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Lung age and respiratory muscle strength in female volleyball players

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SUMMARY

OBJECTIVE: Lung age estimation is a useful approach to determine pulmonary pathologies. In literature, no studies have evaluated and compared lung age in athletes with healthy volunteers. This study aims to compare lung age and respiratory muscle strength in female volleyball players and age-matched healthy volunteers.

METHODS: A total of 18 female volleyball players (22.39±4.97 years) and 20 female healthy volunteers (24.85±3.33 years) were included. Pulmonary functions and respiratory muscle strength were assessed using a spirometer and mouth pressure device, respectively. The lung age was calculated using reference equations associated with gender, height, and forced expiratory volume in 1 second.

RESULTS: Lung age was significantly lower, and forced expiratory volume in 1 L, forced vital capacity, and maximal inspiratory and expiratory pressure (cmH_2O, %) were higher in female volleyball players compared with healthy volunteers ($p \leq 0.05$).

CONCLUSION: The lung age and respiratory muscle strength of female volleyball players were better than healthy volunteers. Regular training in female volleyball players may improve respiratory functions and lung age.

KEYWORDS: Lung. Aging. Respiratory muscles. Athletes.

INTRODUCTION

Lung age estimation is one of the approaches to better understand pulmonary function abnormalities[1]. After the first lung age equation was produced by Morris et al. in 1985[1], many equation varieties have been developed based on age, race, gender, and lung volumes such as forced expiratory volume in 1 second (FEV_1)[2]. Most studies have used lung age estimation for motivational smoking cessation counseling[2,3]. The lung age estimation was also used to estimate postoperative pulmonary complication risk in patients with lung cancer[4]. One study focused on patients with morbid obesity who have higher lung age compared with controls[5].

Increased respiratory muscle strength may result in better performance. Regular evaluation of pulmonary functions and respiratory muscle strength is helpful for maintaining performance in athletes[6]. Respiratory symptoms such as asthma-like symptoms, exercise-induced bronchospasm, and cough are commonly reported in athletes[7]. Lung age is a useful method in detecting respiratory pathologies[4]. Furthermore, pulmonary aging is associated with internal factors such as genetic structure and mutations, systemic changes and inflammations, pulmonary structural changes, and lifestyle and external factors such as environmental exposure. Therefore, evaluation of lung age may provide important information about these factors[8]. In the literature, no studies have evaluated and compared lung age in athletes with healthy volunteers. This study aimed to compare lung age and respiratory muscle strength in female volleyball players and age-matched female healthy volunteers. In this study, we tested the hypothesis that female volleyball players may have later pulmonary aging and better respiratory muscle strength compared to female healthy volunteers.

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METHODS

This was a cross-sectional, retrospective study, in which 18 female volleyball players (22.39±4.97 years) and 20 female healthy volunteers (24.85±3.33 years) who do not follow a regular exercise were included from recorded data during usual care. Participants aged <18 years and who have a history of smoking, COVID-19, and chronic pulmonary disease were excluded. The study was approved by the Ethics Committee of the Gazi University (No. 2021-659).

Demographic characteristics, such as age, weight, height, and body mass index of participants, were regularly recorded during a routine control.

Inspiratory and expiratory muscle strength was measured using a portable mouth pressure device (Micro Medical MicroRM, UK) according to the recommendations from guidelines[9]. The assessments of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were performed at least five times, and the highest value was selected for analysis. The percentages of inspiratory and expiratory muscle strength predicted values were calculated in accordance with reference equations[10].

FEV_1, forced vital capacity (FVC), and FEV_1/FVC ratio were evaluated using a portable spirometer (Cosmed, Class II/Internally Powered Equipment, Italy). The highest value of the measured lung volumes at least three times was selected for analysis. The percentages of the predicted values were calculated based on reference equations[11].

The lung age estimation was calculated based on a reference equation for female adults developed by Newbury et al. The formula: Lung age (years)=1.33×Height (cm)−31.98×ObservedFEV_1−74.65 was used to calculate the lung age of all participants[2].

Statistical analysis

Statistical analyses were performed using SPSS statistical analysis program version 20.0 (SPSS Inc., Chicago, IL, USA). Descriptive variables were expressed as mean difference, 95% confidence interval (95%CI), means (X)–standard deviation (SD), median–interquartile range (IQR), and percentage (%). Shapiro-Wilk test was performed to evaluate the normal distribution of data. Student's t-test, Mann-Whitney U test, and χ^2 test were used to compare normally distributed, non-normally distributed, and categorical variables, respectively. The level of statistical significance was described as p≤0.05. In this study, we planned at least 15 participants in each group based on the results of this study using the lung age estimation values for 95% power (G*Power 3.0.10 system, Franz Faul, Universität Kiel, Germany)[12].

RESULTS

Notably, 18 of 52 players and 20 of 27 healthy volunteers were selected for analysis. As shown in Table 1, demographic characteristics such as age and body mass index were similar in both players and healthy volunteers (p>0.05). As shown in Table 2, lung age was significantly lower, and FEV_1 (L), FVC (L), MIP (cmH_2O, %), and MEP (cmH_2O, %) were higher in players compared with healthy volunteers (p≤0.05). Both MIP and MEP values were below 80% of the predicted values in 3 (16.7%) and 14 (77.8%) players and 9 (45%) and 18 (90%) healthy volunteers, respectively.

DISCUSSION

This is the first study to evaluate and compare lung age in volleyball players with healthy volunteers. This study shows that the lung age was much close to chronological age in players. Inspiratory and expiratory muscle strength in players was better than healthy volunteers without any chronic disease and regular exercise habits.

Lung age provides important practical information to individuals about their pulmonary functions[13]. Although the exact mechanism of lung aging is not known, structural changes,

Table 1. Demographic and clinical characteristics in volleyball players and healthy volunteers.

	Volleyball players (n=18) X±SD/median (IQR)	Healthy volunteers (n=20) X±SD/median (IQR)	p-value
Age, years	22.39±4.97	24.85±3.33	0.079
Weight, kg	67.80 (61.45–71.68)	58.50 (53.25–65.00)	**0.009***
Height, cm	176.50 (171.75–183.75)	165.00 (162.75–168.75)	**<0.001***
Body mass index, kg/m²	21.52±1.64	22.01±2.91	0.539
Sports age, years	12.06±5.96		

SD: standard deviation; IQR: interquartile range. Descriptive analyses were expressed as X±SD and median (IQR) for normally and non-normally distributed, respectively. *Mann–Whitney U test (p<0.05). Statistically significant p-value were written in bold.

genetic predisposition, environmental exposure, inflammation, and chronic diseases have serious effects on pulmonary aging[8]. A lung age greater than the chronological age indicates poorer pulmonary functions[13]. Many studies used it as a motivation tool for counseling of smoking cessation since smoking causes an increased lung age associated with a decrease in FEV_1[1-3,14]. In addition, some studies showed that lung age is a significant predictor in determining postoperative complications and survival[4,13]. Moreover, one study found that lung age is higher in morbidly obese women compared with the control group and is positively correlated with body mass index[5]. The previously mentioned studies have developed different formulas for different ethnicities, ages, and spirometric measurements. However, there is no clear consensus on the most appropriate formula[15,16]. In our study, whether sport improves lung age using the formula developed by Newbury et al.[2] remains the main focus. The current study found that the difference between lung age and chronological age is less in players compared with healthy volunteers. Furthermore, although all participants in groups were nonsmokers, did not have any chronic diseases, and had the same age and body mass index, the lung age of players was better than healthy volunteers. Sports enhance lung growth and pulmonary functions[17]. Therefore, this improvement in players may be attributable to the benefits of physical fitness and steady training.

Previous studies have emphasized better lung function in all athletes compared with nonathletes[18,19]. Contrary to these studies, Mazic et al.[20] found that FVC values of volleyball players were lower than controls and the percentages of FEV_1 values were similar in both the groups. Similar to the results of Mazic et al., the results of our study showed that the percentages of lung volumes were not statistically different in both the groups. In addition, the types of sport, age, height, and weight are associated with pulmonary functions[11,20]. Regular physical exercise improves cardiorespiratory fitness and decreases negative consequences of aging[21]. Better lung age of players may be related to the effects of regular training, and sports may delay lung aging. Other factors affecting pulmonary functions in athletes should be investigated. Respiratory events such as exercise-induced bronchoconstriction and dyspnea were the prevalent reasons for decreased performance in athletes[7]. In addition, lung aging is related to the loss of alveolar tissue, decreased elastic recoil of the lung, and chest wall compliance[22]. The use of the lung age can be an option in determining respiratory problems in athletes.

Exercise training recovers cardiorespiratory fitness and improves muscle performance[23]. In the current study, inspiratory and expiratory muscle weakening was common in healthy volunteers who do not regularly exercise compared with players. Regular training may improve respiratory muscle performance in players involved in our study.

Ohya et al.[24] evaluated respiratory muscle strength in different sports branches and showed that the type of sports has

Table 2. Comparison of lung age, respiratory muscle strength, and pulmonary functions in volleyball players and healthy volunteers.

	Volleyball players (n=18) X±SD/median (IQR)	Healthy volunteers (n=20) X±SD/median (IQR)	Means difference 95%CI/U	p-value
Lung age (years)	27.93±14.02	43.01±7.23	-15.08 (-22.86– -7.29)	**0.001***
Pulmonary function test (L)				
FEV1	4.28 (3.63–4.65)	3.15 (3.02–3.39)	26	**<0.001****
FVC	4.37 (4.13–4.76)	3.72 (3.59–3.98)	82.5	**0.004****
Pulmonary function test (%)				
FEV1	97.50±8.02	94.81±5.97	2.69 (-1.93–7.31)	0.245
FVC	98.22±8.75	97.00±7.66	1.23 (-4.17–6.63)	0.648
FEV1/FVC	98.83±6.25	98.31±5.39	0.52 (-3.31–4.35)	0.784
Respiratory muscle strength				
MIP (cmH_2O)	89.00±19.44	74.15±23.05	14.85 (0.73–28.97)	**0.040***
MIP (%)	95.94±20.04	81.20±25.15	14.74 (-0.34–29.82)	**0.055***
MEP (cmH_2O)	110.11±21.30	90.50±23.14	19.61 (4.93–34.30)	**0.010***
MEP (%)	69.59±13.25	57.69±14.61	11.90 (2.69–21.12)	**0.013***

FEV1: forced expiratory volume in 1 s; FVC: forced vital capacity; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; CI: confidence interval; SD: standard deviation. Descriptive analyses were expressed as X±SD and median (IQR) for normally and non-normally distributed, respectively. *Student's t test (p<0.05). **Mann-Whitney U test (p<0.05). Statistically significant p-value were written in bold.

an impact on MIP in female athletes. Furthermore, the aforementioned study demonstrated that inspiratory muscle strength (74.1 cmH_2O) in volleyball players is lower than other players. Inspiratory muscle strength is higher in athletes playing water sports, as previously reported[20,24]. In our study, inspiratory muscle strength (89 cmH_2O) was higher than that expected in volleyball players and lower than swimmers, as compared with the study by Ohya et al[24]. Predictably, the respiratory muscles and the diaphragm of the swimmers develop more under pressure in water during breathing. Therefore, swimmers have greater lung volumes and inspiratory pressures compared with volleyball players[20]. The inspiratory muscle training substantially improves sports performance by reducing respiratory and limb muscle fatigue, respiratory workload, and attenuating respiratory muscle metaboreflex[25,26]. The effect of inspiratory muscle training on performance in different sports is still unclear. Future studies should be focused on the effect of inspiratory muscle training on performance in different sports.

The limitation of the study is that height and weight of volleyball players due to sportive characteristics were not similar to healthy volunteers.

In conclusion, lung age and respiratory muscle strength in volleyball players were better than healthy volunteers. Sports and steady training may develop these parameters in players. Further studies are needed to investigate the causes affecting lung age in athletes.

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AUTHORS' CONTRIBUTIONS

ZÇ: Conceptualization, Methodology, Data curation, Writing – original draft, Visualization, Investigation. **NAG:** Conceptualization, Methodology, Visualization, Investigation, Supervision, Writing – review & editing. **FY:** Data curation, Visualization, Investigation, Supervision, Writing – review & editing. **NK:** Data curation, Visualization, Investigation, Supervision, Writing – review & editing.

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