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Rhinitis and its Impact on Quality of Life in Swimmers

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Abstract

Introduction: Limited data suggest that swimmers might be affected by rhinitis significantly more often than the general population. This can have impact on quality of life but also on performance. The aim of the present study was to determine the prevalence and impact of QOL of rhinitis in swimming compared to non-swimming athletes and controls.

Materials and methods:

This was an observational case control, questionnaire based study involving elite (n=101) and non-elite swimming athletes (n=107), non-swimming athletes (n = 38) and sex and age-matched controls (n = 50).

The survey instrument consisted of a general and the miniRQLQ questionnaire. Main question used to assess the prevalence of rhinitis was from the ISAAC study.

Results:

Rhinitis was reported significantly more often by the elite swimmers (45%) than non-elite swimmers (31%), non-swimming athletes (32%) and controls (24%). Allergic rhinitis prevalence was similar in all groups (12-18%). The prevalence of non-allergic rhinitis was significantly higher in elite swimmers (33%) and non-elite swimmers (22%) compared to non-swimming athletes and controls. Overall mean miniRQLQ score and all subdomains except the “eye” domain showed significantly reduced QOL in elite and non-elite swimmers compared to non-swimming athletes and controls. Regular nasal medication was used significantly less by elite swimmers (18%) compared to controls (67%) and non-swimming athletes (42%).

Conclusion:

This study revealed a high prevalence of non-allergic rhinitis in swimmers and related impact on QoL. These findings highlight the importance to increase the awareness toward upper airway disorders in the swimming athletes and to ensure adequate management.

Keywords:

Athletes, miniRQLQ, Quality of Life, Rhinitis, Swimmers

INTRODUCTION

Rhinitis, with its proven detrimental effects on quality of life, activities and sleep (1, 2), and its association with asthma (3), has clear potential for compromising athletic ability. Under physiological circumstances, autonomic reflexes usually improve nasal efficiency during exercise. However, repeated exposure to allergens and irritants such as those encountered in the exercise environment may cause changes leading to mucosal damage (4). Rhinitis in athletes has been shown to be more prevalent depending on the type of sports discipline and significantly affect their quality-of-life and performance [7, 13, 14]. These findings let the rhinitis athletes into the spotlight and ARIA document was developed to specifically address the needs of elite athletes suffering from allergic rhinitis [15].

Recent studies suggest that swimmers might be affected by rhinitis significantly more often than the general population (5-8). The number of registered swimmers in Australia exceeds 100,000 and USA

swimming federation counts 404,448 members (9, 10). An extensive literature search revealed only three studies focusing on the occurrence of rhinitis in swimmers showing wide range of prevalence from 21 %, to 74% (7, 11, 12). Unfortunately, all three studies were limited by small sample size and two focused on exercise-induced rhinitis (11-13). When comparing swimmers to other athletes, track and field athletes do not suffer from rhinitis significantly more than general population, regardless of being endurance or sprint specialists (14). On the contrary, 48.6% athletes who spend training hours in cold environment report rhinitis and the distinctive symptom is rhinorrhea (96%), often severe (15).

There is also lack of articles primarily focusing on the performance in swimmers in relation to rhinitis. However, negative impact of allergic rhinoconjunctivitis on performance and quality of life has been demonstrated in 145 mixed Olympians with rhinitis treated with intranasal budesonide. After 4 and 8 weeks of treatment there were statistically significant improvements in symptoms, QOL, and performance scores in athletes who used intranasal budesonide (16).

On this ground, we performed a large-scale study in elite and non-elite swimmers to determine the prevalence of rhinitis. We compared the prevalence to non-swimming athletes and an age and sex matched sample of the general population. Furthermore, we determined the impact of rhinitis on QOL.

METHODS

Study population

- We recruited swimming and non-swimming athletes and sex and age matched controls > 10 years of age. Members of the major swimming clubs in Slovakia and Czech Republic who train in a chlorinated pool, non-swimming members of the local track and field club and sex and age matched non-athletic controls from the local schools and university were recruited. All participants were recruited in the fall and winter of 2016, outside of the pollen season. All swimmers trained in the chlorinated pools with temperature 24-26°C that undergo daily monitoring of chlorine levels according to the European Union standards; measured chlorine levels must fall within the range 0,3 – 0,5 mg/l in the pools with temperature 24-26°C and pH has to stay between 6,5 and 7,6.

Exclusion criteria were, history of URTI in the last 4 weeks and other diseases which can cause significant nasal blockage like septal deviation or chronic rhinosinusitis. The study protocol was approved by the Institutional Ethics Committee of the Faculty of Medicine, Comenius University and University Hospital Bratislava and informed consent was obtained from all participants and/or their parents.

Definitions of population:

- Elite swimmers are swimmers who actively train more than 8 hours per week and have more than one-year experience at this performance level.
- Non-elite swimmers are swimmers who actively train less than 8 hours per week and have more than one-year experience at this performance level; they were further divided into 3 subgroups: 8-6 hours, 6-4 hours and 2-4 hours spent in the pool per week.
- Non-swimming athletes are athletes who actively train more than 8 hours per week and have more than one-year experience at this performance level and do not swim more than 1 hour per week in chlorinated water.
- Controls are subjects who exercise <90 min/week in last 6 months.

Study design

Observational case control, questionnaire based study to determine the prevalence of rhinitis in elite swimmers, non-elite swimmers, non-swimming athletes, and age and sex matched sample of the general population from September to November 2016. Furthermore, we aimed to determine the impact of rhinitis on QOL and swimming performance of rhinitis sufferers compared to non-rhinitics.

The survey instrument

To assess the general, rhinitis and QOL status, subjects had to complete the following questionnaires (see appendix A):

- A general questionnaire including questions about performance, allergic status, nasal symptoms during effort or other conditions, as well as training and sports habits
- Mini Rhinoconjunctivitis Quality of Life Questionnaire (miniRQLQ) Questionnaire collected the information about activity limitations, practical problems and nose symptoms, eye symptoms and other problems.

Main question used to assess the prevalence of rhinitis was from the ISAAC study (17) “Have you had problems with sneezing or a runny or blocked nose when you did not have a cold or the flu in the last 12 months?” “Self-reported current allergic rhinitis” was defined by a positive answer to the question, “Do you have any nasal allergies including hay fever?”(18)

We defined non-allergic rhinitis (NAR) as a positive answer to the question “Have you had problems with sneezing or a runny or blocked nose when you did not have a cold or the flu in the last 12 months?” and a negative answer to “Do you have any nasal allergies including hay fever?”(18)

Statistical analysis

Qualitative data such as demographic data and prevalence were expressed as percentages. Differences in percentages were analysed using χ^2 –analysis. Quantitative data such as miniRQLQ score were expressed as means and standard deviations and as median and range. The distribution of the continuous variables was checked using the Kolmogorov–Smirnov test which did not show normal distribution. Thus, non-parametric testing was used. First, we validated the miniRQLQ for NAR. Then we analysed differences between the four groups for the total miniRQLQ and the different domains of the miniRQLQ. If domains were significantly different we evaluated individual symptoms of that domain.

When the difference between the four groups was significant we tested differences between the separate groups in the same manner as described for the four groups together.

Correlations between hours in the pool and RQLQ was analysed using spearman ranks correlations.

Validation of the RQLQ for NAR

The psychometric properties of the questionnaire, reliability, validity, responsiveness and clinically significant change of the mini-RQLQ have been described for AR (19).

Because symptomatology of NAR and AR are quite similar we expected the content of the mini-RQLQ to be valid for NAR patients. We compared outcomes to the AR patients. Internal reliability was measured estimated by calculating Cronbachs α . The discriminant construct validity was determined by comparing the NAR patients group to healthy controls. Test-retest reliability was evaluated using Pearson correlation. The clinically significant change was expected to be comparable to AR and not evaluated separately for the NAR group (20).

RESULTS

296 subjects participated in the study. Of participants, 101 (34.1%), 107 (36.1%), 38 (12.8%) and 50 (16.9%) were elite swimmers, non-elite swimmers, non-swimming athletes and controls, respectively. The participants’ mean age was 18 years ranging from 10 to 35 years. Other respondents’ characteristics are shown in Table 1.

Prevalence of rhinitis, impact on performance and medical treatment

Among elite swimmers, 45 (45%) reported rhinitis. In the group of non-elite swimmers, the prevalence was 31%, which was comparable to the non-swimming athletes (32%). Controls suffered with rhinitis in 24%. Elite swimmers had a significantly higher prevalence of rhinitis than controls ($\chi^2 = 0.014$) (see table 1).

AR prevalence was similar in all groups (12-18%) (see table I for details of the groups).

The prevalence of NAR among elite swimmers was 33% and among non-elite swimmers was 22%. We observed a significant difference in prevalence of NAR between groups of elite swimmers and controls ($\chi^2 = 0.006$) and elite swimmers and non-swimming athletes ($\chi^2 = 0.021$).

Validation of mini-RQLQ in NAR

To validate the mini-RQLQ in NAR we chose all NAR patients in this study (as defined above) and compared to all AR patients (as defined above) and all subjects without rhinitis. Because symptomatology of NAR and AR are quite similar we expected the content of the mini-RQLQ to be valid for NAR patients. NAR patients indeed had comparable outcomes to AR in the different domains and for the different symptoms of the questionnaire. The only differences were found in the eye domain (see table 2). On all sub-domains of the mini-RQLQ NAR patients had significantly higher outcomes compared to healthy controls (table 2). The Cronbach's α of 0.881 indicated high internal consistency between mini-RQLQ outcomes within the NAR patient group. The test-retest reliability measured in 50 out of 67 NAR patients showed a Pearson's r of 0.896.

MiniRQLQ

Overall mean miniRQLQ score, representing the impact of rhinitis on QoL, showed significant difference between the groups ($p < 0.0001$) (see table 3). Also, all separate domains, apart from the eye domain, showed significant differences (for details see table 3). Within the nasal domain the symptoms stuffy/blocked nose and runny nose showed significant differences but sneezing did not (for details see table 4). In the "activities" domain, significant differences were found for sleep and recreational activities but not for regular activities at home or work. All the individual symptoms in the practical and "other" domain showed significant differences (table 4).

The elite swimmers had significantly higher mean total miniRQLQ scores (median (range) 1.42 (0-4.86)) than the non-swimming athletes (median (range) 0.64 (0-4.29) $p < 0.0001$) and the controls (median (range) 0.75 (0-4.29) $p < 0.0001$). The difference with the non-elite swimmers did not reach significance.

($p=0.077$). All separate domains, apart from the eye domain, showed significant differences when comparing the elite swimmers with the non-swimming athletes and the controls (for details see table 3 in appendix). For details on individual symptoms please see table 4.

Also, the non-elite swimmers had significantly higher mean total miniRQLQ scores (median (range) 1.21 (0-4.29)) than the non-swimming athletes (median (range) 0.64 (0-4.29) $p<0.005$) and the controls (median (range) 0.75 (0-4.29) $p<0.013$). The separate domains nose, practical and other showed significant differences when comparing the non-elite swimmers with the non-swimming athletes and the controls (for details see table 3 in appendix). For details on individual symptoms please see table 4.

There were no significant differences between the non-swimming athletes and the controls.

The role of allergic sensitisation

To determine whether allergic sensitization could play a role we selected the potentially allergic individuals (athletes and controls answering “yes” to the question: Do you have any nasal allergies including hay fever?). Only small number of individuals responded yes to this question (6-12 per group) (for details see Table 1). We felt these numbers were too small for reliable subanalyses.

We analysed the individuals without allergic sensitization which resulted in roughly the same data as the total group (Table 5).

The role of time of exposure to pool conditions

We then asked ourselves whether the number of hours spend in the pool was a determining factor in the impact on QOL and symptoms.

We only analysed the athletes and for purposes of this comparison the non-swimming athletes served as controls. Indeed, there was a significant difference between the “hours spend in the pool” groups for total RQLQ ($p<0.004$) but also for the domains activities ($p<0.06$), practical ($p<0.0001$) and other ($p<0.0001$). In the nasal domain, we saw a trend towards significance ($p<0.08$) and eyes domain remained non-significant (Table 6). Figure 1. shows the differences in means for the total RQLQ and the subdomains. There was a significant negative correlation between total RQLQ and all subdomains except the eye domain and hours spend in the pool, however the correlations were weak (-0.16 - -0.36).

Use of rhinitis medication

We analysed the frequency of using nasal medication in rhinitic individuals only (Table 1.). Among elite swimmers, 8 (18%) were regularly using nasal medication. In the group of non-elite swimmers and non-swimming athletes, the frequency of nasal medication usage ranged from 40% to 57%. Controls were

using nasal medication in 67%. We observed a significant difference between the elite swimmers and controls ($\chi^2 = 0.001$).

Predictive value of miniRQLQ

We were also interested whether the miniRQLQ can be used as a diagnostic tool for screening of rhinitis in this population. We set the threshold for “normal” population based on the upper 95th percentile of the total mean score (1.38 for total RQLQ and 1.40 for the nasal domain) analysed the number of participants who answered negatively to the question about their rhinitis status but scored positively on miniRQLQ score in order to assess the sensitivity. Twenty-four percent of the total population and 25% of the swimming athletes answered “no” to the questions whether they had rhinitis but had a total RQLQ of more than 1.38. The same figures were found when we only analysed the nasal domain of the RQLQ the percentages being 23% for the total population and 27% of the swimming athletes having a nasal domain score of more than 1.40. If we analysed the questions of the nasal subdomain the most interesting observation was that over 40% of the population indicated that they had a blocked nose score over 2.00 (upper 95th percentile of for blocked nose in the normal population 1.80) but still claimed that they do not have rhinitis.

We conclude that, at least in this population, it is better to ask subjects the questions of the nasal domain of the RQLQ or even the question “is your nose blocked” than the question ISAAC normally asked about rhinitis: “Have you had problems with sneezing or a runny or blocked nose when you did not have a cold or the flu in the last 12 months”.

DISCUSSION

This study reports on rhinitis, QoL, and medical treatment in different groups of swimmers compared to the general population and non-swimming athletes.

This study shows that the prevalence of allergic rhinitis (AR) is comparable in swimmers, non-swimming athletes and controls but that non-allergic rhinitis is significantly increased in swimmers compared to non-swimming athletes and controls. This is accordance with the small studies reporting the prevalence of rhinitis in swimmers (7, 11, 12). An interesting new finding is that the prevalence of AR is not increased but only the prevalence of NAR. This study does not support a Dutch study on 2359 swimming children, aged 6–13 years, that indicated that sensitisation to common allergens may be related to increased swimming, especially during pool attendance in the first 2 years of life (21). Which is in agreement with a prospective longitudinal study in British children that could not show an increased risk of developing allergic symptoms or asthma in swimming children. (22).

The impact on nasal physiology of repeated exercise training is less well established. Many of the environments and endeavours which athletes are immersed have the potential for harm to the nasal mucosa. For example, an exercise which takes place in cold air (skiers, snowboarders, ice hockey) subjects the nasal mucosa to local irritants. Aerobic exercise which takes place outdoors may result in inhalation of above average volumes of aeroallergens, nitrous oxide, or pollution due to the increased minute ventilation required to sustain activity (15, 23-27). The latter was confirmed in schoolchildren where the prevalence of rhinitis increased together with the frequency or duration of sports participation (28).

There is still a debate about the causative factor of rhinitis in elite swimmers. The most commonly accepted theory is the repeated exposure to chlorination by-products, such as trichloramines that are well-known strong oxidants causing the disruption of epithelial tight junctions, which could then facilitate the penetration of allergens or pollutants and the migration of inflammatory cells across the epithelial barrier. (13, 29-32). It has been reported that 1h spent in a chlorinated swimming pool is sufficient to increase airway epithelium permeability in swimmers, whereas no change was observed after attending a copper-silver disinfected pool (33). There are also specific aspects of breathing pattern characterized by a low breathing frequency but a high tidal volume compared with other sport athletes, which may favour a hypothesis of significant mechanical stress to the airways (34). Fornander studied indoor swimming pool personnel and reported that 17 % of subjects suffer with airway symptoms (35). Unfortunately, he did not include swimmers or healthy controls for comparison. The difference in prevalence might have shed more light on significance of other factors like high minute ventilation. Lastly, a relationship between allergic sensitization and the development of airway damage/hyperreactivity was proposed showing that atopic individuals had a higher degree of airway hyperreactivity compared to non-atopics (32). In our study, the high prevalence of NAR in elite swimmers (33%) and similar frequency of AR in all groups which supports the irritational background of the rhinitis rather than sensitisation hypothesis.

Rhinitis has a significant impact on QoL and often affects social life and performance (36, 37). This was firstly pointed out particularly for swimmers by Bougault who described a significantly increased in the RQLQ nasal domain scores when compared to the controls. However, the difference in overall score did not reach the significant difference. Interestingly, the scores improved after 2 weeks of training cessation which confirms the irritational properties of chlorine exposure (7). Of note, Gelardi also observed a significant improvement in nasal symptoms judged by VAS score after 30 days of the use of a nose-clip (13). In this study we showed a significant effect of swimming on the total RQLQ and all subdomains except the eye domain. Based on these findings, we asked ourselves whether the number of hours spent in the pool was a determining factor in the impact on QOL and symptoms. Indeed, the hours spent in the

pool a significant effect on total RQLQ and some subdomains. There was a significant negative correlation between RQLQ and subdomains except the eye domain and hours spend in the pool, however the correlations were weak.

The exercise may have negative impact on sleep which can subsequently lead to decreased performance and recovery of athletes. Literature describes several factors related to exercise that might cause the sleep issues: disturbance of body temperature, endocrine, metabolic and autonomic function (38, 39). Based on miniRQLQ results in our study, the sleep in group of elite swimmers is more impaired than in the other groups. One might hypothesise the association with nasal symptoms. However, it is difficult to draw any conclusion because the correlations are similar for both nasal and activity domain. To our knowledge, sleep disturbance was not identified by any other study, therefore further investigations are required.

To our surprise we could not find a validation of the miniRQLQ questionnaire for NAR patients. Therefore, we tried to validate the questionnaire for NAR patients. We were able to show content and construct validity and reliability (20). However, one should realize that this population of athletes and young (age matched) controls does not allow validation for the general NAR population.

We find it useful to evaluate the impact of rhinitis on QoL. But we were also interested if miniRQLQ can be used as a diagnostic tool for screening of rhinitis in the epidemiological studies. We set the threshold for “normal” population based on the upper 95h percentile of the total mean score, the score for the nasal domain and for the questions in the nasal domain and analysed the number of participants who answered negatively to the question about their rhinitis status but scored positively on miniRQLQ score.

Surprisingly a quarter of the subjects who answered negatively on the question about rhinitis had a mean miniRQLQ score higher than the on the upper 95h percentile of the normal population if we used the total miniRQLQ or the nasal domain score and over 40% when only the question: do you have a blocked nose was used. This implies that the question usually asked to define rhinitis: “Have you had problems with sneezing or a runny or blocked nose when you did not have a cold or the flu in the last 12 months?” might not be the best question to ask.

Eighty-two percent of the participating elite swimmers who suffered from rhinitis reported no current use of a rhinitis medication which significantly differs from the controls or non-swimming athletes. This is especially worrying because of the impact on the performance and quality of life. Our explanation is that there might be a certain level of acceptance due to higher prevalence and fear of anti-doping rules violation. Two studies supported our results and showed that elite athletes have a tendency to take no medication for their symptoms (23, 40). However, results of other study indicate that athletes had better compliance to nasal treatment than controls (41).

Although this is the first study to examine the NAR and AR phenotype in swimmers separately, we feel that the weakness of the study is that we have not performed the skin prick tests in order to more accurately assess the allergic status of the participants. The survey was conducted between September and November and so the prevalence and severity of symptoms, as well as the miniRQLQ scores, especially for the AR group, are likely to be lower than during the peak pollen season when pollen is likely to be an important trigger in most patients with SAR and some patients with PAR

CONCLUSION

This study revealed a high prevalence of rhinitis in swimmers and related impact on QoL. These findings highlight the importance to increase the awareness toward upper airway disorders in the swimming athletes and to ensure adequate management.

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Tables:

TABLE 1. Characteristics of 296 respondents

	Elite Swimmers (n=101)	Non-elite swimmers divided into subgroups by number of hours in the pool per week (n=107)			Non-swimming athletes (n=38)	Controls (n=50)	Elite swimmers vs. controls	Elite swimmers vs. non-swimming athletes
		6-8 h (n=42)	4-6 h (n=38)	2-4 h (n=27)			p-value	p-value

Gender (M:F, %)	50:51 (50:50)	18:24 (17:22)	17:21 (16:20)	11:16 (10:15)	18:20 (17:19)	26:24 (52:48)	NS	NS
Age (years, min/max)	18 (+/- 5)	18 (+/- 3)	20 (+/- 5)	19 (+/- 7)	20 (+/- 3)	19 (+/- 5)	NS	NS
Smokers (%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	NS	NS
Rhinitis (%)	45 (45)	15 (36)	11 (29)	7 (26)	12 (32)	12 (24)	0.014	0.16
Allergic rhinitis (%)	12 (12)	4 (10)	3 (8)	3 (11)	7 (18)	6 (12)	0.98	0.32
Non-allergic rhinitis (%)	33 (33)	11 (26)	8 (12)	4 (15)	5 (13)	6 (12)	0.006	0.021
Using rhinitis medication (% of rhinitics)	8 (18)	6 (40)	6 (55)	4 (57)	5 (42)	8 (67)	0.001	0.08

NS = non-significant

Table 2.: MiniRQLQ domain results in AR, NAR and control subjects.

	NAR (n=67)		AR (n=35)		Controls (n=194)		p-value*
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Total	2.58 (1.06)	2.42 (1.07- 4.86) #	2.89 (0.81)	2.71 (1.21-4.57) #	0.80 (0.52)	0.79 (0 – 2.36)	0.001
Nasal Domain	3.45 (1.34)	3.33 (0.33 - 6) #	3.39 (1.03)	3.33 (1.67 - 5.67) #	0.82 (0.68)	0.67 (0 - 4)	0.001
Sneezing	1.15 (0.93)	1 (0 - 3) #	2.54 (1.04)	2.33 (0.33 - 5) #	0.57 (0.51)	0.33 (0 - 2.33)	0.001
Stuffy blocked	3.21 (1.40)	3.33 (0 - 5.33) #	3.66 (1.4)	3.67 (1 - 6) #	0.85 (0.67)	0.67 (0 - 2.67)	0.001
Runny	2.53 (1.68)	2.5 (0 - 7) #	2.3 (1.37)	2 (0 - 6) #	0.76 (1.01)	0.5 (0 - 4)	0.001
Eye domain	2.51 (1.75)	2 (0 - 6) ##	2.35 (1.35)	2.33 (0 - 5.33) #	0.99 (0.85)	0.67 (0 - 3)	0.001
Itchy	3.69 (1.75)	4 (0 - 6) #	3.83 (1.36)	4 (2 - 6) #	0.69 (0.97)	0 (0 - 6)	0.001
Sore	2.96 (1.64)	3 (0 - 6) #	2.57 (1.52)	3 (0 - 6) #	0.97 (1.27)	1 (0 - 6)	0.001
Watery	3.81 (1.73)	4 (0 - 6) ##	3.63 (1.29)	4 (0 - 6) #	0.82 (1.26)	0 (0 - 6)	0.001
Activities	2.33 (1.92)	2	2.86 (1.65)	3	0.81 (1.15)	0	0.001

domain		(0 - 6) #		(0 - 6) #		(0 - 7)	
Sleep	0.7 (1.12)	0 (0 - 4) #	0.91 (0.92)	1 (0 - 3) #	0.32 (0.74)	0 (0 - 4)	0.001
Regular home	1.39 (1.37)	1 (0 - 5) #	2.03 (1.42)	2 (0 - 5) #	0.6 (1.04)	0 (0 - 5)	0.001
Recreational	3.75 (2.03)	4 (0 - 6) #	3.23 (1.77)	3 (0 - 6) #	0.78 (1.05)	0 (0 - 5)	0.001
Practical domain	2.94 (1.79)	3 (0 - 6) #	2.74 (1.58)	3 (0 - 6) #	0.84 (1.15)	0 (0 - 5)	0.001
Rub nose	3.79 (1.90)	4 (0 - 6) #	3.51 (1.42)	4 (1 - 6) #	0.97 (1.3)	0 (0 - 6)	0.001
Blow nose	2.15 (1.64)	2 (0 - 6) #	2.86 (1.83)	3 (0 - 6) #	0.88 (1.32)	0 (0 - 6)	0.001
Other domain	2.69 (1.96)	3 (0 - 6) #	2.11 (1.75)	2 (0 - 6) #	0.63 (1.16)	0 (0 - 5)	0.001
Tiredness	3.18 (1.97)	3 (0 - 6) #	3.03 (2.16)	3 (0 - 6) #	1.26 (1.54)	1 (0 - 7)	0.001
Thirst	1.28 (1.67)	1 (0 - 6) #	1.57 (1.74)	1 (0 - 6) #	0.54 (0.99)	0 (0 - 5)	0.001
Feeling irritable	2.69 (2.05)	3 (0 - 6) #	3.17 (2.23)	4 (0 - 6) #	1.19 (1.69)	0 (0 - 6)	0.001

* p-value: overall Kruskal Wallis

significant compared to controls

% significant compared to AR

Data are given as mean (s.d.) and median score per item in the domain.

Table 3.: MiniRQLQ domain results in elite-swimmers, non-elite swimmers, non-swimming athletes and controls.

	Elite Swimmers (n=101)		Non-elite swimmers (n=107)		Non-swimming athletes (n=38)		Controls (n=50)		
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	p-value*
Total	1.84 (1.3)	1.42 (0-4.86) #%	1.41 (0.98)	1.21 (0-4.29)	1.01 (1.03)	0.64 (0-4.29)	1.09 (1.02)	0.75 (0-4.29)	0.001
Nose domain	2.18 (1.89)	1 (0-6) #%	1.71 (1.23)	1.67 (0-5.33) #%	1.34 (1.43)	0.67 (0-5.33)	1.09 (1.11)	0.67 (0-4)	0.001
Eyes domain	0.96 (1.14)	0.33 (0-5)	0.87 (0.79)	0.67 (0-3)	1.03 (0.83)	1 (0-3)	0.97 (0.92)	0.83 (0-4)	.334
Activities domain	2.28 (1.78)	1.67 (0-6) #%	1.61 (1.41)	1.33 (0-6)	1.18 (1.25)	0.83 (0-5.33)	1.23 (1.22)	0.83 (0-5)	0.001
Practical domain	1.61 (1.59)	1 (0-7) #%	1.46 (1.21)	1 (0-4.5) #%	0.61 (1.12)	0 (0-4)	1.14 (1.78)	0 (0-6)	0.001
Others domain	2.11 (1.53)	2 (0-6) #%	1.41 (1.13)	1.33 (0-5.33) #%	0.75 (1)	0.33 (0-4)	1 (1.19)	0.33 (0-4.33)	0.001

* p-value: overall Kruskal Wallis

significant compared to controls

% significant compared to non-swimming athletes

Data are given as mean (s.d.) and median score per item in the domain.

Table 4.: MiniRQLQ individual results in elite-swimmers, non-elite swimmers, non-swimming athletes and controls.

	Elite Swimmers (101)		Non-elite swimmers (107)		Non-swimming athletes (38)		Controls (50)		
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	p-value*
Nasal Domain									
Sneezing	2.07 (2.14)	1 (0-6)	1.74 (1.83)	1 (0-6)	1.58 (1.76)	1 (0-6)	1.22 (1.53)	1 (0-6)	.183
Stuffy blocked	2.12 (1.77)	2 (0-6) ^{#%}	1.58 (1.55)	1 (0-6) ^{#%}	0.92 (1.48)	0 (0-5)	1.12 (1.38)	1 (0-5)	0.001
Runny	2.35 (2.23)	2 (0-6)	1.83 (1.84)	1 (0-6) [#]	1.53 (1.81)	1 (0-6)	1 (1.36)	0.5 (0-6)	.004
Eye domain									NS
Itchy	1.51 (1.85)	1 (0-6)	1.33 (1.53)	1 (0-7)	1.37 (1.4)	1 (0-4)	1.34 (1.61)	1 (0-6)	Not tested
Sore	0.46 (0.96)	0 (0-4)	0.4 (0.8)	0 (0-4)	0.74 (1.03)	0 (0-3)	0.44 (0.67)	0 (0-2)	Not tested
Watery	0.9 (1.26)	0 (0-5)	0.9 (1.28)	0 (0-5)	0.97 (1.13)	0.5 (0-3)	1.14 (1.4)	0.5 (0-5)	Not tested
Activities domain									
Sleep	2.38 (2.26)	2 (0-6) ^{#%}	1.55 (1.87)	1 (0-6)	0.97 (1.22)	0.5 (0-4)	1.44 (1.53)	1 (0-5)	.006
Regular home	1.75 (1.77)	1 (0-6) [#]	1.42 (1.48)	1 (0-6)	1.26 (1.8)	0 (0-6)	1.6 (1.77)	1 (0-6)	.287
Recreational	2.67 (2.02)	2 (0-6) ^{#%}	1.92 (1.94)	2 (0-6) [#]	1.32 (1.63)	0.5 (0-6)	0.8 (1.4)	0 (0-5)	0.001
Practical domain									
Rub nose	1.5 (1.51)	1 (0-6) ^{#%}	1.7 (1.69)	1 (0-6) ^{#%}	0.5 (0.95)	0 (0-4)	1.24 (1.95)	0 (0-6)	0.001
Blow nose	1.65 (1.82)	1 (0-6) ^{#%}	1.24 (1.51)	1 (0-5) [%]	0.71 (1.54)	0 (0-6)	1.04 (1.84)	0 (0-6)	.003
Other domain									
Tiredness	2.53 (1.94)	2 (0-6) ^{#%}	2.13 (2.01)	2 (0-6) ^{#%}	0.71 (1.06)	0 (0-5)	1.06 (1.6)	0 (0-7)	0.001
Thirst	1.32 (1.73)	1 (0-6) ^{#%}	0.69 (1.09)	0 (0-5) [%]	0.24 (0.54)	0 (0-2)	0.58 (1.01)	0 (0-4)	0.001
Feeling irritable	2.46 (2.14)	2 (0-6) ^{#%}	1.46 (1.76)	1 (0-6)	1.24 (1.85)	0 (0-6)	1.42 (2.01)	0 (0-6)	0.001

* p-value: overall Kruskal Wallis

significant compared to controls

% significant compared to non-swimming athletes

Data are given as mean (s.d.) and median score per item in the domain.

Table 5.: MiniRQLQ results in elite-swimmers, non-elite swimmers, non-swimming athletes and controls with non-allergic rhinitis.

	Elite Swimmers (n=33)		Non-elite swimmers (n=23)		Non-swimming athletes (n=5)		Controls (n=6)		
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	p-value*
Total	1.62 (1.2)	1.14 (0-4.86) ^{#%}	1.3 (0.94)	1.14 (0-4.29)	0.68 (0.79)	0.57 (0-4.29)	0.85 (0.78)	0.64 (0-3.14)	0.001
Nose domain	1.93 (1.82)	1 (0-6)	1.6 (1.21)	1.67 (0-5.33) ^{#%}	0.84 (1.02)	0.67 (0-5.33)	0.85 (0.95)	0.67 (0-4)	0.001
Eyes domain	0.66 (0.77)	0.33 (0-3)	0.74 (0.7)	0.67 (0-3)	0.76 (0.63)	0.67 (0-3)	0.77 (0.54)	0.67 (0-2)	.137
Activities domain	1.94 (1.59)	1.33 (0-5.33) ^{#%}	1.44 (1.28)	1 (0-5.33)	0.84 (1.01)	0.67 (0-5.33)	0.97 (0.99)	0.67 (0-4)	0.001
Practical domain	1.46 (1.59)	1 (0-7) ^{#%}	1.44 (1.23)	1 (0-4.5) ^{#%}	0.35 (0.95)	0 (0-4)	0.84 (1.58)	0 (0-6)	0.001
Other domain	2.04 (1.51)	2 (0-6) ^{#%}	1.32 (1.09)	1 (0-5.33) ^{#%}	0.52 (0.82)	0.33 (0-4)	0.77 (1.01)	0.33 (0-3.33)	0.001

* p-value: overall Kruskal Wallis

significant compared to controls

% significant compared to non-swimming athletes

Data are given as mean (s.d.) and median score per item in the domain.

Table 6.: MiniRQLQ results in relation to hours spent in water.

	8h+ (n=101)		6-8h (n=42)		4-6h (n=38)		2-4h (n=27)		Non-swimming athletes (n=38)		p-value*
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Total	1.84 (1.3)	1.43 (0-4.86)	1.48 (1.1)	1.29 (0-4.29)	1.4 (0.91)	1.18 (0-4.29)	1.3 (0.87)	1.14 (0-4.29)	1.01 (1.03)	0.64 (0-4.29)	.004
Nose domain	2.18 (1.89)	1 (0-6)	1.86 (1.26)	2 (0-5.33)	1.7 (1.24)	1.67 (0-5.33)	1.49 (1.16)	1.67 (0-5.33)	1.34 (1.43)	0.67 (0-5.33)	.080
Eyes domain	0.96 (1.14)	0.33 (0-5)	0.92 (0.87)	0.67 (0-3)	0.81 (0.67)	0.67 (0-3)	0.88 (0.84)	0.67 (0-3)	1.03 (0.83)	1 (0-3)	.622
Activities domain	2.28 (1.78)	1.67 (0-6)	1.72 (1.54)	1.33 (0-5.33)	1.7 (1.44)	1.33 (0-6)	1.3 (1.1)	1 (0-5.33)	1.18 (1.25)	0.83 (0-5.33)	.006
Practical domain	1.61 (1.59)	1 (0-7)	1.54 (1.33)	1.25 (0-4.5)	1.41 (1.14)	1 (0-4)	1.37 (1.16)	1 (0-4.5)	0.61 (1.12)	0 (0-4)	0.001
Other domain	2.10 (1.53)	2.00 (0-6)	1.40 (1.28)	1.00 (0-5.33)	1.37 (0.92)	1.14 (0-4.29)	1.3 (0.87)	1.14 (0-4.29)	1.01 (1.03)	0.64 (0-4.29)	0.001

* p-value: overall Kruskal Wallis

Data are given as mean (s.d.) and median score per item in the domain.

Figures:

Figure 1:

Figure shows the differences in means for the total RQLQ and the subdomains depending on the time of exposure to pool conditions;

