Biomedical & Pharmacology Journal, June 2023. Vol. **16**(2), p. 763-771

Impact of Sport Specific Type on Pulmonary Function and Anthropometric Measures of Adolescents

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https://dx.doi.org/10.13005/bpj/2658

(Received: 02 May 2023; accepted: 29 May 2023)

Involvement in specific sports or physical activities enhances the strength of respiratory muscles and impacts anthropometric characteristics. Current studies have declared that athletes possess greater capability of the respiratory system, and different body characterization in comparison to their age-matched sedentary controls. Aim: our study aimed to examine the differences between lung function and anthropometric characterization among athletic adolescents performing sports which is similar in nature, in accordance with intensity and type of exercise executed. Methods: 97 athletic adolescents aged between 14-18 years enrolled in a sport at the national or international level and engaged in that sport for more than 15 hours per week were included in the study. 20 non- athlete adolescents enrolled as control. All the participants were subjected to full history, thorough medical examination and anthropometric measurements including weight, height, BMI. Pulmonary function tests were performed. Results: As regards the anthropometric measurements, there was a significant difference of weight and height between water polo and both other sports and non-athletes. Moreover, there was a significant difference in BMI between water polo and non-athletes. In pulmonary functions, we detected a significant difference regarding forced vital capacity between both water polo and other sports vs non-athletes. Conclusion: Regular exercises impacted pulmonary capacity and different morphological characterization and it is sport type dependent.

Keywords: Adolescents; Anthropometry; Pulmonary Functions; Sports.

Athletes who practice regular exercises have a propensity for an increase in pulmonary capacity and various morphological characteristics when compared to non-exercising individuals. The preservation of effective lung mechanics is thoroughly related to the appropriate function of the two phases of respiration[1]. Enhanced function of every system in the human body is accomplished via regular exercise. Generally, the strength of muscles comprising respiratory muscles, is improved by regular exercise, therefore it is supposed that it positively affects the function of lungs[2]. Current studies have declared that athletes possess greater capability of the respiratory system in comparison to sedentary controls of same age group[1, 3, 4].

During exercise, respiratory muscles are exposed to fatigue that confines their capability to work optimally, translating into inadequate oxygen supply to the working muscles[5] Consequently, it is advisable to draw attention to the work of respiratory muscles throughout sports training.

Precise disciplines of sport increase the lung function better than others, include basketball, swimming, rowing, and water polo[6]. Swimmers attain greater volumes of lung and greater l capacity of the function of cardiorespiratory system in comparison to athletes practicing other sports[6, 7].

Values of spirometry disclosed in athletes commonly point to standards (i.e., standardized predicted values) for the average population of healthy subjects, as commended by international organizations, for instance, the American Thoracic Society (ATS), the European Respiratory Society (ERS), or European Commonwealth of Coal and Steel (ECCS)[8].

Following sports or a physical activity that could assist in accomplishing effective lung function (FVC, FEV1) is an indispensable protective policy for this busy age when incidence of sedentary lifestyles is growing and so are the related disorders of lifestyle[4,5]. Athletes possess enhanced tests of pulmonary function than non-athletes as each exercise assists to increase the strength of the body muscles comprising muscles of the chest. Lung development, and subsequently lung volumes, could alter its performance relying upon intensity, severity, type, duration and frequency of sports activity[6].

In addition to age, sex, race, weight and height, pulmonary function is influenced by several elements in individuals who are physically normal: the equilibrium between and chest elasticity and lung recoil, (defining the mid-position at the termination of spontaneous expiration and the coordination of neuro-muscular function to maintain the power), individual posture, strength of the muscles of chest and abdomen, and lung elasticity. Dissimilar other sports, swimming motivates the muscles of the whole-body system, with too much use of the muscles of chest wall and abdomen, distinguished by periods of sustained holding the breath resulting in intermittent hypoxia, due to the particular manner of training. Also, swimming is different from other sport disciplines in various means; it is executed in the horizontal position in comparison to other sports' vertical posture, external pressure is greater as the density of the surrounding medium is more than that of air; and also, the heat conduction of water is greater than that of air[9, 10].

This study aimed to examine the differences between lung function and anthropometric characterization among athletic adolescents performing sports which are similar in nature, in accordance with intensity and type of exercise executed.

Subjects and methods

A comparative study was conducted on 117 adolescents, aged between 14-18 years, selected from patients attending Infant and pediatric pulmonary function unit, Medical Research Centre of Excellency, National research Centre.

Study groups were as follows Group A: 97 athletic adolescents including 51 adolescent performing water Polo training, 39 adolescent performing swimming training and 7 performing athletics sport.

Group B included 20 non- athlete adolescents of matched age and gender who were referred by pulmonary function clinic, pediatric department in Azhar university and pediatric department, Suez canal university.

Ethical approval

The study obtained ethical approval of the ethical committee of National Research center and written informed consents were collected from the parents or caregivers of the participants after explanation of the research and before participation. Oral assents were also obtained from the participants.

Forms were collected from parents or caregivers of participant that included demographic data such as gender, age, residence, passive smoking exposure, medical history, and history of previous medication.

Inclusion criteria: were enrolled in a sport at the national or international level and engaged in that sport for more than 15 hours per week. The control group was selected from siblings and relatives of matched age and gender. The control group: not involved in any kind of regular sports.

Exclusion criteria: were smokers, history of surgery of abdomen or chest, pulmonary, cardiac and neuromuscular disorders, taking any medication that may affect results of pulmonary functions prior to the test by 3 weeks.

All the participants were subjected to full history, thorough medical examination and anthropometric measurements including weight, height, BMI.

Pulmonary function tests were implemented in acquiescence with the guidelines of European Respiratory Society/American Thoracic Society (ERS/ATS) by Master Screen The computerized spirometer was calibrated each day with a 3 l syringe prior to the tests[11]. Under standard environmental conditions, the participants were seated comfortably with applying a nose clip to abolish breathing from their nose. Tested parameters included: FVC, FEV1, FEV1/FVC and MEF (The forced mid-expiratory flow)[8]. The participants were requested to breathe tidal breathing through the mouthpiece, after that, requested to exhale as hard and fast as probable till the lungs were totally empty. This test was recurred 2 to 3 times and the greatest value was recorded.

Statistical Methods

The collected data were coded, tabulated, and statistically analyzed with the use of statistical package for social sciences software, SPSS version 24. Quantitative parametric data were presented as mean ± SD, while qualitative data were presented as number and percentage. Independent sample T test was utilized for comparison of two means. Pearson's correlation was utilized to relate variables. The tests were considered statistically significant at $p<0.05$, otherwise the tests were deliberated insignificant.

RESULTS

The current study was conducted on 97 adolescents aged 14-17 years enrolled in different sports and classified according to the type of sport as follow: 51 were playing water Polo, 39 playing swimming and 7 playing athletics sports and 20 non- athlete adolescents.

For the athletic group 50 (51.5%) were males and 47(48.4%) females and for the control group 11(55%) were males and 9 (45%) were females.

Our study revealed a significant difference between athletes and non-athletes as regards weight, height, forced vital capacity, forced expiratory volume in first second and mid-expiratory flow at 75 seconds as demonstrated in Table (1).

In anthropometric measurements there was a significant difference regarding weight and height between water polo and both other sports and non-athletes, also regarding height between other sports and non-athletes. Moreover, there was a significant difference in BMI between water polo and non-athletes. While in pulmonary functions, there was a significant difference regarding forced vital capacity between both water polo and other sports vs non-athletes. A significant difference also was found in FEV1 between water polo vs other sports, water polo vs non-athletes, other sports vs non-athletes. Lastly a significant difference existed regarding MEF75 between water polo vs both other sports and non-athletes. .In general, Water-polo athletes had higher values either in anthropometry or pulmonary functions. (Table 2).

Table 3 showed a significant difference between males and females regarding weight, height, BMI, BMI z- score, FVC, FEV1 and FEV1/ FVC %.Moreover, there were significant positive correlations between the three anthropometric measurements; weight, height and BMI with both FVC & FEV1.as shown in table (4).

DISCUSSION

There are well-established determinants of pulmonary function parameters, anthropometric parameters and sports. Participation in certain sports or physical activities assist in strengthening of respiratory muscle and enhancement in pulmonary function. Previous studies revealed that there is a higher level of pulmonary function parameters in athletes. In children, being physically active improves the quality of life either in childhood or later in adulthood[12, 13]

Though, limited research has been carried out concerning the influence of routine physical activity in respiratory mechanics. In general, it is assented that top athletes and physically active individuals have a propensity for greater levels of cardiorespiratory fitness[7,14,15].

The current study aimed to investigate the influence of sports on pulmonary function and anthropometric measures amongst athletic adolescents who perform sports that is similar in nature, consistent with the type and intensity of exercise performed.

In our study, by comparing anthropometric measurements, we found a significant difference in weight and height between different study groups. This finding is in accordance with many studies that revealed a significant difference in height and weight between the control group and athletes[16-18].

Table 1. Comparison of the anthropometric measures and pulmonary function tests for athlete versus non-athlete adolescent participants

	Groups	Mean ± SD	t-test	p
Age (years)	Athlete	16.13± 1.724	0.269	0.405
	control	12.350	± 1.4420	
Weight (Kg)	Athlete	63.35 ± 13.63	3.150	0.002*
	control	52.57 ± 13.66		
Hight (cm)	Athlete	170.10 ± 10.66	5.356	<.001**
	control	155.10 ± 13.51		
BMI	Athlete	21.661± 2.961	1.866	0.065
	control	20.142± 4.463		
BMI z score	Athlete	0.702± 1.455	1.077	0.284
	control	0.296± 1.733		
FVC (L)	Athlete	114.79 ± 12.45	5.977	<.001**
	control	91.25 ± 26.81		
FEV1 (L)	Athlete	117.665± 18.941	5.200	<.001**
	control	90.384± 28.953		
FEV1/FVC%	Athlete	100.189± 9.525	1.101	0.273
	control	97.453± 10.748		
MEF75 (L)	Athlete	105.625± 26.668	2.432	.017
	control	87.537± 36.158		

Independent samples T test

FVC: Forced vital capacity, FEV_1: Forced expiratory volume in first second.

Table 2. Comparison of the anthropometric measures and pulmonary function tests (percentage of predicted values of spirometry) for athletes by sport practiced versus non-athletes

Sport type (no.) athlete	Water Polo (51)	Other sports (46)	non athlete (20)	Water polo vs other sports	Water polo vs non-athlete	other sports vs non
age	16.63 ± 1.232	15.95 ± 2.017	15.89± 1.522	0.240	0.228	0.481
weight	67.108± 14.203	59.196±11.780	52.579± 13.664	0.004**	<.001**	.111
Height	173.594± 9.991	166.237±10.127	155.105± 13.516	<.001**	<.001**	<.001**
BMI	22.067± 3.238	21.211± 2.581	20.142± 4.463	0.156	0.049*	0.342
BMI z score	0.833± 1.809	0.557± .915	0.296± 1.733	0.352	0.284	0.713
FVC	116.976±10.053	112.380±14.40	91.253± 26.816	0.072	<.001**	<.001**
FEV1	122.198± 18.552	112.629±18.272	90.384 ±28.953	0.013*	<.001**	<.001**
FEV1/FVC%	100.241± 8.787	100.129±10.435	97.453± 10.748	0. 958	0.450	0.491
MEF	111.080± 28.389	99.564 ±23.460	87.537± 36.158	0.035*	0.006*	0.204

*. The mean difference is significant at the 0.05 level and highly significant at 0.001 level

a. Dunnett t-tests treat one group as a control and compare all other groups against it.

(One way ANOVA, Post Hoc Test)

By analysis of our results, we demonstrated that athletes performing water polo sport were significantly higher in weight and height in comparison to athletes performing other type of sports and moreover in comparison with control group. Furthermore, we documented a significant difference in BMI between athletes performing water polo and non-athletes control group. This can be explained by the fact that water polo is a team game with a ball in the water, and it is controlled by compound movements. Furthermore, it is distinguished by rapid actions with prominent bouts of numbers, robust and defined shooting on goal, which necessitates psychomotricity of players at a high level[19, 20].

The shape of the athlete, i.e., his characteristics of anthropometry, is an enormously essential element in each sports discipline[20]. The morphology of water polo players was studied by many researchers as the characteristics of anthropometry of elite players of water polo have altered over the previous years[19-21]. The figure of the body has altered as height becomes greater and limbs are longer with the waist is narrower and shoulders are wider. Body weight has amplified. The level of muscle mass has augmented relative to adipose tissue. The perceived alterations are a result of the trend of acceleration and morphological adaptation of sports (optimization). These superior physical features are essential for their vertical jump above water. Indeed, players of water polo are in the vertical position most of the match time executing activities with alternating intensities[22, 23].

This supports the theory that this type of sport has an impact on anthropometric features. As in our study the water polo players had higher wight

Table 3. Comparison of the anthropometric measures and pulmonary function tests (percentage of predicted spirometry values) for athletes by Gender

	Males (50)	Females (47)	t	P value
Wt (Kg)	71.680± 11.2076	54.500± 9.9335	-7.970	<.001**
Ht (cm)	177.408± 6.9154	162.336± 8.167	-9.829	<.001**
BMI	22.706± 2.8223	20.549± 2.713	-3.833	<.001**
BMI z score	1.120± 1.795	0.257± .768	-3.043	<.003**
FVC (L)	115.929± 11.809	108.596± 9.126	-3.396	<.001**
FEV_1 (L)	118.492± 18.998	110.785± 9.049	-2.553	.0.012*
FEV1/FVC%	99.688± 9.376	95.741± 9.775	-2.040	.044*
MEF75 (L)	109.647± 28.741	101.341± 23.833	-1.469	0.145

* Significant at the 0.05 level
** Highly Significant at the 0.001 level

Table 4. Correlations between anthropometric measures and pulmonary function tests (percentage of predicted spirometry values) for total athletic group

		FVC	FEV_1	FEV_1/FVC%	MEF75
age	Pearson Correlation	0.128	0.112	-0.030	0.195
	Sig. (2-tailed)	0.217	0.281	0.788	0.058
wight	Pearson Correlation	0.618*	0.643*	-.0168	0.110
	Sig. (2-tailed)	0.034	0.023	0.130	0.290
Hight	Pearson Correlation	0.726*	0.628*	-0.104	0.078
	Sig. (2-tailed)	0.022	0.027	0.355	0.452
BMI	Pearson Correlation	0.387*	0.346*	-0.176	0.111
	Sig. (2-tailed)	0.025	0.033	0.114	0.286
BMI z score	Pearson Correlation	-.0294	-0.171	-0.012	0.032
	Sig. (2-tailed)	0.084	0.154	0.915	0.760

FVC: Forced vital capacity, FEV_1: Forced expiratory volume in first second,
* Significant at the 0.05 level

, height and BMI than other sports .In concordance with our findings , Lekovic and coleagues 2016[17] showed that swimmers have higher values of weight and height than other sport type such as football. .

Regarding gender, we found a significant difference between males and females' athletes as regards height, weight, BMI, and BMI z- score. These gender differences have been observed in other studies[18, 24] and can be explained by the unequal hormonal system, which is very different between males and females as higher levels of testosterone in males may increase mass of body muscles and consequently body mass index, which provides males with more strength and more weight[25, 26].

Lately, it is documented that characteristics of anthropometry and general motor execution were linked to the execution of particular motor capabilities which are important for match success and general development of players over the developmental years.[43]

Regarding pulmonary function, in our study, we found a significant difference as regards FVC between athletic and non-athletic groups. Furthermore, we found that water polo players had significantly higher pulmonary function particularly FVC and FEV1 compared with other sport types and compared with control group.

This is in agreement with many research that demonstrated a significant difference in parameters of pulmonary function of athletes in comparison to non-athletes[12, 27, 28]. However, little is known in Egyptian athletics.

In water sports, muscles of respiration, comprising swimmer's diaphragm, are needed to make higher pressure, causing from immersion in water through the respiratory cycle, resulting in functional reinforcement of the muscles, along with enhancement in the elasticity of chest wall, causing higher level of lung function. Furthermore, anthropometric features of water polo players are highly associated with high performance levels as explained before, prompting intensive offensive and defensive actions in each playing position[29, 30].

Our results were in accordance with several previous studies that showed significant difference in in FVC, FEV1 and VC, and maximal voluntary ventilation (MVV) between athletic and control group and between water polo players, swimmers and other types of sports[7, 31-34].

Very few studies have showed no difference as regards predicted and measured VC, FVC, FEV1 amongst the studied groups[16].

Parameters of lung function have an association with regular exercise as it causes increase in ventilation as tidal volume and respiratory frequency[35]. Most of studies revealed that FVC and FEV1 were the most affected parameters as explained before. The cause behind this might be that exercise could augment intake of oxygen in muscles of respiration that conduct signals to higher centers that, in sequence, will activate muscles of inspiration and result in potent inhalation and exhalation. This will result in great concentration of surfactant on surface of alveoli that will lessen the surface tension in alveoli and decrease the physiological dead space that additionally increases ventilation and consequently the lung function in athletes[36]. Throughout strong exercise, volume of ventilated air may rise about 10–20 times rather than resting times; though, structure of ventilation system is controlled properly to adapt with great demands of ventilation through such exercises[37].

We documented significant positive correlations between the anthropometric measurements and FVC & FEV1 and non-significant negative correlations between BMI Z-score and FVC & FEV1. Similar findings were demonstrated formerly[7, 38]. This emphasizes the role of anthropometry in selection of athletes particularly in national teams apart from height, weight and BMI. Here are definite measurements that could influence the potential for success in certain sports. It has been stated that values of body fat and body mass are inversely associated with power- and velocity-specific motor capabilities[39, 40].

Sport specific type has an impact on parameters of pulmonary function. For instance, individuals who swim frequently, possess good function of lungs, whereas swimming in water produces pressure on chest wall and furthermore staying in water for a longer time lead to reinforcement of respiratory muscles that, in sequence, can enhance the resistance of airways[41].

The respiratory muscles are designated in such a way that they deal with the increase in the lung ventilation throughout exercise. The diaphragm, the main inspiratory muscle, comprises nearly 60% of slow twitch fibers which possess greater oxidation and blood flow than muscles of hands and legs. As the diaphragm works continually through the lifetime, it requests all these characteristics to work constantly. The utmost significant feature of fibers of respiratory muscles is that they get adapted with physical exercise and training, get changed with disorders of respiration, age and specific drugs for instance corticosteroids and beta-2-agonists[42].

In the era of new respiratory viruses and with the growing number of asthmatic children, it is commended to advise the children principally asthmatic children to take part in regular exercise. In the Covid-19 pandemic, authorities cancelled organized sport, or deferred sport contribution as part of a policy to decrease transmission of the virus. This had an important effect on young athletes and their families with regard to their psycho-social and physical performance. Additionally, many studies emphasize that physical activity enhances immune health and has probable value in prevention of complications of respiratory infections.

CONCLUSION

The current study documented a significant difference in anthropometric measurements between athletes and non-athletes as well as between water polo and other sports. Also regarding pulmonary functions, a significant difference was found between athletes and non-athletes in forced vital capacity and forced expiratory volume in first second, in addition to mid expiratory flow at 75 seconds with water-polo and other sports. Lastly, there were significant positive correlations between the three anthropometric measurements: weight, height and BMI with both FVC & FEV1. Regular exercises impact pulmonary capacity and different morphological characterization.

ACKNOWLEDGEMENTS

The authors would like to thank the National Research Centre for supporting this work.

Limitations of the study

small sample size in our study as well as one visit study protocol. Also there's more value in assessment of body composition parameters such as measurement of : mass of body fat, percentage of fat mass, body fat- free mass and their impacts on pulmonary functions and sports performance.

Strength of the study

The scarcity of research in this field in Egypt.

Recommendation

Our study recommended a large-scale study with multiple visit protocol.

Ethical approval

The protocol of this survey was approved by the Medical Research Ethics Committee of the National Research Centre (Registration number 18-007) .A written informed consent was taken from the parents or guardians of all children enrolled in the study (mothers/or fathers/ or any caregivers). The study was fully voluntary. Participants were well informed about their rights to withdraw at any time. Data was collected in a confidential manner, and it was de-identified, de-linked, and stored in a safe location. All methods were carried out in accordance with the declaration of Helsinki. The conduct of the study complied with the International Ethical Guidelines for Biomedical Research Involving Human Subjects[43].

All procedures performed involving human participants were in accordance with the ethical standards of research involving humans as subjects.

Funding

Non applicable.

Availability of data and materials

The datasets used and/or analyzed for the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

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