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Comparing respiratory symptoms and spirometry disorders among healthy people and workers of indoor swimming pools: A case–control study

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Abstract:

BACKGROUND: The water disinfection of swimming pools through chlorination method causes unwanted changes such as chlorine-containing byproducts within the air, which might affect the swimming pool workers' respiratory health. The present study is aimed to determine the frequency of respiratory symptoms and spirometry abnormalities among the workers of indoor swimming pools (instructors and lifeguards).

MATERIALS AND METHODS: The present case–control study was conducted on forty individuals working in indoor swimming pools and forty others working at chlorine-exposure-free jobs as the control group. A questionnaire, including demographic information, smoking information, respiratory symptoms, and years of employment in the swimming pool, was completed for every participant. All the personnel, as well as the participants in the control group, underwent pulmonary examinations and spirometry tests. Then, the obtained data were analyzed using the SPSS 16 software as well as the statistical tests, including *t*-test, Chi-square test, correlation coefficient, and regression analysis.

RESULTS: The mean age of the participants in the case and control groups was 32.3 and 32.5 years, respectively. Both the case and control groups consisted of 18 males (45%) and 22 females (55%). Among the respiratory symptoms, lacrimation, rhinorrhea, sneeze, throat irritation, and chest tightness were significantly higher in the case group than that of the control group (15%, 80%, 35%, 57.5% and 72.5% vs. 0%, 40%, 12.5%, 2.5% and 27.5%, respectively). The pulmonary examinations indicated a statistically significant difference between the two groups in terms of the prevalence of wheeze and rhonchi ($P = 0.014$ and 0.006, respectively). Moreover, showing a statistically significant difference, the forced vital capacity (FVC) and forced expiratory volume in 1 s/FVC indicators were lower in the case group than the control group ($P = 0.04$ and 0.016).

CONCLUSION: Regarding the findings, there was a direct relationship between working in indoor swimming pools and the prevalence of respiratory symptoms and pulmonary dysfunction.

Keywords:

Chlorine compounds, respiratory symptoms, spirometry, swimming pools

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Introduction

Swimming pools are commonly disinfected by water chlorination. Chlorine-based substances (chloroisocyanurate, hypochlorite, and chlorine gas), which are mainly considered chlorine, release a nonspecific bio acid known as hypochlorous into the water that is capable to oxidize any

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organic matter in a swimming pool. Chloramines, which are one the most irritant hypochlorous acid byproducts, are formed following a reaction between chlorine and nitrogen-containing substances.

Despite monochloramines and dichloramines (NHCl2 and NH2Cl) which are water soluble, trichloramine (NCL3), also called nitrogen trichloride, is a water-insoluble gas and the most volatile chloramine which provides pools their typical chlorine aroma, and it can cause asthma in lifeguards and instructors in indoor swimming pools.

Numerous studies have done to determine high-risk occupations persuading respiratory diseases. Respiratory and allergic diseases, including bronchial hyperresponsiveness and asthma, are more prevalent in lifeguards due to high exposure to chlorine and also exposure to chlorine can cause asthma, acute lung edema, and destruction of the upper and lower airway mucosa.

Respiratory symptoms are commonly observed, usually among children, lifeguards, pool staff, and swimmers who are regularly exposed to chlorine in indoor swimming pools.[1]

Exposure to high levels of chlorine gas causes some side effects, including inflammation of the upper and lower respiratory tract, dyspnea, rhonchi, wheeze, chest tightness, lacrimation, rhinorrhea, coughing and phlegm, sneeze, throat irritation, as well as skin symptoms such as itching, eczema, and various types of dermatitis.[2] The incidence of such side effects depends on the frequency of respiratory contacts and duration of exposure.

The World Health Organization has identified the potential risks associated with amusement water parks, including infections caused by the microbes associated with feces and *Protozoa* (such as giardia and *Cryptosporidium parvum*).[3]

Imperfect removal of these biological compounds leads to an increased risk of asthma. Therefore, it can be claimed that there is a wide range of various compounds in the water of swimming pools that may increase the risk of respiratory diseases.[4]

In addition to the medical history and clinical examinations, spirometry is among the widely used screening methods for occupational lung diseases. The main purpose of screening spirometry in the case of exposure to the occupational harmful factors is the early diagnosis of lung dysfunction before the emergence of clinical symptoms at early and controllable stages.[5]

Scarce studies have been done to determine the work-related respiratory symptoms among lifeguards as compared to healthy people. The present study is aimed to determine the frequency of respiratory symptoms and spirometry disorders among the indoor swimming pool workers (instructors and lifeguards).

Materials and Methods

The present case–control study was conducted during October 2017–January 2018. The case group consisted of the participants randomly selected from among the lifeguards and instructors of four indoor swimming pools in Qazvin Province, and the control group included the individuals from the whole community working at jobs without harmful respiratory exposure, who were the matched as the case group in terms of mean age, gender, education, history of smoking, and history of respiratory diseases. The control group was recruited from patient's companion attending to Velayat Hospital, Qazvin. Each participant signed informed consent after a brief explanation regarding the purpose and methods of the study. Given the noninvasive setting of the present study, no ethical approval was required according to Iranian law.

The inclusion criteria included having at least 1-year history of employment in swimming pools for at least 5 days a week. Furthermore, smoking, history of employment at jobs with respiratory contaminants, and diagnosed pulmonary disease were considered the exclusion criteria.

The questionnaire addressed the demographic characteristics, history of smoking, symptoms emerging after the presence at swimming pools such as respiratory symptoms (throat irritation, coughing and phlegm, sneeze, rhinorrhea, dyspnea, and chest tightness), and job background (years of employment and previous jobs), which was completed by a physician for both case and control groups through face-to-face interviews. Moreover, the clinical examinations, including chest examination for wheeze (high-pitched, coarse whistling sound) and rhonchi (rattling, continuous, and low-pitched breath sound) as well as crackles (crepitant rale a fine sound like that of rubbing a hair between the fingers or by particles of salt thrown on fire; heard at the end of inhalation), cardiac examination for rejecting dyspnea and cardiac causes, and pharyngeal examination for throat secretions and redness, were performed by an expert physician.

The pulmonary function tests were performed by a spirometry technician is Velayat Hospital – who was blinded to the type of groups – on all the swimming pool workers using Spirometer (CHEST M.I.,INC.JAPAN) (HI-9801) device in accordance with the principles recommended by the American Thoracic Society, the results of which were interpreted by a lung specialist.

The obtained data were analyzed using the SPSS software version 16 as well as statistical tests including *t*-test, Chi-square test, and Pearson's correlation coefficient. The statistical significance level was considered 0.05 in all statistical tests.

Results

In the present study, the case group consisted of forty lifeguards and instructors working at forty indoor swimming pools, and the control group included forty individuals from the community working at jobs without harmful respiratory exposure. The mean age of the participants in the case and control groups was 32.3 ± 7.9 and 32.5 ± 8 years ($P > 0.05$), respectively. The working duration in the swimming pools was 34.2 ± 27.2 months (12–110 months), with an average of 41 h per week.

Both case and control groups consisted of 18 males (45%) and 22 females (55%). In the case group, 27 participants (67.5%) were working only in the swimming pool with no second job. The prevalence of respiratory symptoms along with the results of pulmonary examinations for both control and case groups is reported in Table 1. Out of the respiratory symptoms, lacrimation, rhinorrhea, sneeze, throat irritation, and chest tightness were of higher prevalence in the case group than the control group, indicating a significant difference between the two groups in this regard.

As for the pulmonary function indicators, the forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1)/FVC indicators in the case group were significantly lower than the control group [Table 2]. As indicated by the comparison of the spirometry patterns, only two of the lifeguards had an obstructive pattern, and the rest in this group along with the whole control group were in the normal status.

As inferred from the investigation of the correlation between the years of employment and spirometry changes, the longer the history of employment, the lower the FEV1/FVC indicators would be [Table 3]. Furthermore, with regard to the relationship between years of employment and changes in the prevalence of respiratory symptoms, it was found that the increased job background of the lifeguards led to the significantly increased prevalence of coughing and phlegm, throat irritation, and rhonchi [Table 4].

Table 1: Comparing the prevalence of respiratory symptoms based on the lung examinations and respiratory symptoms in the control and case groups (*n*=40)

Variable	Group		*P*
	Case, *n* (%)	Control, *n* (%)	
Symptoms			
Lacrimation	6 (15)	0	0.011
Rhinorrhea	32 (80)	16 (40)	<0.001
Sneeze	14 (35)	5 (12.5)	0.018
Coughing and phlegm	15 (37.5)	17 (42.5)	0.64
Throat irritation	23 (57.5)	1 (2.5)	0.001
Chest tightness	29 (72.5)	11 (27.5)	<0.001
Dyspnea	15 (38.5)	13 (32.5)	0.58
Red eye	1 (2.5)	1 (2.5)	1
Throat redness	9 (22.5)	6 (15)	0.39
Throat secretions			
Examination findings			
Wheeze factor (lung examination)	13 (32.15)	4 (10)	0.014
Rhonchi (lung examination)	7 (17.5)	0	0.006
Crackle	0	0	1
Obstructive pattern	2 (5)	0	0.15

Table 2: Comparing mean values of pulmonary function indicators in the case and control groups (*n*=40)

Variable	Group (mean±SD)		*T*	*P*
	Case	Control		
FEV_1	82±7.8	84.15±3.9	1.56	0.12
FVC	**106.8±14.7**	**114±15.8**	2.11	0.04*
PEF during expiratory maneuver	**99.2±19.3**	**107±19.3**	1.8	0.059
FEF 25-75	**89±25.3**	**97.2±17.4**	1.68	0.091
FEV_1/FVC	**0.95±0.08**	**0.99±0.05**	2.68	0.016*

Statistical significance was determined in bold/*t*-test was applied for data analysis. FEV_1: Forced expiratory volume at 1 s, FVC: Forced vital capacity, PEF: Peak expiratory flow, FEF: Forced expiratory flow, SD: Standard deviation

Discussion

Based on the results of the present study, the respiratory symptoms and spirometry disorders showed higher prevalence among the workers of indoor swimming pools than the control group. Regarding the respiratory symptoms and pulmonary examinations, the two groups exhibited significant differences only in the variables of lacrimation, rhinorrhea, sneeze, throat irritation, chest tightness, and wheeze factor. Moreover, the two groups were shown to be significantly different in spirometry indicators (FVC and FEV1/FVC ratio). Besides, it was found that the longer duration of chlorine gas exposure and the presence in the swimming pool would lead to a higher prevalence of respiratory symptoms.

According to Goyder's study on the correlation respiratory symptoms and duration of working in the swimming pool, the prevalence of ocular symptoms (79%) and throat irritation (71%) among these participants 6 days after the exposure was higher than the respiratory symptoms.[6] The results of this study were different from those of the present work, one of the reasons of which could be that the symptoms were

Table 3: Correlation between years of employment and spirometry indicators in the case group

Variable	Correlation coefficient	95% CI	*P*
FEV_1	−0.296	57.8-106.1	0.064
FVC	0.169	102.2-111.3	0.298
FEV_1/FVC*	−0.399	0.92-0.97	0.011
PEF during expiratory maneuver	0.083	93.2-105.1	0.609
FEF 25-75	−0.174	81.1-96.8	0.283

FEV_1: Forced expiratory volume at 1 s, FVC: Forced vital capacity, PEF: Peak expiratory flow, FEF: Forced expiratory flow, CI: Confidence interval

Table 4: Relation between years of employment and the prevalence of respiratory symptoms in the case group

Respiratory symptoms	Years of employment		*P*
	Below 24 months (*n*)	≥24 months (*n*)	
Coughing and phlegm	5	10	0.033
Rhonchi	3	9	0.013
Throat irritation	9	14	0.019
Chest tightness	16	13	0.97
Dyspnea	7	8	0.41

The Chi-square test was applied for data analysis

investigated following acute exposure to chlorine gas, and also the individuals with a history of smoking and allergies were not excluded from this study.

In a study by Jacobs *et al*., in 2007, on the correlation between the NCL3 gas exposure and respiratory symptoms among the workers of indoor swimming pool, the results showed that the higher number of employment years would lead to the higher prevalence of respiratory symptoms.[7] Similarly, the present study showed a direct relationship between the prevalence of symptoms and years of employment.

In a native cognitive study by Bernard *et al*. throughout Europe, on the relationship between the prevalence of asthma among children in developed countries and chlorine gas exposure in indoor swimming pools, the obtained results showed the increased prevalence of wheeze among those children using indoor swimming pools.[8] In the present study, notwithstanding the different mean ages of the case and control groups, the prevalence of wheeze was observed to be higher in the case group than that of the control group.

Parrat *et al*. conducted a study in 2011 to investigate the pulmonary effects of NCL3 exposure on the swimmers and staff in the indoor swimming pools. The obtained results showed the higher prevalence of the symptoms, including coughing, rhinitis, dyspnea, chest pain, sinusitis, eye inflammation symptoms, and skin symptoms (itching, eczema, redness, and dry skin) in the case group compared to the control. Also for the mentioned symptoms was incremental for higher cumulative exposure levels (which was defined by combining the ratio of professional activity, measured NCL3 concentration, and the time spent working in potentially NCL3-contaminated areas).[9] These results were approved by those of the present work. However, in Parrat *et al*.'s study, the case and control groups did not have the same mean age, and also the participants with a history of smoking and allergies were not excluded from the study.

In Boskabady *et al*.'s investigation on the effects of chlorine gas exposure on lung function and respiratory and allergic symptoms among male lifeguards in the indoor swimming pools, the prevalence of symptoms, including phlegm, dyspnea, as well as allergic symptoms such as rhinorrhea, was shown to be significantly higher in the case group than the control group. Besides, the spirometry parameters, including maximal expiratory flow and peak expiratory flow (PEF) in the case group exhibited a significant reduction as compared to the control group. In Boskabady *et al.'s* study, all the participants in the case group had at least one of the respiratory symptoms and the symptoms demonstrated higher prevalence. This could be attributed to the point that only the male lifeguards were included in the study, and the required job background for the case group was only 1 year.[10] However, in the present work, the mean of employment years was 1 year, and both male and female lifeguards were included. In addition, among the pulmonary function indicators, the two groups demonstrated a significant difference in terms of FVC and FEV1/FVC indicators, which were lower in the case group than the control group.

In this regard, another research was conducted by Fantuzzi *et al.* in Italy as a cross-sectional study with a focus on the prevalence of eye, skin, and respiratory symptoms among the workers of indoor swimming pools exposed to water chlorination byproducts. According to the results of this study, the symptoms exhibited a higher prevalence among the lifeguards than the staff working in other parts of the pools, and 7.5% of the participants had no symptoms.[11] However, in the present study, all the participants in the case group had at least one of the respiratory or ocular symptoms. Such a difference could be due to the point that the case group in the present work consisted only of the lifeguards, and other employees were not taken into consideration.

Another study on this area of subject, which was conducted in 2009, addressed the effect of swimming on the PEF rate among atopic children, according to the results, of which 34 participants (35.4%) in the case group were shown to have at least one of the measures of asthma or any type of atopic diseases. In general, the results of this study demonstrated that swimming in the chlorinated indoor swimming pools not only

did not lead to the exacerbated asthma symptoms but also could improve the asthmatic patients' pulmonary function.[12] The results of the present work showed the higher prevalence of symptoms among the lifeguards compared to the ordinary people in the society (those with no chlorine gas exposure). Therefore, one of the reasons for such a difference between the results of these two studies might be lack of history of asthma among the participants of the case group.

In a case–control study in Brazil, the researchers investigated the prevalence of respiratory symptoms and reduced pulmonary function among adolescent swimmers using the ISAAC questionnaire. The spirometry test results indicated FEV1/FVC <0.75 39 participants. However, in the present study, the FEV1/FVC ratio in the case group was lower than that of the control group but not lower than 0.75. Such a difference between the results could be attributed to the difference of the two studies in terms of the mean age of participants in the case group.[13] One of the limitations of the present study was that we did not consider the job of the control group, although none of them has exposure to chlorine in their working environment. Moreover, we did not evaluate the symptoms during weekends or holidays, it was due to lack of patients' cooperation.

Conclusion

Based on the observations in the present study, the use of chlorine-based products for swimming pool water disinfection causes unwanted problems, including the emergence of chlorine-containing byproducts within the air. Accordingly, chlorination might affect the swimming pool workers' respiratory health.[4,7] Chlorine added to water in the swimming pools is combined with the secretions of swimmers, including urea, saliva, and sweat as well as their hair, lotions, cosmetics, sunscreens, and skin particles, and results in a harmful compound for human health, known as chloramines, which causes burning effects on the respiratory system in indoor swimming pools.[3]

Particular attention to the respiratory health of the workers of indoor swimming pool and competitive swimmers is one of the simplest measures that can be taken to reduce the respiratory tract dysfunction among this population with minimum financial costs. However, it is necessary to conduct further studies to perceive the effect of such disorders on athletic performance as well as the swimmers' health during and after the end of their occupational period.

Data availability

The statistical data used to support the findings of this study are included in the article.

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Conflicts of interest

There are no conflicts of interest.

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