Swimmers’ Respiratory Health

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PLAN

I. Swimming: Is it good or not for asthmatic subjects?

II. Evidence for airway disorders in swimmers
   - Respiratory symptoms
   - Airway hyperresponsiveness
   - Airway inflammation
   - Airway remodelling
   - Other airway disorders

III. Mechanisms for airway disorders

IV. Management and prevention

V. Reversibility

VI. Conclusion
I. Swimming: The Best Physical Activity for those with Asthma?
Benefits of swimming in asthma

- ↑ Cardiorespiratory health
- ↓ Risk to develop asthma
- ↑ Asthma management
- ↓ Frequency of:
  - Respiratory symptoms
  - Asthma exacerbations
  - Asthma medication use
  - Emergency visit and scholar truancy

1 Potts Sports Med 1996 (review); 2 Bougault et al. Sci Sport 2005 (review in french)
Evidences of airway disorders due to regular chlorinated swimming pool attendance\textsuperscript{1,2}

- ↑ Occupational asthma in lifeguards
- ↑ Risk to develop bronchitis and further asthma in school children
- ↑ Asthma and airway hyperresponsiveness in elite swimmers
- ↑ Respiratory symptoms in bathers

\textsuperscript{1}Potts Sports Med 1996 (review); \textsuperscript{2}Bougault et al. Sci Sport 2005 (review in french)
Chlorine by-products inhalation

![Diagram of chlorine by-products](image_url)

**Fig. (1).** Major chlorine-based oxidants present in the water and air of indoor or outdoor chlorinated swimming pools and of similar aquatic environments.
II. Evidences for Airway Disorders in Competitive Swimmers? Do they develop Asthma?
Therapeutic use exemption (TUE)
Summer Olympic Games
Beijing 2008

Data from K. Fitch 2008, with permission
Asthma

Definition/Diagnosis:

- Respiratory symptoms (report and medical history)
- Airway hyperresponsiveness (AHR)
- Variable airway obstruction (spirometry/reversibility)
- Airway inflammation (eNO, induced sputum, EBC, biopsies)

Other characteristics:

- Treatment response
- Bronchial remodelling

Bousquet et al. Am J Respir Crit Care Med 2000
Asthma-like Symptoms
Lower Airway Respiratory Symptoms

✓ Swimming in indoor chlorinated swimming pools

Table 1. Prevalence of respiratory tract symptoms obtained by questionnaire

<table>
<thead>
<tr>
<th>Study</th>
<th>n</th>
<th>Lower airway symptoms (%)(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cough</td>
</tr>
<tr>
<td>Swimmers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deitmer and Scheffler(^b)</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Zwick et al.(^b)</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>Moms et al.(^b)</td>
<td>210</td>
<td>24</td>
</tr>
<tr>
<td>Potts(^b)</td>
<td>738</td>
<td>36</td>
</tr>
<tr>
<td>Langdeau et al.(^b)</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Helenius et al.(^b)</td>
<td>16</td>
<td>63-81</td>
</tr>
<tr>
<td>Turcotte et al.(^b)</td>
<td>95</td>
<td>10</td>
</tr>
<tr>
<td>Levesque et al.(^b)</td>
<td>305</td>
<td>26</td>
</tr>
</tbody>
</table>

Table from Bougault et al. Sports Med 2009 (review)
Airway Hyperresponsiveness
**Airway hyperresponsiveness (AHR)**

- **Prevalence**:
  - General population: 4 to 35%
  - Swimmers: 36 to 79%

- **According to the IOC-MC criteria**:  

<table>
<thead>
<tr>
<th>Authors</th>
<th>n</th>
<th>AHR (%)</th>
<th>Age (years)</th>
<th>Training (Hours/week)</th>
<th>Training History (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castricum et al. ³</td>
<td>33</td>
<td>59</td>
<td>M: 19±5</td>
<td>Non available</td>
<td>Non available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>W: 16±2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bougault et al. ⁴</td>
<td>45</td>
<td>60</td>
<td>20±4</td>
<td>28±8</td>
<td>12±4</td>
</tr>
<tr>
<td>Pedersen et al. ⁵</td>
<td>33</td>
<td>≈30</td>
<td>14±1</td>
<td>20±5</td>
<td>3±1</td>
</tr>
</tbody>
</table>

Lower Airway Respiratory Symptoms

✓ AHR and exercise-induced respiratory symptoms (EIRS)²:

![Bar chart showing prevalence of AHR and EIRS among young adult and adolescent swimmers.]

Airway Inflammation
Airway inflammation

✓ **Induced sputum**\(^1,2,3\):
  - Elite swimmers:

  - **Neutrophil cell count**\(^1\)
    - \(r=0.58, P < 0.0005\)
    - Swimmers (n=32)
    - Winter sport athletes (n=32)

  - **Eosinophil cell count**
    - No change in adolescent elite swimmers\(^2\)
    - ↑ with a diagnosis of asthma or demonstration of AHR\(^1,3\)

\(^1\)Bougault *et al.* *Eur Respir J* 2009; \(^2\)Pedersen *et al.* *J Allergy Clin Immunol* 2008; \(^3\)Helenius *et al.* *Allergy* 1998
Airway inflammation

✓ Bronchial biopsies in 23 elite swimmers (21±2 years old)\(^1\)

- AHR +
- AHR -
- No allergies

\(^1\)Bougault et al. J Allergy Clin Immunol (In press)
Airway inflammation

✓ Bronchial biopsies in 23 elite swimmers (21±2 years old)\(^1\)

\(^1\)Bougault et al. J Allergy Clin Immunol (In press)
Airway Remodelling
Swimmers have a similar inflammatory and remodelling process compared with mild asthmatics.

1Bougault et al. J Allergy Clin Immunol (In press)
Allergies and Rhinitis

✓ Prevalences:
  o ↑ risk of allergies and rhinitis in swimmers\textsuperscript{1}
  o Upper airway symptoms: 74\%\textsuperscript{2,3}

✓ Swimmers’ rhinitis\textsuperscript{3}:
  o 63\% Neutrophils
  o 20\% Eosinophils and mast cells
  o 7\% Rhino-sinusitis

✓ Quality of life impaired by rhinitis\textsuperscript{2}

✓ Completely prevented by using a nose-clip\textsuperscript{3}

III. Mechanisms for Airway Disorders
Mechanisms for airway disorders: Exercise as an inducer of AHR?

The prime suspect? Chlorammines

✓ ↑ Oxidative stress in blood\textsuperscript{1,2} and airways\textsuperscript{3} in swimmers

✓ Elevated eNO is strongly associated with indoor pool attendance\textsuperscript{4}

✓ ↑ bronchial epithelium permeability after chlorinated swimming pool’s environment exposure\textsuperscript{4}

✓ The development of asthma is strongly linked to pool attendance before 6-7 years of age\textsuperscript{4}

✓ Lifeguards’ occupational asthma\textsuperscript{5,6}

\textsuperscript{1}Gougoura et al. Eur J Appl Physiol 2007; \textsuperscript{2}Varraso et al. Toxicol Ind Health 2002; \textsuperscript{3}Bougault et al. ERJ 2010; \textsuperscript{4}Bernard et al. 2002, 2006; \textsuperscript{4}Massin et al. Occup Environ Health 1998; \textsuperscript{5}Thickett et al. Eur Respir J 2002;
Chlorine hypothesis

![Diagram showing the effects of chlorine on the skin and respiratory tract.](image)

Fig. (3). Scheme illustrating how chlorine-based oxidants in water or air can disrupt the epithelial barriers of exposed organs and thereby facilitate the penetration of allergens and the allergic sensitization.

IV. Management of Airway Disorders
Prevention/Treatment

✓ **Management** plan for asthma\(^1\) and/or rhinitis\(^2\)

✓ **Prevention:**
  - ↓ chloramines in the air
  - Anti-oxidant supplementation\(^3\)

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\(^1\)Fitch *et al.* *J Allergy Clin Immunol* 2008; \(^2\)Katelaris *et al.* Sports Med 2003 (review); \(^3\)Mickleborough *et al.* *Am J Respir Crit Care Med* 2003;
How to Reduce Chloramines in the Air?
1) To change swimmers’ behaviour

- To respect zones without shoes
- To wear a swimsuit exclusively used for swimming
- To wear a swim cap
- To respect hygiene precautions before entering the pool
- To take off make-up and other cosmetics
- To take a shower with soap
- To pass in a footbath
- To use accessories used only in the pool
2) - Premises’ organization

- No crossing between dirty and clean area
- Footbath should contain chlorine-disinfected water
- To maintain a sufficient ventilation \((60 \text{ m}^3 / \text{hour})\)
- Maximum cut-off for \(\text{NCl}_3\) in the air = 0.3 mg/m\(^3\)
V. Are Airway Disorders Reversible?
Respiratory disorders: A transient phenomenon?¹,²,³

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VI. Conclusion
Clinical consequences and possible effects on performance
Consequences of airway disorders

✓ Famous olympic asthmatic swimmers under treatment:
  o Mark Spitz (7 gold medals in 1972), Tom Dolan (2 gold medals), Alain Bernard, Grant Hackett, …

✓ Clinical consequences and on performance of:
  o EIB:
    • Reduced performance?
    • Development of airway remodelling¹
  o Asymptomatic AHR:
    • Development of a further asthma?²

Should we screen swimmers?
Should we screen swimmers for airway disorders?

✔ Inexpensive pre-screening assessment
  o Questionnaire (AQUA)¹
  o Spirometry
  o Reversibility to a bronchodilator

✔ Swimmers with respiratory symptoms
  o Bronchial provocative challenge²

Acknowledgments
Photo: Yan Doublet

E-mail: valerie.bougault@univ-lille2.fr
Thank you for your attention
Airway remodelling in a swimmer without allergy and without AHR

A: Tenascin
B: Collagen III
C: Collagen I
D: Mucin 5