

ORIGINAL ARTICLE

Effect of intense swimming training on rhinitis in high-level competitive swimmers

V. Bougault^{1,2}, J. Turmel¹ and L. P. Boulet¹

¹Centre de recherche de l'Institut universitaire de cardiologie et de pneumologie de Québec, QC, Canada and ²Université du Droit et de la santé de Lille, Lille, France

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Summary

Background Rhinitis is commonly reported by swimmers. Seasonal allergic rhinitis may impair athletes' performance and quality of life (QOL). No data are currently available on the changes of nasal symptoms during and after a swimming season. We aimed to determine in competitive swimmers: (1) the prevalence of rhinitis and its impact on their QOL during an intense training programme, (2) the changes in nasal symptoms and QOL after a resting period and (3) the relationship between rhinitis and airway hyperresponsiveness (AHR).

Methods Thirty-nine swimmers and 30 healthy controls answered the Rhinitis Quality of Life Questionnaire (RQLQ) and scored nasal symptoms on a seven-point Likert scale during the week preceding their visit. Subjects had allergy skin prick tests and a methacholine challenge. Peak nasal inspiratory flows were also measured. The athletes performed these tests during an intense training period (V1), outside the pollen season and after at least 2 weeks without swimming (V2).

Results At V1, rhinitis symptoms were reported by 74% of swimmers and 40% of controls ($P < 0.01$). Eighty-four percent of swimmers and 72% of controls were atopic (NS). RQLQ score was higher in swimmers compared with controls at V1 (27.3 ± 28.5 vs. 9.5 ± 12.7 , respectively, $P < 0.005$). The presence of AHR during training did not correlate with the presence of rhinitis symptoms. At V2, the nasal symptoms and RQLQ scores were similar in swimmers and controls.

Conclusion Intense swimming training is associated with an increase in nasal symptoms and impairment in QOL in most competitive swimmers. Such an increase is not related to seasonal allergen exposure in atopic athletes and probably results from chlorine derivative exposure.

Keywords airway responsiveness, competitive swimmers, quality of life, rhinitis, training

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Correspondence:

Valérie Bougault, Faculté des sciences du sport, Université du droit et de la santé de Lille2, 9 rue de l'université, 59790 Ronchin, France.

E-mail: valerie.bougault@univ-lille2.fr

Introduction

Allergic rhinitis (AR) is clinically defined as a symptomatic disorder of the nose induced by an IgE-mediated inflammation after allergen exposure of the nasal mucosa [1]. Rhinitis is a prevalent disorder in athletes [2, 3], and is commonly characterized by nasal congestion, rhinorrhoea, sneezing, itching of the nose and/or post-nasal drainage [1].

During regular training, athletes are repeatedly exposed to allergens, cold air and/or irritants, all of which can contribute to the development or exacerbation of their nasal symptoms [1]. Among elite athletes, those involved in endurance sports more often report physician-

diagnosed AR than other athletes or control subjects [4]. This is especially true for swimmers, repeatedly exposed to chlorine derivatives, with up to 74% of them complaining of nasal symptoms [2, 5–8].

In Olympic athletes affected by seasonal allergies, it has been shown that rhinitis may worsen their quality of life (QOL) [9, 10], whereas intranasal medication may improve it [9]. Although seasonal allergies are a common cause of rhinitis, recent data suggest that swimmers' rhinitis is mostly of non-allergic origin [7]. Rhinitis may thus be persistent over the year or mostly associated with periods of intense training, but no data are currently available on changes in the rhinitis clinical expression during and after a training season. Regardless of their atopic status, indoor

competitive or recreational athletes often consider that exercise-induced rhinitis alters their ability to train and compete [11].

In the general population, it is usually recognized that chronic rhinitis is a contributing factor to the development of asthma and may affect its control [12, 13]. In athletes, airway hyperresponsiveness (AHR) is frequently observed, especially in swimmers, reaching a prevalence as high as 76% in some studies [14, 15]. The relationship between changes in airway responsiveness and rhinitis, however, remains to be studied in swimmers.

Our first aim was to determine the prevalence of rhinitis in competitive swimmers and to observe its impact on QOL, during an intense period of training. Secondly, we aimed to observe the changes in nasal symptoms and QOL after a resting period of 2 weeks or more without swimming. Finally, we wanted to describe the relationship between the rhinitis status and lower airway responsiveness in competitive swimmers.

Methods

Study population

Competitive swimmers over 16 years of age from local swimming teams were recruited during an intense period of training, mainly in fall and winter 2008, outside of the pollen season. Their swimming training occurred only in chlorinated swimming pools. Healthy age and gender-matched control subjects without asthma symptoms were also recruited from the local schools and university, during the same period. Control subjects were sedentary or moderately active, but were not involved in competitive sports and did not regularly attend a swimming pool. All subjects were non-smokers, non-obese (Body Mass Index $< 29 \text{ kg/m}^2$) and free of any disease that may have interfered with the study. Subjects were tested at least 2 weeks after any episode of chest or upper respiratory tract infection. All subjects gave their written informed consent and the study protocol was approved by our Institutional Ethics Committee. The study protocol was registered at <http://www.clinicaltrials.gov> (NCT 00686452).

Study design

Each evaluation was performed when the athletes had not trained for at least 12 h.

Subjects filled the questionnaires and had measurements of peak nasal inspiratory flow (PNIF) and methacholine test twice. The first visit occurred in fall–winter 2008, during an intense period of training for swimmers (V1). For the second visit, subjects were asked to come back during the swimmers' resting period, i.e. after at least 2 weeks without swimming, in spring–summer or fall 2008 (V2). Swimmers were allowed to run at a light

intensity before V2. Short-acting inhaled β_2 -agonists, leukotriene receptors antagonists and inhaled corticosteroids were stopped ≥ 12 , 24 and 48 h before the two visits, respectively. Anti-histamines were stopped ≥ 48 h before the tests.

Assessment of rhinitis status

To assess their rhinitis status, after a medical examination and interview about nasal symptoms, subjects had to complete several questionnaires:

- A general questionnaire regarding past and current respiratory condition, family history of asthma and allergies, nasal symptoms during effort or other conditions, as well as training and sports habits. The questionnaire also included an item on the reported cold episodes during the past year.
- The seven-domain Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ, 28 questions) [16]. The instrument has 28 items in seven domains (activity limitation, sleep disorders, non-rhinoconjunctivitis symptoms, practical problems, nasal symptoms, eye symptoms and emotional function). Subjects were asked to recall impairments experienced during the previous week and to respond to each item on a seven-point scale (0 = no impairment, 6 = maximum impairment).
- Assessment of symptoms of nasal congestion, sneezing, secretions, itching and cough on a seven-point Likert scale (0, not at all; 6, maximal).

Rhinitis was defined as the presence of current sneezing or nasal obstruction during exercise or in other circumstances, and exercise-induced rhinitis was defined as the report of nasal symptoms during or immediately after the exercise only.

PNIF were measured as an index of nasal obstruction [17], with a nasal peak flow meter (In Check, Clement-Clarke International Ltd, Harlow, Essex, UK), using the method described previously by Youlten [18]. Three satisfactory maximal inspirations were obtained and the highest value was used for analysis.

Atopic status

Immunoenzymofluorometry was used to measure serum IgE, and allergy skin prick tests were performed. A subject was classified as atopic if at least one allergen caused a weal of at least 3 mm in diameter, in the presence of a negative saline control and positive histamine. Twenty-six common airborne allergens, including animal danders, house dust mite (HDM), mixed tree and mixed grass pollen and moulds were tested.

Airway responsiveness

Spirometry was carried out according to the American Thoracic Society (ATS) specifications [19]. An ATS-approved spirometer was used (Medisoft micro 5000, Medisoft SA, Sorinnes, Belgium). Predicted values were obtained from Knudson et al. [20].

Airway responsiveness to methacholine was measured using the Juniper tidal breathing method [21], as described previously [14]. For this study, AHR was defined as a methacholine provocative concentration inducing a 20% decrease in forced expiratory volume in 1 s (FEV₁) (the PC₂₀ methacholine) $\leq$ 16 mg/mL.

Statistical analysis

Data are expressed as mean $\pm$ standard deviation or percentage values. Clinical characteristics and changes from V1 to V2 data were analysed using Student's *t*-test or Wilcoxon's rank, or sum test for continuous variable, and the χ^2 test were used to compare prevalence rates between the two groups. Statistical results for the methacholine PC₂₀ are expressed with the log-transformed values. Logistic regressions were performed to measure the association between rhinitis symptoms and AHR, groups, training hours, allergies and nasal symptoms scores. The results were considered significant at a *P*-value $\leq$ 0.05. Data were analysed using the statistical package program SAS, version 9.1.3 (SAS Institute Inc., Cary, NC).

Results

Visit 1

Characteristics of the subjects. Subjects' characteristics are presented in Table 1. Thirty-nine swimmers aged from 16 to 23 years old and 30 controls aged from 17 to 26 years old were recruited. Swimmers were mostly national and international level Canadian athletes (31 swimmers). Provincial-level athletes (8 swimmers) were also recruited. Whatever the parameter studied, no significant difference was observed between provincial-level swimmers and national to international level swimmers.

The prevalence of atopy was not significantly different between the swimmers and controls, whatever the type of aeroallergen tested (animal danders, HDM, mixed tree and mixed grass pollen and moulds) (Table 2).

Rhinitis in swimmers. During the interview, 16% of swimmers reported daily and/or regular nasal obstruction during the swimming season. Sneezing during exercise was reported by 47% of swimmers and 17% of controls (*P* < 0.05) and post-nasal drainage during exercise by 29% of swimmers and 3% of controls (*P* < 0.01). Sneezing in other conditions than exercising or swimming was reported by 32% of swimmers and 7% of controls (*P* < 0.05).

PNIF was not significantly different between the two groups (148 $\pm$ 59 L/min in swimmers vs. 155 $\pm$ 59 L/min in controls, *P* = 0.61).

Table 1. Subjects' characteristics during visit 1 (V1)

	Controls (<i>n</i> = 30)	Swimmers (<i>n</i> = 39)	<i>P</i> -value
Gender (M : F)	12 : 18	16 : 23	–
Age (years)	21 $\pm$ 2	19 $\pm$ 2	–
Atopy (%)	22 (73)	33 (85)	0.25
Serum IgE (UI/mL)	103 $\pm$ 134	159 $\pm$ 206	0.23
Number of colds and/or 'flu-like episodes' reported in the past year	2 $\pm$ 1	3 $\pm$ 2	0.01
Rhinitis (%)	12 (40)	29 (74)	0.009
Rhinitis during physical exercise (%)	6 (20)	22 (56)	< 0.005
Rhinitis during other periods than physical exercise (%)	2 (7)	12 (31)	0.014
Years of training*	4 $\pm$ 3	11 $\pm$ 2	< 0.001
Hours of training per week	5 $\pm$ 4	24 $\pm$ 7	< 0.001
Hours of swimming per week	0 $\pm$ 0	21 $\pm$ 7	< 0.001
Physician-diagnosed asthma during childhood (%)	0 (0)	5 (13)	0.06
Using anti-histamines on demand (%)	6 (20)	11 (28)	0.48
Using inhaled β_2 -agonists (%)	0 (0)	6 (15)	0.06
Using oral inhaled corticosteroids (%)	0 (0)	2 (5)	0.15
FEV ₁ (% predicted)	106 $\pm$ 15	120 $\pm$ 17	< 0.001
FVC (% predicted)	113 $\pm$ 14	133 $\pm$ 15	< 0.001

Prevalence is expressed as number of subjects (% of subjects) and other data are expressed as mean $\pm$ SD.

*For control subjects, number of year training means the number of years since they began their physical activity.

FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity.

Table 2. Prevalence of allergies in subjects

	Controls (<i>n</i> = 30)	Swimmers (<i>n</i> = 39)	<i>P</i> -value
Positive skin prick test response to at least one allergen	22 (73)	33 (85)	0.25
Sensitization to			
Animal danders	10 (33)	19 (49)	0.20
Tree pollens	10 (33)	13 (33)	0.99
Grass pollens	10 (33)	15 (38)	0.66
House-dust mite	17 (57)	28 (72)	0.15

Prevalence is expressed as number of subjects (% of subjects).

Table 3. Scores to the Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ) and nasal symptoms during the week preceding the visit 1 (seven-point Likert scale)

	Controls (<i>n</i> = 30)	Swimmers (<i>n</i> = 39)	<i>P</i> -value
RQLQ score			
Activity limitations (3 items)	0.9±1.5	3.1±4.0	0.006
Sleep disorders (3 items)	1.2±2.1	2.8±4.5	0.07
Non-rhinoconjunctivitis symptoms (7 items)	3.1±6.6	6.5±9.7	0.10
Practical problems (3 items)	1.8±2.5	4.5±4.7	0.006
Nasal symptoms (4 items)	2.5±3.0	6.2±5.7	<0.005
Ocular symptoms (4 items)	0.9±1.7	2.1±3.4	0.07
Emotional function (4 items)	1.3±2.5	2.1±3.4	0.31
Global score (28 items)	11.7±14.3	27.3±28.5	0.008
Nasal symptoms score (Likert scale: 0–6)			
Nasal obstruction	0.6±1.0	1.7±1.7	<0.005
Nasal secretions	0.7±1.0	1.7±1.7	0.008
Nasal sneezing	0.6±0.8	1.7±1.6	<0.005
Nasal pruritus	0.0±0.2	1.1±1.8	<0.005
Cough	0.4±0.8	1.4±1.6	<0.005

Data are expressed as mean±SD or *n* (%) for prevalence.

Details of the RQLQ and nasal symptoms Likert scale scores are represented in Table 3. The RQLQ score for ocular symptoms was significantly lower compared with nasal symptoms' score in swimmers ($P<0.0001$) and controls ($P=0.01$). A correlation was observed between ocular and nasal symptom scores in swimmers only ($r=0.38$, $P=0.02$).

At V1, the odds ratio for swimmers to present rhinitis was significantly higher than for controls ($P<0.01$; OR [95% CI]: 4.238 [1.445–12.427]). The prevalence of rhinitis at V1 was not associated with allergies to animals, grass pollen or house dust. Tree pollen allergy was an independent predictor of rhinitis ($P<0.05$; OR [95% CI]: 3.801 [1.119–12.913]).

Changes in nasal symptoms and quality of life after a resting period

Characteristics of the subjects. Characteristics of the subjects at V2 are presented in Table 4. Twenty-one swimmers and 16 controls who completed V1 completed also V2, after a resting period of at least 2 weeks without swim-

ming. Nine swimmers could not attend the second visit, three swimmers stopped their swimming career and did not want to finish the study and six swimmers did not have a resting period. Fourteen controls tested at V1 did not perform V2. The lack of time was the main reason for not attending this visit. Characteristics of these subgroups of swimmers and controls, who completed or not V2 during V1 were not significantly different from the group who performed only V1. Eight swimmers who were included continued to swim regularly a few hours per week at low intensity during the resting period (mean swimming hours per week was 2 ± 3 in swimmers at V2).

Changes in FEV₁, forced vital capacity and blood IgE from V1 to V2 were not significantly different between the two groups (Table 4).

Changes in nasal parameters. There was a trend towards an improvement in PNIF from V1 to V2 in swimmers compared with controls (Δ PNIF from V1 to V2: 14 ± 44 L/min in swimmers vs. -11 ± 33 L/min in controls, $P=0.08$).

The mean RQLQ scores at V1 and V2 are represented in Fig. 1. At V2, there was no significant difference in RQLQ scores between swimmers and controls, whichever item

Table 4. Subjects' characteristics at V2

	Values at V1		Values at V2		P-value for V2	Δ (from V1 to V2)		
	Controls (n = 16)	Swimmers (n = 21)	Controls (n = 16)	Swimmers (n = 21)		Controls (n = 16)	Swimmers (n = 21)	P-value for Δ
Gender (M : F)	9 : 7	7 : 14	9 : 7	7 : 14	–	–	–	–
Age (years)	21 $\pm$ 2	19 $\pm$ 2	–	–	–	–	–	–
Serum IgE (UI/mL)	144 $\pm$ 160	217 $\pm$ 258	120 $\pm$ 136	197 $\pm$ 247	0.27	13 $\pm$ 123	28 $\pm$ 219	0.81
Hours of training per week	0 $\pm$ 0	26 $\pm$ 6	4 $\pm$ 3	4 $\pm$ 5*	0.94	–0 $\pm$ 5	21 $\pm$ 7	<0.001
Hours of swimming per week	0 $\pm$ 0	22 $\pm$ 6	0 $\pm$ 0	2 $\pm$ 3*	0.03	–0 $\pm$ 0	21 $\pm$ 7	<0.001
FEV ₁ (% predicted)	102 $\pm$ 12	119 $\pm$ 18	97 $\pm$ 11*	118 $\pm$ 18	<0.001	–4 $\pm$ 5	2 $\pm$ 7	0.24
FVC (% predicted)	108 $\pm$ 11	134 $\pm$ 15	104 $\pm$ 11	129 $\pm$ 16*	<0.001	–3 $\pm$ 6	5 $\pm$ 7	0.44
Methacholine PC ₂₀ (mg/mL)	43.9 [5.8–128]	5.5 [1.2–44.2]	57.3 [12.4–128]	12.1 [0.97–128]*	<0.001	–	–	0.06

Prevalence is expressed as number of subjects (% of subjects) and methacholine PC₂₀ as geometrical mean [range]. Other data are expressed as mean $\pm$ SD.

* P <0.005 from V1 to V2 in swimmers or controls.

FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity; Δ (from V1 to V2), variation from V1 to V2; P -value for V2, P -value between swimmers and controls at V2; P -Value for Δ , P -Value for the variation from V1 to V2 between swimmers and controls.

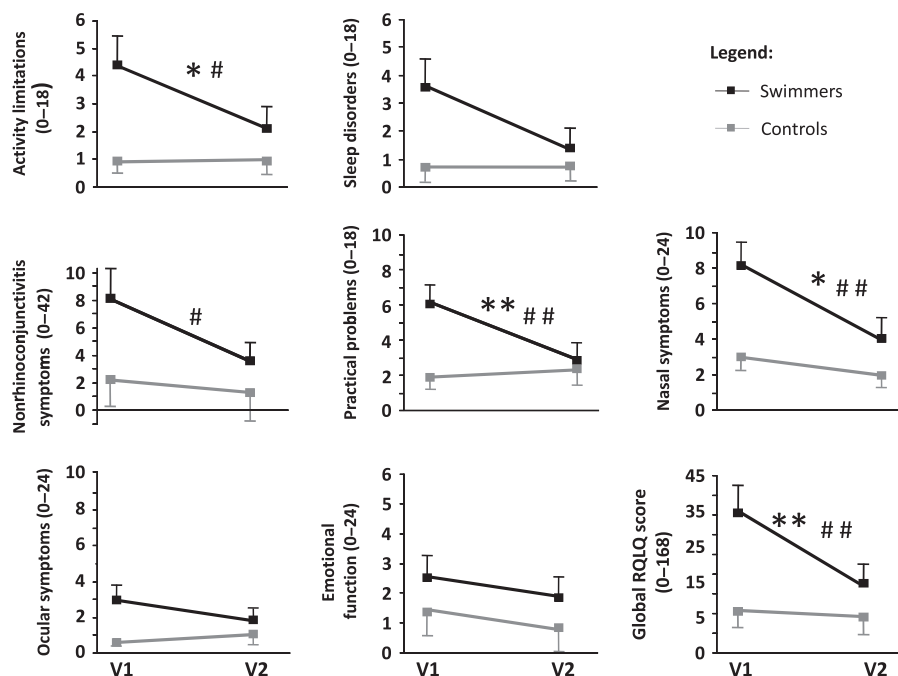


Fig. 1. Changes in mean Rhinitis Quality of Life Questionnaire (RQLQ) scores in swimmers (n = 21) and controls (n = 16) between an intense period of training (V1) and at rest (V2). Data are expressed as mean $\pm$ SEM. Significant variations in scores from V1 to V2 of swimmers compared with controls are represented by: * P <0.05; ** P <0.01. Significant changes in scores between V1 and V2 in swimmers are represented by: # P <0.05; ## P <0.01.

was considered. In the control group, no significant change was observed in any RQLQ item score between V1 and V2.

The Likert-scale scores for nasal symptoms are reported in Fig. 2. In controls, no significant change was observed

in nasal symptom scores between V1 and V2, but a trend towards a lower nasal secretion score was observed during V2 (P =0.06). Among swimmers who scored nasal symptoms on a Likert scale at V1, 88% had no more symptoms at V2.

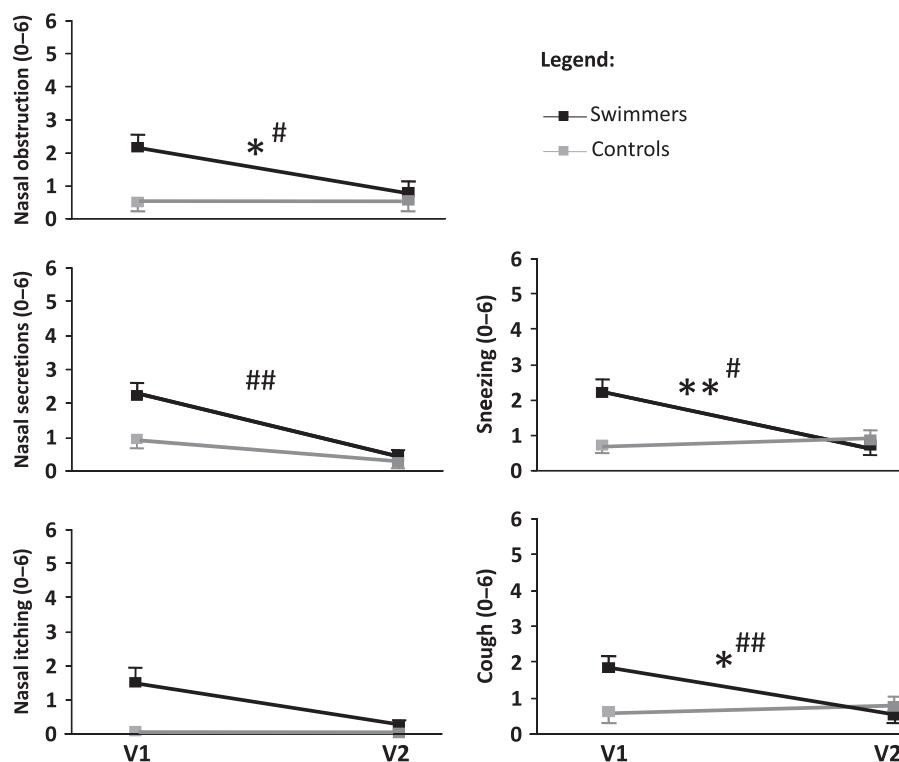


Fig. 2. Changes in mean seven-point Likert-scale scores for nasal symptoms in swimmers ($n = 21$) and controls ($n = 16$) between an intense period of training (V1) and at rest (V2). Data are expressed as mean $\pm$ SEM. Significant variations in scores from V1 to V2 of swimmers compared with controls are represented by: * $P < 0.05$; ** $P < 0.01$. Significant changes in scores between V1 and V2 in swimmers are represented by: # $P < 0.05$; ## $P < 0.01$.

In swimmers only, changes in PNIF from V1 to V2 correlated to the changes of Likert-scale score for nasal congestion ($P < 0.05$).

Airway responsiveness to methacholine and rhinitis

The prevalence of AHR to methacholine challenge at V1 ($PC_{20} < 16$ mg/mL) was significantly higher in swimmers (74% vs. 17% in controls, $P < 0.001$). Forty-four percent of swimmers had a $PC_{20} < 4$ mg/mL.

Among swimmers who reported rhinitis symptoms, 73% had also AHR at V1 ($PC_{20} < 4$ mg/mL in 30%, 22% between 4 and 8 mg/mL and 21% between 8 and 16 mg/mL). Among swimmers with AHR, 73% reported rhinitis. Twenty-one percent of swimmers had rhinitis without AHR, and 5% had neither rhinitis nor AHR. According to a logistic regression model, the prevalence of rhinitis at V1 was not associated to AHR.

No significant correlation was observed between methacholine PC_{20} and the RQLQ scores or the nasal symptom rating. We observed no correlation between the prevalence of rhinitis and methacholine AHR, whether the cut-off of 4, 8 or 16 mg/mL was chosen ($P > 0.05$). We observed a correlation between PNIF and methacholine PC_{20} in swimmers only ($P = 0.037$, $r = 0.35$) (Fig. 3).

Among the subjects who came twice to the laboratory, 62% of swimmers and 6% of controls had AHR at V2 ($P < 0.001$). There was a significant change in methacholine PC_{20} from V1 to V2 in swimmers ($P = 0.002$) but not in controls ($P = 0.35$). There was a trend to have a greater increase in PC_{20} from V1 to V2 in swimmers compared with controls ($P = 0.06$).

No significant correlation was observed between RQLQ scores, nasal symptoms rating changes and airway responsiveness changes from V1 to V2 in swimmers or in controls.

Discussion

During an intense period of training, rhinitis and nasal symptoms are very common in competitive swimmers. In our study, 74% of them were affected by symptoms of rhinitis, with a significant impairment of QOL. This study confirms the role played by training in swimming pools in inducing upper airways symptoms, as suggested previously by Levesque et al. [6] in young competitive swimmers. After a period of at least 2 weeks without swimming, despite an evaluation mainly performed during the seasonal allergy period (spring-summer), nasal symptoms and QOL improved, reaching the same scores as those observed in healthy active controls. No correlation

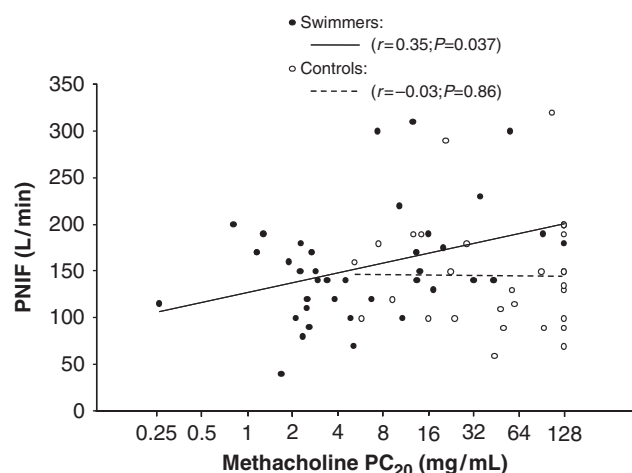


Fig. 3. Relationship between methacholine PC₂₀ and peak nasal inspiratory flow (PNIF) in swimmers (●) and controls (○).

was seen between airway responsiveness and nasal symptoms or QOL scores, despite a significant correlation between PNIF and AHR to methacholine observed in swimmers during an intense period of training.

The prevalence of rhinitis was high in swimmers (74%) compared with control subjects (40%), but similar to the prevalence of 74% found by Gelardi et al. [7] in 54 competitive swimmers. This result supports previous data in summer sports athletes, indicating that aquatic sport athletes have the greatest prevalence of rhinitis among all athletes, although it varies according to the criteria used for diagnosis [4, 10]. Endurance training itself may be a causative factor for nasal symptoms, especially rhinorrhoea and/or obstruction [3, 11]. The mechanisms involved in nasal rhinorrhoea or nasal obstruction during exercise are still unclear. However, the autonomic nervous system stimulation during physical activity has been shown to be involved in the development of exercise-induced nasal disorders and rhinorrhoea [22, 23]. In our study, only 16% of swimmers complained of chronic nasal obstruction, the main nasal symptom described being sneezing, especially after exercising. Our results confirm those of Clearie et al. [24], who recently observed no correlation between PNIF and the report of nasal symptoms after a 2-h swimming session in 36 competitive swimmers, except for nasal obstruction.

In our study, tree pollen allergy was an independent factor associated with rhinitis, whereas no correlation was found between rhinitis and other allergens. Thirty-three percent of controls and swimmers were tree pollen positive, and consequently we should have found the same prevalence of rhinitis in the two groups. However, swimmers have a further fourfold risk to develop rhinitis related to their swimming status, compared with controls, confirming the role of swimming training in chlorinated pool on the development of what appears to be non-AR.

The rate of mucociliary transport, an important respiratory tract defence mechanism, has been shown to increase with exercise, especially in swimmers' nasal mucosa, and in subjects exposed to chlorine [25–28]. Chlorine inhalation has been shown to reduce nasal airflow in AR subjects, and is considered to have irritant properties on airways [28, 29]. Inflammation of the nasal mucosa and swelling of the adenoids have also been observed more frequently in competitive swimmers compared with controls [30]. Mediators derived from injured epithelial cells may be the main mechanism involved in these effects. Gelardi et al. [7] observed that 50% of competitive swimmers' non-AR was mostly obstructive, and characterized by the presence of neutrophils. In our study, swimmers also complained of nasal congestion, secretions and sneezing, but we did not measure nasal airway inflammation. Interestingly, in the study of Gelardi et al. [7] after the use of a nose-clip for 30 days during training, the nasal symptoms were significantly reduced. The use of goggles by a majority of swimmers during swimming training, may prevent ocular symptoms. This may have been the case in our study, such symptoms being not significantly increased compared with controls at V1, contrary to nasal symptoms, which were more prevalent in swimmers. A study on nasal and ocular symptoms in elite swimmers compared with synchronized elite swimmers would be interesting in addition to our observations. Indeed, swimmers often train and compete with goggles but without a nose-clip, whereas synchronized swimmers mainly compete with a nose-clip but without goggles.

During swimming, ambient air is quasi-exclusively inhaled through the mouth, even at low work rates. The clinical and functional significance of swimming rhinitis may thus be questioned. Our study showed clearly that nasal symptoms during the training season worsen the QOL of competitive swimmers. However, these athletes often do not consult a physician, often considering, according to the results of interviews, that it is a normal response to chlorine. Indeed, only 28% of competitive swimmers used anti-histamine medication when needed before entering the study, and none was taking nasal corticosteroids. Moreover, those taking anti-histamines were often swimmers who had seasonal allergic rhinitis. Nasal corticosteroids have been shown to improve performance and QOL scores in olympic athletes with allergic rhinoconjunctivitis [9]. On the other hand, some authors have shown a reduced effectiveness of asthma medications in athletes [31]. No data currently exist on the effect of non-AR treatment in swimmers. Consequently, the effect of intranasal anti-cholinergic or corticosteroids on swimmer's rhinitis and on mechanisms of development of this condition remains to be better documented.

A previous study showed an attenuation of AHR in swimmers who had stopped their high-level training career [32]. Interestingly, in our study, nasal symptoms

and related QOL also improved and even normalized over a period of only 2 weeks away from the pools. Our study thus suggests that nasal symptoms are associated with high swimming activity and are reversible with the cessation of intense swimming training. The mechanisms for this rapid recovery remain to be determined. We hypothesize that the upper airway epithelium of swimmers may not have sufficient time to recover from injuries caused by repeated chlorine derivative exposure, between two swimming training sessions. At least 2 weeks appear sufficient, however, for the upper airway epithelium to recover from this insult. Structural changes of the upper airways may also occur in elite swimmers, by affecting mucociliary clearance and conditioning of inspired air, but this remains to be confirmed.

We observed a prevalence of 74% of both rhinitis and AHR in swimmers. However, we found no correlation between the presence of AHR and rhinitis, or with the RQLQ scores. This suggests that the mechanisms involved in the upper and lower airway disorders may be independent or that their interaction may occur over prolonged time periods. The significant relationship observed between PNIF and methacholine PC₂₀ in swimmers during an intense period of training only, suggests a role played by the intensity of training in a chlorinated environment on upper and lower airways. Epithelial damage and/or inflammation may appear as a result of chlorine derivatives' exposure particularly following high ventilation levels. The persistence of nasal disorders may lead to water loss and dryness of the rhinosinusal mucosa [25]. In the lower airways, this mechanism has been involved in the development of AHR in athletes [33].

We observed an important attrition of subjects between V1 and V2. The reduced number of subjects at V2 may have influenced the results. However, the subjects' characteristics at V2 were similar compared with the whole groups who came at V1, and hence we do not think that this may have had an impact on the results.

In conclusion, the prevalence of rhinitis and AHR was high in the competitive elite swimmer group, as for AHR was of 74% in elite swimmers. Our study suggests that during an intense training period, nasal symptoms are highly prevalent in competitive swimmers and impair their QOL. This is an important consideration as this may worsen their performance. After a 2-week period of rest, swimmers' rhinitis symptoms were attenuated and even disappeared, indicating that intense swimming training is responsible for their rhinitis and not seasonal increase in allergen exposure. However, we found no correlation between AHR and rhinitis parameters. Finally, we observed that swimmers rarely take medication to treat their swimming-induced rhinitis. The main aetiology being likely non-allergic, further studies are needed to study the effect of current intranasal medication on swimmers nasal symptoms, QOL and performance.

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