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ORIGINAL ARTICLE

Investigating the Impact of Chlorine Exposure on the Respiratory Health of Young Female Swimmers Aged 10 to 15 Years

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K E Y W O R D S

Chlorine;
Respiratory system;
Swimming

A B S T R A C T

Chlorine and disinfectants commonly used in swimming pools to maintain water hygiene and prevent contagious diseases react with substances in the water or the swimmers' bodies to produce toxic gases to the respiratory tract. These gases accumulate significantly in the confined spaces of indoor pools, and their inhalation can lead to respiratory illnesses. Many pools use large amounts of chlorine to prevent diseases, which poses substantial health risks. Studies conducted to date indicate that prolonged exposure to chlorine gas can have adverse effects on swimmers' respiratory systems, including conditions such as asthma, shortness of breath, and chronic bronchitis. Given the vital role of the respiratory system in the human body and the widespread popularity of swimming as a sport, it becomes imperative to understand the impact of disinfectants on the body. This research is significant as it focuses on identifying the harmful effects of chlorine on the respiratory system of professional female swimmers aged 10 to 15 who have been consistently engaged in swimming over the past three years. The findings of this study will contribute to the development of safer swimming environments and the promotion of healthier sports practices.

Introduction

Attention to sports and efforts to promote them among all segments of society are essential due to their beneficial and vital effects. Physical activities enhance human stamina and strength, increasing the capacity to endure stress and anxiety during challenging times. The healthier a person is, the better the heart and lungs can function, enabling prolonged walking, activity, and sports participation, ultimately improving overall performance in various aspects of life. However, sports must be conducted properly and adequately in a healthy environment. Improper or imbalanced physical activities may not only fail to yield benefits but may also lead to illnesses.

Physical exercises are highly beneficial for health, significantly impacting physical and mental well-being. These exercises activate and strengthen all vital systems of the body. A vibrant and energetic state and a well-proportioned and toned physique create an ideal condition for swimmers. This explains the widespread global interest in swimming as a sport that plays a fundamental role in maintaining and enhancing physical and mental health.

Swimming offers numerous benefits to the body. It helps regulate breathing, improves sleep patterns, and stabilizes the cardiovascular system's endurance and blood pressure. Since swimmers must perform in

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water, ensuring the water's quality and cleanliness is paramount. To prevent diseases, pool water must be disinfected, with chlorine being one of the most commonly used methods. Chlorine is added manually or as gas at various intervals. It takes approximately half an hour for chlorine to absorb into the water and two hours to dissipate and spread into the surrounding air. Consequently, swimmers and pool staff inhale this gas, which can adversely affect their respiratory systems and be highly dangerous.

Waterborne diseases affecting swimmers include eye infections, ear infections, skin fungi, and respiratory issues such as asthma and chronic bronchitis caused by chlorine exposure. Current studies indicate that chlorine has adverse effects on swimmers' respiratory systems. This research examines chlorine's impact on athletes' respiratory systems, highlighting the potential risks of inhaling chlorine and its harmful effects. Chlorine gas (chloroform) enters the body through respiration without filtration until it reaches the lungs. Chlorine vapors are known to be a strong irritant to sensitive tissues and bronchial passages within the lungs. These potential risks underscore the importance of understanding and mitigating the effects of chlorine exposure in swimming pools.

This research intends to analyze and assess the impact of chlorine on the respiratory systems of swimmers in pools. To control pathogens in pool water, a disinfectant must be available. The most common disinfectant in pools is chlorine, available in various chemical forms, such as calcium hypochlorite (solid) or sodium hypochlorite (liquid). When these compounds are added to pool water, the chlorine reacts with the water to form various chemical compounds. The most notable of these compounds is hypochlorous acid, which eliminates bacteria and pathogens in the water.

However, the chlorine level in the water must be optimal to effectively eliminate microbes, fungi, and other pathogens while mitigating its risks. The residual chlorine level in pool water under normal, non-epidemic conditions has been recommended by global sources to range from a minimum of 1 mg/L to a maximum of 3.5 mg/L. This range is crucial as it ensures a safe swimming environment by effectively killing harmful microorganisms while minimizing the potential health risks associated with excessive chlorine exposure.

Criterion and standard for chlorine increase

The criterion and standard for increasing chlorine is that the minimum residual chlorine in pool water should be 1 milligram per liter (ppm1 or one part per million). If the residual active chlorine in the pool water is between 2 to 3 milligrams per liter, the living environment of most microorganisms will be destroyed. Given that swimming is a sport favored by most people, and adolescents show a strong interest in pursuing competitive swimming, it is essential to conduct this research to understand the respiratory issues in female athletes who swim competitively over the long term. This issue needs to be examined, and appropriate specialized solutions should be proposed and analyzed to minimize the harmful effects of these chemicals and create a healthy environment for practicing sports. Professional swimming girls aged 10-15 who train in chlorinated pools may negatively affect their respiratory system.

Materials and Methods

This research is a semi-experimental study conducted in May 2013. A group of female professional swimmers, aged 10-15, from Shahroud city, who have regularly trained for over 3 years in chlorinated pools, practicing three sessions of 90 minutes each week, were examined. The control group consisted of girls of the same age who had no exposure to chlorine. Each group consisted of 20 individuals. The samples in both groups were selected randomly, with no preference given to one group over the other. Before starting the study, they will fill out a questionnaire to identify individuals who cannot participate. These participants will be excluded from the study. Spirometry tests will be conducted for both groups. In the athlete group, the respiratory system will be compared with the control group, and differences between the groups will be analyzed using SPSS software and relevant tests. Our research methods' thoroughness ensures our findings' validity and reliability.

Data collection tools and data analysis methods

Before starting the work, the personal details of the participants were collected via a questionnaire. For laboratory equipment, spirometry was performed using the Ponyex spirometer model manufactured by Cosmed. Data analysis was done using descriptive statistics and data correlation with the standard SPSS software to analyze the correlation between variables and all available information.

The variables measured using the spirometer with and without salbutamol spray include:

Forced Expiratory Volume (FEV1)

The maximum amount of air that can be exhaled in the first second of expiration.

Forced Vital Capacity (FVC)

The volume of air that can be exhaled after taking a deep breath with maximum effort.

Peak Expiratory Flow (PEF)

The maximum speed of expiration.

FEV1/FVC

The fraction of the vital capacity that can be exhaled in the first second of expiration.

Forced Expiratory Flow (FEF 25-75%)

A more precise variable for diagnosing early stages of obstructive airway diseases, especially in smaller airways. However, due to natural variability in this parameter among healthy individuals, it should be interpreted cautiously. For example, individuals with smaller-than-normal lungs may exhale a smaller air volume during forced expiration, making them appear less than expected, even if their lung function is normal.

The residual chlorine concentration in the pool water was reported to be approximately 2.30 to 3 mg/L, with a pH of 7.4 to 7.6.

Ethical approval was obtained from the Medical University of Shahrud Ethics Committee, and approval code 04/930 was granted. The study adhered to the 24 ethical codes for protecting human participants in medical research.

In this study, there were two groups: a test group of 20 female swimmers aged 10–15 years who had been training regularly for over three years in chlorinated pools and a control group of 20 females who had not been exposed to chlorine. Spirometry tests were performed on both groups with and without salbutamol spray. The salbutamol spray helps open the bronchial airways and retains more air.

In the first group, the effect of chlorine on the respiratory system of the participants was assessed and compared with the control group.

The participant's age, height, and weight were recorded to perform the test, as these factors influence lung volume and the test outcome.

Measurement methods

Questionnaire: Parents and participants were asked to complete a questionnaire before starting the study. The questionnaire included personal details such as the absence of contact with pets, cigarette second-hand smoke, chemical cleaners, and the absence of illness, particularly colds. A sample of the questionnaire is provided in the appendices. Consent forms were obtained from the participants' families for their cooperation in the study.

Laboratory Equipment: Spirometry was performed with the MIR 3 spirometer, which was made in Italy and approved by the American Thoracic Society (ATS).

Data analysis was performed using SPSS software for descriptive and inferential statistics (correlation coefficient).

Procedure: Participants removed their shoes and stood by a flat wall while their height was measured with a tape measure. For accuracy, specific body points, including the back of the head, shoulders, hips, and ankles, were in contact with the wall.

-Weight was measured using a digital scale (Camry, model JO805179323).

-Spirometry tests were performed on a fixed chair suitable for the participant's age group.

-Tests were conducted under identical conditions for all participants, between 4:00 PM and 8:00 PM, in a well-ventilated room away from chlorine exposure.

-To perform the test, the participant placed the mouthpiece in their mouth, took a deep breath, and exhaled forcefully into the device. The procedure was repeated without interruption. Between 3 to 8 maneuvers were performed for each participant.

Salbutamol Spray Test: After the first spirometry test, salbutamol spray was administered by placing the inhaler in the participant's mouth and pressing it three times to deliver the medication to the bronchi. After 20 minutes, the second spirometry test was performed.

Data analysis

Descriptive statistics such as mean and standard deviation were used for data analysis. The data were analyzed using SPSS version 19 for inferential statistics. Initially, the measured variables FEV1 (Forced Expiratory Volume in 1 sec) FVC (Forced Vital Capacity) etc.) were entered into Excel, and statistical analysis was carried out. For descriptive statistics, the normality of the data was assessed using the Kolmogorov-Smirnov test. For inferential statistics, the t-test was used, considering the normality of the data distribution. Significant differences were observed in some variables and charts, meaning that the probability of an event occurring by chance was very low, indicating a high likelihood of a real cause.

For example, FEV1 was slightly different in the athlete group with and without the spray, but there was no significant difference in the control group.

Data analysis is a crucial part of verifying research hypotheses. Analyzing data is one of the most critical aspects of the research process in studies based on collected information (Table 1).

Table 1. Data analysis

Subjects	Mean age	The standard deviation of the age	Mean Height	The standard deviation of Height	Mean Weight	The standard deviation of Weight
Athletes	12	0.902	155	0.78	45.65	11.403
Non-athletes	11	0.972	150	0.83	43	11.821

After being collected, the raw data are analyzed using statistical techniques and, after processing, are provided in the form of information to the users. In the first section, descriptive statistics are used to examine the demographic variables of the study, including age, height, and weight in the sample.

The second section analyzes the research hypotheses using inferential statistical techniques, such as the mean difference test and other inferential methods. It should be noted that SPSS software was used for data analysis.

The normality test for the variables under study in the athletes is as follows:

-Null hypothesis (H_0): The data are normally distributed (the data come from a normal population).

-Alternative hypothesis (H_1): The data are not normally distributed (the data do not come from a normal population).

Table 2. The Shapiro-Wilk test is used to test the normality of the data distribution among athletes.

Study Groups	Variables	Shapiro-Wilk Test		
		Sig.	**Df**	**Statistic**
Athletes Subjects	weight	0.961	11	0.778
	Height	0.8.89	11	0.173
	Age	0.950	11	0.648

Since the significance levels for the weight, height, and age variables in the athletes' group in the Shapiro-Wilk test are 0.778, 0.173, and 0.648, respectively, and these values are more significant than the error threshold of 0.05, the null hypothesis is accepted. This indicates that the mentioned variables are normally distributed, and there is no significant difference between the two groups.

The Normality test for the studied variables in non-athlete participants

Table 3. Data of the Shapiro-Wilk test for normality of data distribution in non-athlete participants.

Study Groups	Variables	Shapiro-Wilk Test		
		Sig.	**Df**	**Statistic**
Non-athletes Subjects	weight	0.876	11	0.093
	Height	0.955	11	0.708
	Age	0.921	11	0.326

Since the significance levels for the variables of weight, height, and age in non-athlete participants in the Shapiro-Wilk test were 0.093, 0.708, and 0.326, respectively, and these values are greater than the error threshold of 0.05, we accept the null hypothesis, meaning the mentioned variables are normal. There is no significant difference between the two groups. The spirometry test results conducted on both swimmer and non-swimmer groups are presented in the table below.

Table 4. Descriptive Statistics for the Mean and Standard Deviation in the Study Sample

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
FEV1.pre	40	1.75	3.45	2.4428	.06655	.42091
S.FEV1. pre	20	1.91	3.45	2.5960	.10004	.44737
S.FEV1. post	20	2.07	3.68	2.6970	.10217	.45690
NS.FEV1. pre	20	1.75	3.15	2.2895	.07552	.33774
NS.FEV1. post	20	1.80	3.13	2.2990	.07029	.31436
S.FVC. pre	20	2.23	3.94	3.0605	.10570	.47270
NS.FVC. pre	20	2.09	3.79	2.6685	.09709	.43421
S.FVC. post	20	2.21	3.96	3.0845	.12063	.53947
NS.FVC. post	20	2.05	91.80	7.0725	4.46018	19.94654
S.FEV1.FVC. pre	20	72.50	92.20	84.7900	1.24190	5.55394
NS.FEV1.FVC. pre	20	75.60	97.50	86.0850	1.13105	5.05822
S.FEV1.FVC. post	20	75.60	95.60	87.6800	1.15644	5.17175
NS.FEV1.fvc. post	20	75.60	96.30	88.0100	1.05281	4.70832
S.PEF. pre	20	3.59	6.54	4.9225	.18038	.80666
NS.PEF. pre	20	3.16	7.33	4.7210	.24020	1.07419
S.PEF. post	20	3.67	7.08	5.2875	.20686	.92511
NS.PEF. post	20	3.47	7.14	4.9110	.22884	1.02339
S.PEF2575. pre	20	1.62	4.75	3.0095	.19381	.86676
NS.PEF2575. pre	20	1.90	4.64	2.7875	.16182	.72370
S.PEF2575. post	20	1.57	5.63	3.3525	.21722	.97142
NS.PEF2575. post	20	1.87	4.90	2.8800	.16883	.75505

S = Swimmer (Athlete); NS = Non-Swimmer (Non-Athlete)

The table above examines the mean and standard deviation (SD). The normality of the data is determined using the Kolmogorov-Smirnov (K-S) test, and considering the normality of the data, the t-test is applied. The table below analyzes the two groups under study. Since the groups are independent, the T-TEST was used to analyze and interpret the data.

Table 5. T-test scores in the study sample

	F	T	Df	Mean Difference
FEV1. Pre	3.575	2.445	38	.30650
		2.445	35.348	30650
FEV1. Post	2.529	3.209	38	.39800
		3.209	33.695	39800
FVC. Pre	.797	2.731	38	39200
		2.731	37.729	39200
FVC. Post	3.980	-.894	38	-3.98800
		-.894	19.028	-3.98800
FEV1/FVC. Pre	.251	-.771	38	-1.29500
		-.771	37.673	-1.29500
FEV1/FVC. Post	.227	-.211	38	-.33000
		-.211	37.670	-.33000
PEF. Pre	2.078	.671	38	.20150
		.671	35.259	.20150
PEF. Post	.298	1.221	38	37650
		1.221	37.619	.37650
PEF25%75. Pre	1.636	.879	38	.22200
		.879	36.827	.22200.
PEF25%75. Post	1.940	1.717	38	.47250
		1.717	35.819	.47250

As the table above shows, significant differences exist in most of the factors within the statistical samples studied.

Table 6. Spirometry Findings Distribution Among Athlete and Non-Athlete Subjects

Variable	Mean of the Athlete Group	SD	SE	Mean of the Non-athlete Group	SD	SE
FEV1.Pre	2.59	0.4	0.1	2.28	0.3	0.07
FEV1.Post	2.69	0.4	0.1	2.29	0.3	0.07
FVC. Pre	3.06	0.4	0.1	2.66	0.4	0.09
FVC.Post	3.08	0.5	0.1	7.07	19.9	4.4
FEV1.FVC. Pre	84.79	5.5	1.24	86.08	5.05	1.1
FEV1.FVC. Post	87.68	5.1	1.1	88.01	4.7	1.05
FEF. Pre	4.92	0.8	0.1	4.72	1.07	0.2
FEF. Post	5.28	0.9	0.2	4.91	1.02	0.2
FEF25.75. Pre	2.87	0.90	0.2	2.84	0.75	0.2
FEF25.75. Post	3	0.8	0.1	2.88	0.7	0.1

In the table above, the distribution of spirometry findings in athletic and non-athletic subjects has been analyzed. The parameters evaluated include the maximum volume of air that can be exhaled in the first second during forced expiration (FEV1), the volume of air that can be exhaled with maximal effort after a deep inhalation (FVC), the fraction of vital capacity that can be exhaled in the first second during forced expiration (FEV1/FVC), the peak expiratory flow (FEF), and the early obstructive stages of the airways (FEP25-75), both before and after the bronchodilator spray. The mean values for the study groups are presented, along with the standard deviation (SD) and standard error (SE), which estimate the degree of closeness between the sample mean and the population mean.

Table 7. Comparing FEV1 in the athlete group and the control group

variable	Athlete	Non-athlete	P
FEV1Pre	2.59	2.28	0.072
FEV1Post	2.69	2.29	0.023
P	0.048	0.092	

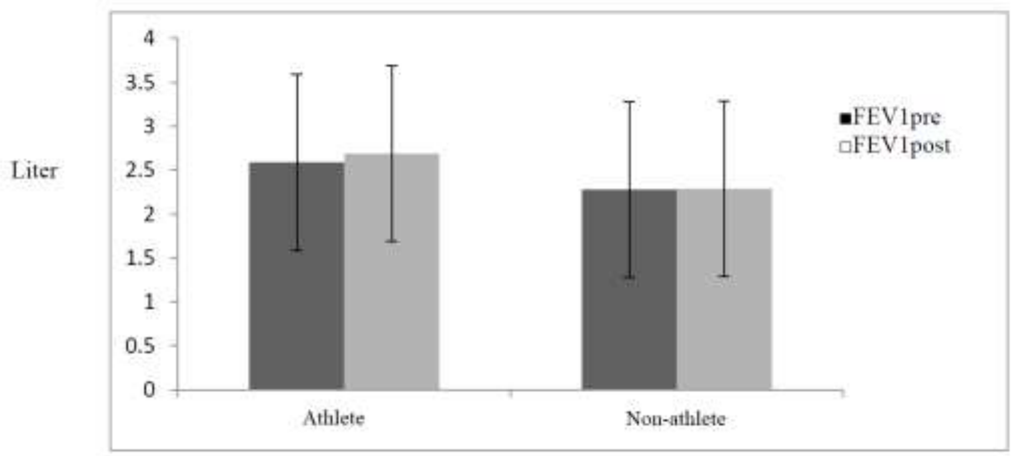

Figure 1. Comparing FEV1 in the athlete group and the control group

The FEV1 (Forced Expiratory Volume in the first second), which is the volume of air that can be exhaled from the lungs in the first second of forced exhalation, was analyzed. The mean, standard deviation (SD), standard error (SE), and P-value indicate that there is no significant difference between the athlete and non-athlete groups. In the athlete group, there is a slight difference between the test with and without the spray, but in the non-athlete group, no such difference is observed (the scale is in liters). The value in the athlete group without the spray is 2.59 ± 0.4 (mean + SD); in the non-athlete group, it is 2.28 ± 0.3. The difference between them is 0.31. In the spray test, the value for the athlete group is 2.69 ± 0.4, while in the non-athlete group, it is 2.29 ± 0.3. The difference between them is 0.4.

Table 8. Comparing FEV1 in the athlete group and the control group

Variable	Athlete	Non-athlete	P
FVC Pre	3.06	2.66	0.052
FVC Post	3.08	7.07	0.0312
P	0.0214	0.071	

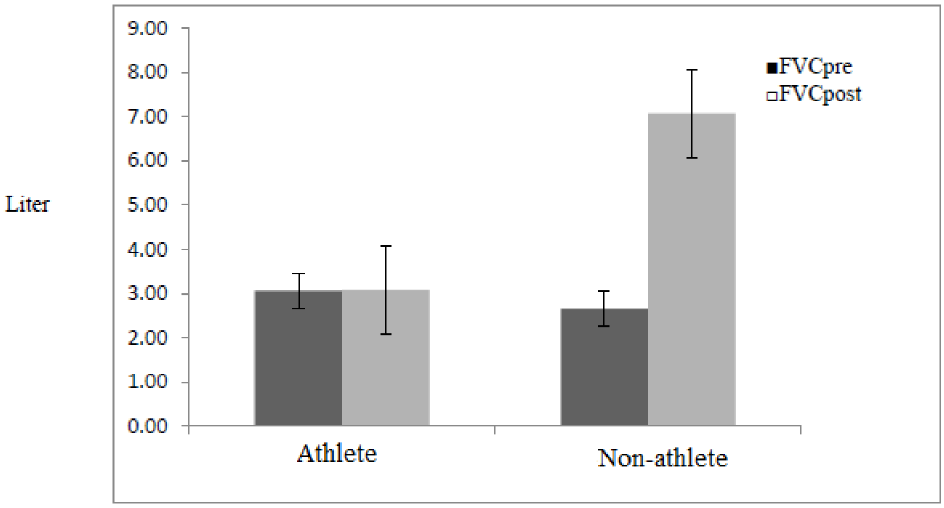

Figure 2. Comparing FEV1 in the athlete group and the control group

FEV1 (the volume of air that can be exhaled in the first second during forced exhalation) was examined. The mean, standard deviation (SD), standard error (SE), and P-value indicate no significant difference between the athlete and non-athlete groups. The test with and without the spray shows a slight difference in the athlete group, but in the non-athlete group, no difference is observed (the values are measured in liters).

The value of the athlete group without the spray is 2.59 ± 0.4 (mean ± SD); in the non-athlete group, it is 2.28 ± 0.3. The difference between them is 0.31. In the spray test section, the athlete group shows a value of 2.69 ± 0.4, and the non-athlete group shows 2.29 ± 0.3. The difference between these values is 0.4.

Table 9. Comparison of FVC (Forced Vital Capacity) in the Athlete and Control Groups

Variable	Athlete	Non-athlete	P
FVC Pre	3.06	2.66	0.052
FVC Post	3.08	7.07	0.0312
P	0.0214	0.071	

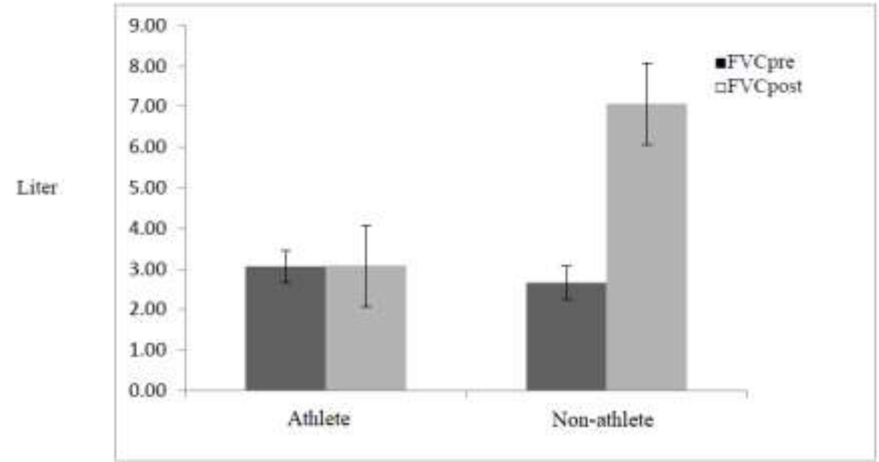

Figure 3. Comparison of FVC (Forced Vital Capacity) in the Athlete and Control Groups

This chart measures the volume of air that can be exhaled from the lungs during a deep breath with maximum effort. Both the depth and the speed of the breath are important in this maneuver.

The chart shows that in the pre-spray test, the athlete group has a value of 3.06 ± 0.4, and the non-athlete group has a value of 2.66 ± 0.4, with a difference of 0.4. In the post-spray test, the athlete group has a value of 3.08 ± 0.5, while the non-athlete group has a value of 7.07 ± 19.9, with a difference of 4.1.

If the p-value is low, it suggests that the observed changes are unlikely to have occurred by chance. Therefore, a real difference between the groups exists, and the observed changes in the data are statistically significant. According to standard conventions, when the p-value is sufficiently small, it indicates a significant difference between the groups and the data. Based on the data obtained in the table below, significant changes are observed in the non-athlete group.

Table 10. Comparing FEV1/FVC ratio in athletes and control group

variable	Athlete	Non-athlete	P
FEV1.FVC. Pre	84.79	86.08	0.086
FEV1.FVC. Post	87.68	88.01	0.011
P	0.0251	0.0954	

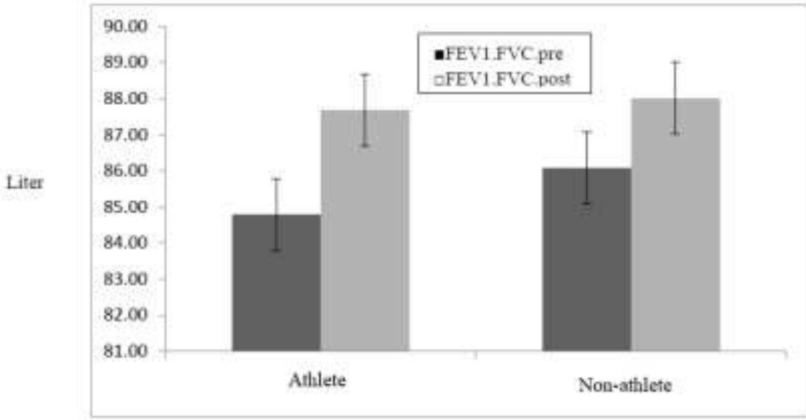

Figure 4. Comparing the FEV1/FVC ratio in athletes and the control group

The table and chart above illustrate the fraction of vital capacity that can be exhaled in the first second of expiration (FEV1/FVC ratio). In healthy young individuals, this ratio is approximately 85%, which decreases with age, and the lowest normal limit is considered to be between 70% and 75%.

According to the obtained P-value, in the test without the spray, the athletes had a mean of 84.79 ± 5.5, while the non-athletes had a mean of 86.8 ± 5.5, with a difference of 1.29. In the test with the spray, the athletes had a mean of 88.01 ± 4.7, and the non-athletes had a mean of 88.01 ± 5.1, with a difference of 0.33. It is observed that in the athlete group, significant changes were observed before and after using the spray.

Table11. Comparing PEF in the Athlete and Control Groups

Variable	Athlete	Non-athlete	P
PEF. Pre	**4.92**	**4.72**	**0.055**
PEF. Post	**5.28**	**4.91**	**0.017**
P	**0.027**	**0.066**	

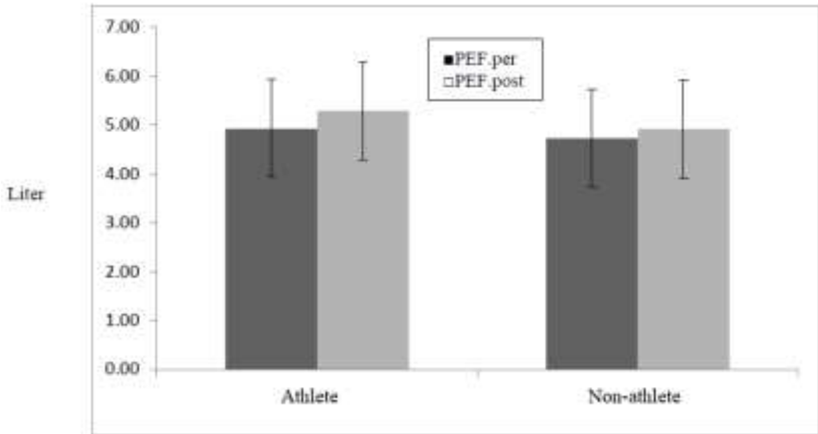

Figure 5. Comparing PEF in the Athlete and Control Groups.

The table and chart above represent the measurement of Peak Expiratory Flow (PEF). During exhalation, a person's airflow rate from their lungs reaches a maximum value, known as the Peak Expiratory Flow rate.

Based on the P-value and the results, in the test without spray, the value for the athletes group is 4.92 ± 0.8, and for the non-athletes group, it is 4.72 ± 1.07, with a difference of 0.2. In the test with spray, the value for the athletes group is 5.28 ± 0.9, and for the non-athletes group, it is 4.91 ± 1.02, with a difference of 0.37. Given the significance level and P-value, a conclusion can be made about the differences between the groups and the data. A significant difference in PEF is observed in the athletes' group before and after the spray.

Table12. Comparing PEF.25.75 in athletes and control groups.

Variable	Athlete	Non-athlete	P
PEF.25.75 Pre	3	2.78	0.099
PEF.25.75 Post	3.35	2.88	0.031
P	0.04	0.069	

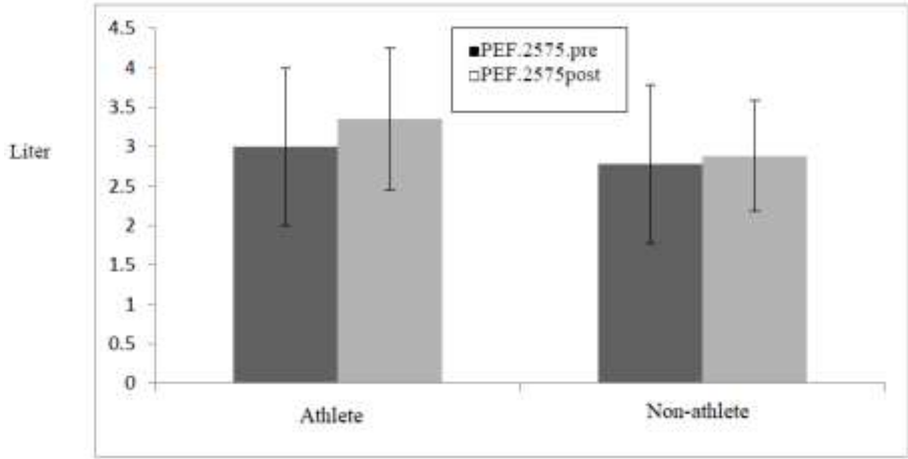

Figure 6. Comparing PEF.25.75 in athletes and control groups

It is a more accurate variable for detecting the early stages of obstructive airway disease, especially in small airways. However, because this parameter varies considerably among healthy individuals, there is no consensus on decision-making based solely on it. For example, in individuals whose lungs are smaller than normal, less air is expelled from the lungs during forced exhalation. Thus, although the lung size may be normal relative to the individual's body, the amount of air exhaled may appear lower than expected. As a result, changes in this index should be interpreted with caution when considered alone.

Based on the P-value, in the test without spray, the group of athletes had a value of 0.8 ± 3.009, and the non-athletes had a value of 0.7 ± 2.78, with a difference of 0.69. In the test with spray, the athletes showed 0.9 ± 3.35, and the non-athletes showed 0.7 ± 2.88, with a difference of 0.47. It can be concluded that the observed changes in the athletes' group are statistically significant. (p=0.4)

The present study aimed to investigate the effect of chlorine on the respiratory system of champion swimmers (girls aged 10 to 15 years).

Discussion and Conclusion

This study aimed to examine the effects of chlorine on the respiratory system of female swimmers aged 10 to 15 who have been exposed to this gas for many years. Studies conducted so far have shown that prolonged exposure to chlorine gas can adversely affect the respiratory systems of swimmers or swimming pool workers. Since the respiratory system is one of the vital and important parts of the body, and swimming is a popular activity for many people, as well as the fact that disinfectants also affect the body, this study is necessary to prevent potential adverse effects and maintain athletes' health.

Spirometry tests with and without salbutamol spray were performed for both groups. The salbutamol spray helped to completely open the bronchi within the lungs, allowing a larger volume of air to be retained. In the first group, the effect of chlorine on the respiratory system of the participants was assessed and compared with the control group, which had no exposure to chlorine. Since age, weight, and lung volume (depending on the size and age of the individuals) play an important role in the test, the participant's age, height, and weight were considered during the testing process. The distribution of spirometry results in athletes and non-athletes was examined in the table. The means of the groups are presented, along with the standard deviation (SD) and standard error (SE), which estimate how close the sample mean is to the population mean.

Additionally, the comparison of FEV1 between athletes and the control group was reviewed in the table. The mean, SD, SE, and P-value indicate that there is no significant difference between the athlete and non-athlete groups. The obtained P-value confirms this relationship when compared with the minimum value. The comparison of FVC between athletes and the control group was also examined in the table, considering both the depth and speed of breathing. The data shows that the difference between athletes and non-athletes in the test without the spray is 0.4, and the difference in the test with the spray is 4.1. If the P-value is low, it suggests a significant difference between the groups and meaningful changes in the data. According to standard practice, the significance level is considered small enough to conclude that a difference exists between the groups and the data, which shows significant changes in the non-athlete group.

The comparison of FEV1/FVC in the athlete and control groups in the table represents the fraction of vital capacity that can be exhaled in the first second of forced exhalation. The difference observed in the test without the spray for the athlete group and the control group was 1.29, and this difference in the test with the spray was 0.33. It is observed that there are significant changes in the athlete group before and after the spray. The comparison of PEF in the athlete and control groups is shown in the table. The difference in the test without the spray between the athlete and control groups is 0.2, and in the test with the spray, the difference is 0.37. Based on the significance level and the P-value, it can be concluded that there is a significant difference between the groups and the data. The PEF level in the athlete group before and after the spray shows a significant difference.

The comparison of 25-75 PEF in the athlete and control groups is also presented in the table. The difference in the test without the spray between the athlete and control groups is 0.69, and in the test with the spray, the difference is 0.47, indicating that the changes observed in the athlete group are significant.

The findings of this study suggest that competitive swimming in female adolescents aged 10-15 years who train in chlorinated pools could potentially harm their respiratory system. The results obtained from data analysis and the research topic are consistent with most studies conducted in this field. This study was conducted on girls aged 10 to 15 who had been training regularly for over three years, three sessions per week, each lasting 90 minutes, in chlorinated pools in the city of Shahrud. The second group consisted of girls of the same age who were not exposed to chlorine.

The mean, SD, and SE in the comparison of FEV1 in the athlete and control groups show no significant difference between the two groups. In comparing FVC in the athlete and control groups, significant changes were observed in the non-athlete group in both the test without and with the spray. In comparing FEV1/FVC in the athlete and control groups, the difference observed in both the test without the spray and the test with the spray for the athlete and control groups indicates significant changes in the athlete group before and after the spray. In comparing PEF in the athlete and control groups, the differences in both the test without the spray and the test with the spray show differences between the groups and the data, with significant differences observed in the athlete group before and after the spray. In the 25-75 PEF comparison, the difference between the test without the spray and the test with the spray between the athlete and control groups shows that the observed changes in the athlete group are significant.

By comparing these groups, it can be said that competitive swimming in female adolescents aged 10 to 15 years who train in chlorinated pools is likely to harm their respiratory system. Studies conducted in this area show that inhaling disinfectant vapors can lead to symptoms like shortness of breath or asthma in swimmers, especially in young children. Breathing in even a small amount of chlorine for a short period can affect the human respiratory system. Chlorine has a varying impact on the respiratory system, including symptoms like coughing, chest pain, or fluid accumulation in the lungs. The amount of chlorine used and the method of its application in pools are crucial in preventing its harmful effects. Chlorine levels in pools should be maintained within standard limits; deviations from this level, either too high or too low, can have detrimental effects. A small amount of chlorine, such as 3.5 PPM in a cubic meter of water, can be identified by its unpleasant odor. Chlorine levels higher than 2 PPM in a cubic meter of water cause only an unpleasant odor but can make breathing difficult. Levels above 3 PPM in a cubic meter, whether in water or air, can cause eye irritation, lung irritation, skin burns, and discoloration of blonde hair. Levels exceeding 5 PPM will result in irreversible damage to the body.

Research suggestions

-Investigate the impact of factors other than disinfectants used in pools on the health of athletes.

-This research should also be conducted on female athletes from other provinces.

-This topic could be examined by gender and age, and the results compared accordingly.

-This research could be conducted in pools that use non-chlorine disinfectants, and the results could be compared with the findings of this study.

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