FVC) were measured. The forced expiratory flows at *50%FVC* (MEF50) and *25%FVC* (MEF25) were measured by the flow-volume curve. *Maximum voluntary ventilation* (MVV) is a method that points to the state of respiratory muscles, lung compliance and airway resistance. The measurements were taken by the microQuark spirometer (Cosmed, Italy) with written consent given by parents. The subjects repeated the forced expiration in sitting position three times, and measuring procedures were carried out following the known standards (Knudson et al., 1967, Miller et al., 2005).

Morphological measures that were used in this research are: *body height* and *body mass*, along with the subsequent calculation of the Body Mass Index expressed by the ratio of body mass in kilograms and body height in meters squared.

In accordance with the aim of this study, data analysis was carried out by calculating basic descriptive indicators of absolute values of pulmonary ventilation parameters, two morphological measures and Body Mass Index: mean (M), standard deviation (SD), minimum result (Min), maximum result (Max), measure of distribution skewness (SKEW), measure of distribution kurtosis (KURT) and value for determining statistically significant deviation of the measured variables from normal distribution (MaxD) by applying the Kolmogorov-Smirnov test (KS-test).

Student's independent samples t-test was used to determine the differences in ventilation indicators between the subgroups defined by the criterion variable of competitive success of young female volleyball players. In doing so, the value of t-test coefficient and level of significance p were also calculated. Data analysis was carried out by the *Statistica, ver.12.00* computer software.

Results

The results of descriptive statistics of morphological variables, of absolute values of pulmonary ventilation function parameters of young female volleyball players (N=57) are presented in Table 1.

Table 1 Descriptive statistics of morphological characteristics and absolute values of pulmonary ventilation function parameters of young female volleyball players (N=57)

	Variables	AS	Mdn	Min	KS	SD	MaxD	Skew	Kurt
	Body height (cm)	168.66	169.50	150.00	180.00	6.68	0.10	-0.68	0.31
	Body mass (kg)	58.34	58.00	38.00	78.00	9.07	0.07	0.08	-0.42
	Body mass index (kg/m^2)	20.48	20.15	15.40	27.00	2.80	0.08	0.50	-0.31
ABSOLUTE VALUES	Forced vital capacity-FVC (l)	3.14	3.07	2.07	4.36	0.49	0.10	0.46	-0.13
	Forced expiratory volume in 1 second - FEV1 (l)	2.99	2.91	1.99	4.23	0.51	0.12	0.66	0.29
	Forced expiratory volume in 1 second / forced vital capacity FEV1/FVC (l)	94.53	95.90	83.80	99.60	3.80	0.15	-0.84	0.15
	Maximum expiratory flow at 50% FVC- MEF_{50} (l)	4.25	4.08	2.89	6.20	0.81	0.13	0.32	-0.86
	Maximum expiratory flow at 25% FVC- MEF_{25} (l)	2.61	2.50	1.40	4.10	0.73	0.11	0.47	-0.61
	Maximum voluntary ventilation-MVV	109.58	108.05	59.60	152.40	20.52	0.05	0.13	-0.13

KS= 0.20

LEGEND: M – mean, **Mdn** – median, **Min** – minimum value, **Max** – maximum value, **SD** – standard deviation, **MaxD** – value for determining statistically significant deviation of measured variables from normal distribution, **Skew** – coefficient of distribution skewness, **Kurt** – coefficient of distribution kurtosis**, KS** – Kolmogorov-Smirnov test.

By examining Table 1, one can see the results of descriptive statistics of morphological variables and *Body Mass Index* and *absolute values* of pulmonary ventilation function parameters of young female volleyball players (N=57).

Table 2 Descriptive indicators and analysis of difference of morphological characteristics and pulmonary ventilation function parameters of less successful and more successful young female volleyball players

	Variables	Less successful (N=24)	More successful (N=32)		
		M	M	t test	p
	Body height (cm)	167.42	169.59	-1.21	0.23
	Body mass (kg)	57.83	58.72	-0.36	0.72
	Body mass index (kg/m^2)	20.54	20.43	0.14	0.89
ABSOLUTE VALUES	Forced vital capacity-FVC (l)	3.06	3.20	-1.01	0.32
	Forced expiratory volume in 1 second -FEV1 (l)	2.89	3.08	-1.23	0.23
	Forced expiratory volume in 1 second / forced vital capacity FEV1/FVC (l)	93.58	95.43	-1.59	0.12
	Maximum expiratory flow at 50% FVC- MEF_{50} (l)	3.95	4.47	-2.47	0.02
	Maximum expiratory flow at 25% FVC- MEF_{25} (l)	2.29	2.85	-3.02	0.00
	Maximum voluntary ventilation-MVV	107.55	111.10	-0.64	0.53

LEGEND: M – mean, **t-test** – value of statistical significance coefficient, **p** – level of statistical significance.

The analysis of distribution parameters showed that all the variables applied did not deviate significantly from normal distribution values and were suitable for further multivariate statistical analysis. Distribution normality was tested by Kolmogorov-Smirnov test with critical value of 0.20.

By comparing the mean results of values of pulmonary ventilation function parameters in young female volleyball players presented in Table 1 with referent values of pulmonary ventilation, increased values were obtained in the following parameters: *forced expiratory volume in 1 second / forced vital capacity FEV1/FVC*, *maximum expiratory flow at 50% FVC- MEF_{50}* and *maximum expiratory flow at 25% FVC- MEF_{25}*, average referent values were found in the *forced expiratory volume in 1 second -FEV1,* whereas the remaining two parameters, *forced vital capacity-FVC* and *maximum voluntary ventilation-MVV* were somewhat lower.

Means of morphological characteristics and pulmonary ventilation function parameters of more successful (n=32) and less successful (n=24) and their differences obtained by Student's independent samples t-test are presented in Table 2

By analysing the results in Table 2, one can notice that more successful young players had higher mean values of morphological characteristics *body height* and *body mass*, lower value of *Body Mass Index* and higher mean absolute values of all measured ventilation parameters.

By Student's independent samples t-test significant difference between two subgroups of young female volleyball players classified according to the success criterion were found in two out of the total six spirometry tests: *maximum expiratory flow at 50% FVC-* MEF_{50} and *maximum expiratory flow at 25% FVC-* MEF_{25}.

Discussion and Conclusion

By applying the Student's independent samples t-test, the analysis of differences of ventilation parameters between the subgroups defined according to the criterion variable of competitive success of young female volleyball players was carried out and significant differences were found in two tests of pulmonary ventilation function out of the six applied parameters. In all spirometry tests, more successful volleyball players had higher mean absolute values in comparison to the less successful players.

In the *maximum expiratory flow at 50% FVC-* MEF_{50} and *maximum expiratory flow at 25% FVC-* MEF_{25} pulmonary ventilation function parameters more successful volleyball players differed significantly from less successful players. The MEF_{50} *and* MEF_{25} are a part of the flow-volume curve and can be viewed as dynamic pulmonary parameters because they are related to factor-time and determine the airways conductance. These parameters belong to the last (third) part of the expiratory part of the flow-volume curve and are exclusively dependent on elastic force of the lung. We can assume that the training structure in more successful volleyball players had more impact on the elastic force of the lung and airways conductance, which would explain the obtained results.

It was expected that more successful young players, who were somewhat taller and had greater body mass, and therefore "bigger" lungs, would achieve better results in spirometry parameters. It is known that exercises of dominantly aerobic character have a positive influence on vital capacity, whereas the exercises of anaerobic character contribute to the development of dynamic ventilation parameters. Volleyball is characterized primarily by loads of anaerobic alactate character. Short points last averagely 7 seconds on average, with pauses lasting averagely 14 seconds between two points. Actions during points abound in jumps, accelerations, quick changes of direction and landings. This is why more successful players are often faster and more explosive than less successful players and are also characterized by good jumping endurance (Lidor & Ziv, 2010; Borras et al., 2011; Milić et al., 2012; Grgantov et al., 2013). It can be assumed that such structure of motor and functional abilities in more successful female volleyball players was also partly the cause for their superior results in dynamic ventilation indicators, in comparison to the less successful players.

Namely, pulmonary function significantly changes with age. Minute ventilation increases with age until the point of physical maturity and then decreases with age. These changes are related to growth of the whole pulmonary system. From the time a child enters kindergarten until puberty the mass of the lungs is almost tripled – from 211 g to 640 g on average. During that time vital capacity – VC increases from about 1000 mL to 3000 mL, as well as total lung capacity from 1400 mL to 4500 mL. Structure of the lungs is not completely developed at birth, and the number of alveoli and airways is increased almost 10 times before the child reaches maturity. In late childhood and adolescence those changes occur mostly through the expansion of the existing alveoli and airways. Nevertheless, the impact of training on the respiratory system is significant. Exercises that require great minute volume of breathing stimulate growth and development of the thorax in young female volleyball players and in this way it becomes wider, longer and with greater capacity. In a bigger thorax so called "sports lungs" develop, with greater air volume, but also blood volume and surface of lung alveoli. Moreover, training increases strength and leads to hypertrophy of respiratory muscles, as well as more economic breathing with lower frequency (Lakhera et al., 1994; Jeličić, 2000; Hraste, 2004).

Significance of this study lies in its purpose to serve expert teams in selection when planning and programming the training process of young female competitors in volleyball.

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