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Evaluation of exercise-induced bronchoconstriction and rhinitis in adolescent elite swimmers

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ABSTRACT

OBJECTIVE: Exercise-induced bronchoconstriction (EIB) without asthma and non-allergic rhinitis is frequently reported in athletes who are facing high-risk of airway dysfunctions such as elite swimmers. Therefore, we aimed to evaluate the effect of exercise on nasal and pulmonary functions, additionally to determine the prevalence of EIB and rhinitis in adolescent elite swimmers.

METHODS: The study included 47 adolescent licensed-swimmers (26 males and 21 females) aged between 10 and 17 years old. The prevalence of asthma and allergic disease and the symptom severity scores measured before and after swimming training were assessed through an interview form which includes information related to our study goal. In addition, acoustic rhinometry was utilized to evaluate nasal airway, spirometry was utilized to evaluate EIB in accordance with standard protocols.

RESULTS: Six swimmers had a history of allergic rhinitis (12.8%), while three (6.4%) had asthma. Post-swim mean forced vital capacity (FVC) was significantly higher than pre-swim FVC (p=0.019) and forced expiratory volume 1 (FEV-l)/FVC ratio was significantly lower than pre-swim FEV-l/FVC ratio (p=0.034). In addition, the prevalence of EIB was 8.5%. Moreover, level of nasal discharge statistically increased in post-swim period (p=0.003).

CONCLUSION: We have documented that swimming cause's nasal discharge but do not effect nasal passages. In addition, we observed that the overall prevalence of EIB in swimmers was not different from that of the general population, furthermore swimming exercise significantly increased FVC of swimmers. Therefore, we concluded swimming training can be recommended for children diagnosed with asthma or allergic rhinitis.

Keywords: Exercise; exercise-induced bronchospasm; nasal symptoms; pulmonary functions; rhinitis; swimmers.

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Airway dysfunction is one of the most common medical issues reported in athletes (8% among Olympic athletes). The incidence increases up to the rate of 76% in athletes with high risk such as elite swimmers who undergo high volume and intensity training in chlorinated pool for a long period of time [1, 2]. Similarly exercise-induced bronchoconstriction (EIB) without asthma and non-allergic rhinitis is frequently documented in swimmers [3, 4].

EIB is bronchospasm induced by intense physical activity. EIB typically begins in a few minutes after physical activity, and continues until the normalization of bronchial tone within 30–60 min during rest and it is defined as a temporary airflow obstruction without diagnosis of asthma after exercise. Thus, it is different from the exercise-induced asthma (EIA), which is an asthma symptom that occurs after exercise

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[5, 6]. Although increased parasympathetic activity have been documented in these athletes compared to sedentary individuals, the pathophysiology of EIB is not clearly defined yet [4]. Besides, osmolar (airway drying) and vascular (thermal) hypotheses are being debated to explain exact mechanism of EIB and EIA. Both are based on the increased loss of water and heat through respiration due to increased ventilation during exercise [7, 8]. The prevalence of EIB varies between 5% and 20% in the general population and reported more frequently in adolescents [9].

Athletes who undergo intense training regimens should be tested with spirometry and bronchial provocation tests even without history of disease [5]. Swimmers have larger "Forced Vital Capacity (FVC)" and greater one second "Forced Expiratory Volume (FEV)" compared to other athletes with a higher ventilation rate [10, 11]. Supportively, horizontal swimming position simplifies air to enter the upper part of the lungs, thus vital capacity improves more in swimming than other branches [12]. In addition, EIB is characterized by a decrease of FEV in a second ≥10% [5].

Elite athletes frequently suffer from non-allergic nasal symptoms, moreover the incidence increases up to 74% in elite swimmers with additional chlorine exposure [3]. Therefore, we aimed to evaluate the effect of exercise on nasal and pulmonary functions, additionally to determine the prevalence of EIB and rhinitis in adolescent elite swimmers.

MATERIALS AND METHODS

Sample

This study was performed with the approval of Ethics Committee of Sisli Hamidiye Etfal Training and Research Hospital with the approval number of 484 at the date of April 28, 2015. The study included 47 adolescent licensed-swimmers (26 males and 21 females) aged between 10 and 17 years old in swimming department of a private sports club, after obtaining the necessary permits from the club management. Participants were enrolled in this study after obtainment of written informed consent from at least one of the parents. Detailed history and nasal examinations were carried out to all of the potential participants. Swimmers with nasal cavity mass, nasal polyposis, and adenoid vegetation were excluded from the study. Allergic rhinitis diagnosis was based on history and nasal examination, laboratory test was not performed. The study was conducted in 2 phase as a questionnaire and test section.

Highlight key points

- Swimming exercise can cause an increase in nasal discharge but has no effect on nasal congestion, sneezing and olfaction after exercise period.
- Swimming exercise causes significantly increased FVC.
- In swimmers, overall prevalence of EIB is not different from general population.
- Swimming can be a reliable sport for adolescents diagnosed with asthma or allergic rhinitis.

Swimmer Assessment Questionnaire

This self-reported assessment is designed to evaluate the prevalence of asthma and allergic disease, and the symptom severity scores were measured before and after swimming training. The questionnaire includes questions regarding exercise duration, intensity of training and medical history, including nasal congestion, nasal discharge, sneezing, and olfaction before and after swimming training. The severity of symptoms was assessed through a self-report scale. Each scale was scored between 0 (no symptom) and 10 (severe symptom).

Measurements

Acoustic rhinometry was performed through Rhinometrics SRE 2000 (Rhinometrics, Lynge, Denmark) in the 10th min of pre- and post-training period. The rhinometer was calibrated and conducted in sitting position based on manufacturer's recommendations. At least three measurements were performed for each nasal cavity. The nasal volumes (Vol 1–2), total nasal volumes (Tvol 1–2), distances (Dist 1–2), and minimal cross-sectional areas (MCA 1–2) were obtained by rhinometric measurements in both nasal cavities while the subject was in apnea after a non-forced expiration.

Spirometry was performed through portable KoKo Legend spirometer (nSpire Health, Longmont, CO, USA) according to American Thoracic Society recommendations in the 10th min of pre- and post-training period. Spirometry was conducted in sitting position based on manufacturer's recommendations and subjects performed a maximal inspiration followed by a maximal expiration to measure FVC, FEV in 1 s, FEV1/FVC ratio, and peak expiratory flow (PEF). EIB was evaluated in accordance with standard protocols by spirometry.

Table 1. Evaluation of acoustic rhinometry in pre- and post-swimming training period

	Mean±SD	Median	Interval between quarters	
			25% percentile	75% percentile
VOL1-Left				
Before training	1.59±0.34	1.54	1.35	1.82
After training	1.60±0.36	1.61	1.37	1.79
p-value	0.912			
VOL1-Right				
Before training	1.67±0.36	1.61	1.47	1.92
After training	1.62±0.33	1.56	1.39	1.88
p-value	0.250			
VOL2-Left				
Before training	4.19±1.89	4.11	2.66	5.20
After training	4.42±2.05	3.94	2.97	6.00
p-value	0.421			
VOL2-Right				
Before training	4.92±1.86	4.72	3.52	5.98
After training	4.34±1.75	4.01	3.01	5.37
p-value	0.127			

SD: Standard deviation; VOL: Volume.

Table 2. Evaluation of spirometri in pre- and post-swimming training period

	Mean±SD	Median	Interval between quarters	
			25% percentile	75% percentile
FVC%				
Before training	110.02±14.56	112	103	117
After training	113.77±17.28	113	104	122
p-value	**0.019***			
FEV1%				
Before training	102.87±11.78	103	96	110
After training	102.66±13.47	104	93	112
p-value	0.797			
FEV1/FVC				
Before training	102.13±7.53	102	98	108
After training	99.51±9.34	101	93	107
p-value	**0.034***			
PEF				
Before training	86.53±16.70	84	77	95
After training	86.49±14.82	87	78	94
p-value	0.978			
FEF 25–75				
Before training	103.36±21.14	100	87	115
After training	99.85±23.36	96	79	121
p-value	0.091			

*: P<0.05 statistically significant; FVC: Forced vital capacity; FEV: Forced expiratory capacity; PEF: Peak expiratory flow; FEF: Forced expiratory flow; SD: Standard deviation.

Statistical Analysis

All of the data were analyzed with SPSS (Statistical Package for the Social Sciences) software for Windows (v21.0; IBM, Armonk, NY, USA). Individual and general data were summarized using descriptive statistics including mean, standard deviation, median (min–max), frequency distributions, and percentages. Comparison of the dependent variables with normal distribution was made with Paired Sample T test. For the continuous variables that were not normally distributed, the Wilcoxon test was conducted to compare groups. Presence of correlation was analyzed with Spearman's Rho and Pearson tests. $P<0.05$ was considered statistically significant.

RESULTS

In this study, 47 adolescent swimmers were included, of which 26 (55.3%) were male and 21 (44.7%) female with the mean age of 13.4±1.6 (Ranged=10–17 years). The mean age of swimming onset was 8.1±1.8 (Ranged=5–13 years) years. The total pool exposure was found to be as 63.3±23.2 months (Ranged=24–132 months) and 5033.0±2465.5 h (Ranged=960–13824 h) for swimmers. Six swimmers had a history of allergic rhinitis (12.8%), four (8.5%) atopic dermatitis while three (6.4%) were diagnosed with asthma.

There was no statistically significant difference according to the acoustic rhinometry before and after training (Table 1). According to the results of spirometric evaluations; after swimming training, mean FVC (113.77±17.28) was significantly higher than pre-swim FVC (110.02±14.56) and post-swim. FEV-l/FVC ratio (99.51±9.34) was significantly lower than pre-swim FEV-l/FVC ratio (102.13±7.53) (p=0.019 and 0.034, respectively) (Table 2).

According to the results of symptom severity assessment; the level of nasal discharge significantly increased after swimming training (2.04±2.52) when compared to the pre-swim (1.11±1.94) nasal discharge level

Table 3. Evaluation of symptoms in pre- and post-swimming training period

	Mean±SD	Median	Interval between quarters	
			25% percentile	75% percentile
Nasal conges-tion				
Before training	1.87±2.55	0	0	4
After training	2.28±2.53	1	0	4
p-value	0.246			
Nasal dis-charge				
Before training	1.11±1.94	0	0	1
After training	2.04±2.52	0	0	4
p-value	**0.003***			
Sneeze				
Before training	0.79±1.92	0	0	1
After training	0.79±1.73	0	0	1
p-value	0.687			
Olfaction				
Before training	0.30±0.93	0	0	0
After training	0.19±0.54	0	0	0
p-value	0.339			

*: P<0.05 statistically significant; SD: Standard deviation.

(p=0.003). On the contrary, there were no statistically significant differences found according to the nasal congestion, sneezing, and olfaction before and after training period (Table 3). Similarly, there was no statistically significant correlation between pre- and post-training differences in rhinometry and spirometry evaluations (Table 4).

Table 5. FEV, PEF, and FEF25_75 percent change assessments in spirometric evaluations

	Mean±SD	Minimum	Maximum
FEV percent change	0.26±5.43	–10.31	12.87
PEF percent change	–1.21±14.08	–53.57	25.29
FEF percent change	2.41±8.05	–13.27	22.68

*: P<0.05 statistically significant; FEV: Forced expiratory capacity; PEF: Peak expiratory flow; FEF: Forced expiratory flow; SD: Standard deviation.

The FEV, PEF, and FEF 25–75% of change in spirometry assessments are summarized in Table 5. Only four cases (8.5%) showed a decrease of more than 15% in PEF. Thus, the prevalence of EIB was determined as 8.5% in our study. In addition, only one of all cases with exercise related-bronchospasm had a history of allergic rhinitis.

DISCUSSION

During exercise, mucosal decongestion occurs due to adrenergic effect and after exercise congestion develops with parasympathetic effect [13]. In the lower respiratory tract, bronchodilatation and increase in minute inhalation volume occurs during exercise, but in the middle of the exercise or after the exercise, bronchoconstriction and exercise related bronchospasm arise [14]. In addition, environmental factors such as temperature, quality of air, humidity, and intensity of exercise are effective in inducing bronchoconstriction during exercise [1, 2, 6]. Therefore, upper and lower respiratory tract should be examined together in swimmers with high volume and

Table 4. Comparison of spirometry and rhinometry outcomes

	After training							
	VOL1 Left odd		VOL1 Right odd		VOL2 Left odd		VOL2 Right odd	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
FVC odds	0.108	0.468	0.164	0.271	0.038	0.798	–0.037	0.803
FEV1 odds	0.164	0.270	0.176	0.238	0.141	0.346	0.083	0.578
FEV1/FVC odds	0.040	0.790	0.081	0.587	0.021	0.889	0.138	0.354
PEF odds	–0.256	0.083	–0.036	0.809	–0.050	0.740	–0.122	0.415
FEF25–75 odds	0.164	0.270	0.103	0.492	–0.037	0.806	0.080	0.594

FVC: Forced vital capacity; FEV: Forced expiratory capacity; PEF: Peak expiratory flow; FEF: Forced ex-piratory flow; SD: Standard deviation; VOL: Volume.

intensity training in chlorinated pool for a long period of time. Thus, we have evaluated the effect of swimming exercise on the upper respiratory tract through assessment of self-report questionnaire, on both upper and lower respiratory tract through spirometry and nasal passage assessment with acoustic rhinometry. Adolescent athletes are more frequently and dramatically affected by airway dysfunctions such as EIB, EIA, non-allergic rhinitis, and airway hyperactivity during exercise than adults [6]. Therefore, the present study included 47 adolescent licensed-swimmers aged between 10 and 17-years-old. In addition, the mean age of swimmers was 13.4±1.6 years and the mean age of swimming onset was 8.1±1.8 years.

Bougault et al. [3] reported that increase of nasal symptoms arised due to chlorine derivative exposure during intense swimming training in 39 competitive swimmers. Supportively Deitmer and Scheffler [15] documented that the sinusitis and nasal symptoms such as nasal discharge, nasal obstruction, and nasal itching were significantly higher in swimmers than control group and researchers associated the pathogenesis with entrance of pool water into the nasal cavity and sinuses. Similarly Gelardi et al. [16] concluded that exposure to chlorine causes neutrophilic inflammation and neutrophilic rhinitis in elite swimmers. Moreover, Passàli et al. [17] evaluated the mucociliary transport (MCT) time in 106 professional athletes included swimmers, skiers, boxers, and runners and they have documented the highest MCT time (27.4±4.97 min) in swimmers. These MCT findings obtained from swimmers have also been found to be significantly higher than the general population (13±3 min) and researchers associated this alteration of MCT with possible pathologies such as rhino-sinusitis, rhino-otitis, and asthma in swimmers. In accordance with these data, the level of nasal discharge significantly increased after swimming training in our study. On the contrary, there were no statistically significant differences found regarding nasal congestion, sneezing, and olfaction. We conducted our study at summer season, in an outdoor swimming pool disinfected with ozone. In our considerations, unlike other studies, swimmers were not affected regarding nasal symptoms in our study due to the fact that the concentration of chemicals exposed in the outdoor pool is less than that in the indoor pool. In most of the studies, study participants had their trainings in inside pools, where concentration of chemicals exposed is expected to be higher; however, especially in summer period many swimmers train in outside pools. This fact might have an impact on the results and should be taken into consideration. Unlike other studies, our study group had their training in outside pool which might explain the lack of effect on nasal symptoms. In a retrospective study conducted by Kohlhammer et al. [18] with 2606 adults; no association was found between swimming and asthma, additionally it has been shown that allergic rhinitis is more frequently seen in school-aged swimmers. In present study six swimmers had a history of allergic rhinitis (12.8%), while three (6.4%) were diagnosed with asthma. In diagnosing allergic rhinitis, we relied on detailed history and nasal examination. As expressed in guideline by American Academy of Otolaryngolog Head and Neck Surgery [19], specific symptoms we looked for were nasal congestion, runny nose, itchy nose, or sneezing and specific examination findings were clear rhinorrhea, nasal congestion, pale discoloration of the nasal mucosa, and red and watery eyes. Further laboratory tests or skin prick test are recommended for patients who do not respond to empiric treatment, thus we did not perform any further tests in diagnosing allergic rhinitis.

Autonomic reflexes enhance nasal efficiency and reduce nasal resistance during exercise through an increase in sympathetic tone, results constriction of nasal blood vessels due to adrenoreceptor stimulation. On the contrary, isometric exercises cause limited nasal impact in normal individual, but increased nasal resistance in subjects with rhinitis [20]. Ottaviano et al. [21] evaluated nasal resistance with basal anterior active rhinomanometry in 15 swimmers and 15 different branches of athletes as a control group, and they could not obtain a statistically significant difference between the groups. Similarly Ondolo et al. [22] reported no statistically significant difference regarding nasal resistance before and after training in 30 swimmers. Supportively, in our study, there was no statistically significant difference regarding acoustic rhinometry results before and after training as well as no alteration was observed in nasal resistance, and our study group was larger than those studies which confirms and strengthens these findings.

Although the prevalence of EIB is reported to be between 5% and 20% in general population, the incidence increases up to 45% in the adolescence period. Actually there is no gold standard method for prevalence analysis. Therefore, it is obvious that the findings vary according to the geographical features, population, method used for EIB detection (laboratory-based, exercise, etc.) and branch of sport [9, 23]. In the Western countries, the EIB incidence is reported to be between 4.7% and 12% in children, and approximately 25% in the athletes. Caillaud et al. [23] documented a rate of 3.33% for EIB independently of asthma in 7781 school-aged children with a mean age of 10 years from six cities of France. In another study, EIB incidence was reported around 12% in pediatric population and 30% of those children were subsequently diagnosed with asthma [24]. Supportively in a study of the school-aged athletes, 10% experienced EIB, another similar study has also reported an EIB of 7.4% for school-aged free runner students [25, 26]. However, swimming and running are commonly considered to be high-risk sports for EIB. In fact, any sport can be excluded from being a risk for EIB and EIA by providing appropriate conditions. For instance, swimming in a well regulated temperature and humidity pool, long running by closing the mouth and nose without obstructing normal breath, shorter duration exercise that do not reach high ventilation limits can minimize the risks. Furthermore, physical condition in regularly swimming asthmatics is even better than healthy children without asthma. It has been shown that even after a 6-week swimming program, the aerobic capacity of asthmatic children were increased, the decrease of FEV1 decelerated, and bronchoconstriction was prevented [27]. As it is mentioned above EIB is highly associated with multifactorial processes; therefore, prevalence of EIB varies in published data. Hence, in our study, the EIB prevalence of 8.5% is consistent with the related literature. In addition, in our consideration, it may be beneficial to approach the findings of EIB prevalence analysis in a multifactorial way.

Athletes such as swimmers and weight lifters achieve better pulmonary function tests than other athletes like sprinters due to less strenuous muscle exercise [11]. Wells et al. [28] evaluated the effects of a 12-week inspiratory and expiratory muscle training program in 34 adolescent swimmers. The experimental group (n=17) which performed intense program gained significant improvement in forced inspiratory volume in 1 s and FEV1.0 ($p=0.05$ and 0.045, respectively). The researchers concluded that swimming results in improvements of pulmonary function and sustainable breathing power. Similarly, in a study by İsmail et al. [12], consisting of 40 swimmer and 40 sedentary control group, a statistically significant improvements on FEV and FVC values in swimmer group was reported at the end of 8-week swim training program ($p<0.001$). In accordance with published data, post-swim-FVC was found significantly higher than pre-swim FVC in our study. The fact that even a single training in adolescent athletes causes an increase in FVC, demonstrating the positive effects of swimming to lung capacity is an important finding that swimming training can be reliably recommended for athletes diagnosed with EIB.

Conclusion

In our study, we documented that swimming causes nasal discharge but do not effect nasal passages and nasal resistances. In addition, swimming exercise causes significantly increased FVC. We also observed that the overall prevalence of EIB in swimmers was not different from that of the general population. Therefore, swimming training can be regarded as a reliable sport for children diagnosed with asthma or allergic rhinitis. Future studies are needed to reveal the effect of swimming on disease control.

Ethics Committee Approval: The Health Sciences University Sisli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 28.04.2015, number: 484).

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REFERENCES

1. Kennedy MD, Gill JMS, Hodges ANH. Field versus race pace conditions to provoke exercise-induced bronchoconstriction in elite swimmers: Influence of training background. J Exerc Sci Fit 2017;15:12–7.
2. Price OJ, Hull JH, Ansley L. Advances in the diagnosis of exercise-induced bronchoconstriction. Expert Rev Respir Med 2014;8:209–20.
3. Bougault V, Turmel J, Boulet LP. Effect of intense swimming training on rhinitis in high-level competitive swimmers. Clin Exp Allergy 2010;40:1238–46. [CrossRef]
4. Molis MA, Molis WE. Exercise-induced bronchospasm. Sports Health 2010;2:311–7. [CrossRef]
5. Mata LM da, Sanches RC, Leite MR, Pacagnelli FL, Vanderlei LCM, Pissulin FDM. Evaluation of frequency of positive exercise-induced bronchospasm between swimmers and sedentary individuals. Fisioter em Mov 2017;30. [CrossRef]
6. Caggiano S, Cutrera R, Di Marco A, Turchetta A. Exercise-induced bronchospasm and allergy. Front Pediatr 2017;5:131. [CrossRef]
7. Joshi S, Powell T, Watkins WJ, Drayton M, Williams EM, Kotecha S. Exercise-induced bronchoconstriction in school-aged children who had chronic lung disease in infancy. J Pediatr 2013;162:813–8.e1. [CrossRef]
8. Hallstrand TS, Moody MW, Wurfel MM, Schwartz LB, Henderson WR Jr, Aitken ML. Inflammatory basis of exercise-induced bronchoconstriction. Am J Respir Crit Care Med 2005;172:679–86. [CrossRef]
9. Del Giacco SR, Manconi PE, Del Giacco GS. Allergy and sports. Allergy 2001;56:215–23. [CrossRef]
10. Castricum A, Holzer K, Brukner P, Irving L. The role of the bronchial provocation challenge tests in the diagnosis of exercise-induced bronchoconstriction in elite swimmers. Br J Sports Med 2010;44:736–40.

11. Mahotra NB, Shrestha L. Effects of type sports on pulmonary function tests: a comparative study in nepalese settings. J Nobel Med Coll 2013;2:18–21. [CrossRef]
12. İsmail G, Kürkçü R, Devecioğlu S. The effect of swimming on pulmonary functions, blood pressure and body composition. J Clin Exp Invest 2011;2:35–41. [CrossRef]
13. Harris WE, Giebaly K, Adair C, Alsuwaidan S, Nicholls DP, Stanford CF. The parasympathetic system in exercise-induced rhinorrhoea. Rhinology 1992;30:21–3.
14. Beck KC, Offord KP, Scanlon PD. Bronchoconstriction occurring during exercise in asthmatic subjects. Am J Respir Crit Care Med 1994;149:352–7.
15. Deitmer T, Scheffler R. Nasal physiology in swimmers and swimmers' sinusitis. Acta Otolaryngol 1990;110:286–91. [CrossRef]
16. Gelardi M, Ventura MT, Fiorella R, Fiorella ML, Russo C, Candreva T, et al. Allergic and non-allergic rhinitis in swimmers: clinical and cytological aspects. Br J Sports Med 2012;46:54–8. [CrossRef]
17. Passàli D, Damiani V, Passàli GC, Passàli FM, Bellussi L. Alterations in rhinosinusal homeostasis in a sportive population: our experience with 106 athletes. Eur Arch Otorhinolaryngol 2004;261:502–6. [CrossRef]
18. Kohlhammer Y, Döring A, Schäfer T, Wichmann HE, Heinrich J; KORA Study Group. Swimming pool attendance and hay fever rates later in life. Allergy 2006;61:1305–9. [CrossRef]
19. Seidman MD, Gurgel RK, Lin SY, Schwartz SR, Baroody FM, Bonner JR, et al; Guideline Otolaryngology Development Group. AAO-HNSF. Clinical practice guideline: Allergic rhinitis. Otolaryngol Head Neck Surg 2015;152:S1–43. [CrossRef]
20. Alves A, Martins C, Delgado L, Fonseca J, Moreira A. Exercise-induced rhinitis in competitive swimmers. Am J Rhinol Allergy 2010;24:e114–7. [CrossRef]
21. Ottaviano G, Staffieri A, Stritoni P, Ermolao A, Coles S, Zaccaria M, et al. Nasal dysfunction induced by chlorinate water in competitive swimmers. Rhinology 2012;50:294–8. [CrossRef]
22. Ondolo C, Aversa S, Passali F, Ciacco C, Gulotta C, Lauriello M, et al. Nasal and lung function in competitive swimmers. Acta Otorhinolaryngol Ital 2009;29:137–43.
23. Caillaud D, Horo K, Baiz N, Banerjee S, Charpin D, Lavaud F, et al. Exercise-induced bronchospasm related to different phenotypes of rhinitis without asthma in primary schoolchildren: the French Six Cities Study. Clin Exp Allergy 2014;44:858–66. [CrossRef]
24. Fayezi A, Amin R, Kashef S, Al Yasin S, Bahadoram M. Exercise-induced asthma in asthmatic children of southern Iran. Glob J Health Sci 2014;7:115–8. [CrossRef]
25. Anderson SD, Kippelen P. Assessment and prevention of exercise-induced bronchoconstriction. Br J Sports Med 2012;46:391–6. [CrossRef]
26. Benarab-Boucherit Y, Mehdioui H, Nedjar F, Delpierre S, Bouchair N, Aberkane A. Prevalence rate of exercise-induced bronchoconstriction in Annaba (Algeria) schoolchildren. J Asthma 2011;48:511–6. [CrossRef]
27. Karadağ B. Asthma and Sports. Turkiye Klinikleri J Pediatr Sci 2009;5:55–60.
28. Wells GD, Plyley M, Thomas S, Goodman L, Duffin J. Effects of concurrent inspiratory and expiratory muscle training on respiratory and exercise performance in competitive swimmers. Eur J Appl Physiol 2005;94:527–40. [CrossRef]