### Safety of Pediatric Aquatic Therapy—Lungs

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<td>Swimming is often recommended as a sport because of its several benefits to health. It is also recommended in asthmatic children as a sport with a lower potential for prompting exercise-induced asthma. However, there is growing interest in the potentially harmful effects of repeated respiratory tract exposure to chlorinated products and the problem of possible swimming-related health hazards is gaining importance at international level.</td>
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| Airway irritants such as ozone are known to impair lung function and induce airway inflammation. Clara cell protein (CC16) is a small anti-inflammatory protein secreted by the nonciliated bronchiolar Clara cells. CC16 in serum has been proposed as a noninvasive and sensitive marker of lung epithelial injury. In this study, we used lung function and serum CC16 concentration to examine the pulmonary responses to ambient O3 exposure and swimming pool attendance. |

| These O3 levels did not cause any significant changes in mean serum CC16 concentrations before or after outdoor exercise, nor was any decrease in lung function detected. |

| However, children who regularly visited chlorinated indoor swimming pools had significantly lower CC16 levels in serum than did nonswimming children both before and after exercise (respectively, 57 +/- 2.4 and 53 +/- 1.7 microg/L vs. 8.2 +/- 2.8 and 8.0 +/- 2.6 microg/L; p < 0.002). |

| These results indicate that repeated exposure to chlorination by-products in the air of indoor swimming pools has adverse effects on the Clara cell function in children. |

| A possible relation between such damage to Clara cells and pulmonary morbidity (e.g., asthma) should be further investigated. |

Emai: bernard@toxi.ucl.ac.be

To study whether exposure to nitrogen trichloride in indoor chlorinated pools may affect the respiratory epithelium of children and increase the risk of some lung diseases such as asthma.

METHODS: In 226 healthy children, serum surfactant associated proteins A and B (SP-A and SP-B), 16 kDa Clara cell protein (CC16), and IgE were measured. Lung specific proteins were measured in the serum of 16 children and 13 adults before and after exposure to NCl(3) in an indoor chlorinated pool. Relations between pool attendance and asthma prevalence were studied in 1881 children. Asthma was screened with the exercise induced bronchoconstriction test (EIB).

RESULTS: Pool attendance was the most consistent predictor of lung epithelium permeability. A positive dose-effect relation was found with cumulated pool attendance and serum SP-A and SP-B. Serum IgE was unrelated to pool attendance, but correlated positively with lung hyperpermeability as assessed by serum SP-B. Changes in serum levels of lung proteins were reproduced in children and adults attending an indoor pool. Serum SP-A and SP-B were already significantly increased after one hour on the pool side without swimming. Positive EIB and total asthma prevalence were significantly correlated with cumulated pool attendance indices.

CONCLUSIONS: Regular attendance at chlorinated pools by young children is associated with an exposure dependent increase in lung epithelium permeability and increase in the risk of developing asthma, especially in association with other risk factors. We therefore postulate that the increasing exposure of children to chlorination products in indoor pools might be an important cause of the rising incidence of childhood asthma and allergic diseases in industrialized countries. Further epidemiological studies should be undertaken to test this hypothesis.


Email: bernard@toxi.ucl.ac.be

The pool chlorine hypothesis postulates that the rise in childhood asthma in the developed world could result at least partly from the increasing exposure of children to toxic gases and aerosols contaminating the air of indoor chlorinated pools.

To further assess this hypothesis, we explored the relationships between childhood asthma, atopy, and cumulated pool attendance (CPA). We studied 341 schoolchildren 10-13 years of age who attended at a variable rate the same public pool in Brussels (trichloramine in air, 0.3-0.5 mg/m3).

Examination of the children included a questionnaire, an exercise-induced bronchoconstriction (EIB) test, and the measurement of exhaled nitric oxide (eNO) and total and aeroallergen-specific serum IgE.

CPA by children (range, 0-1,818 hr) emerged among the most consistent predictors of asthma (doctor diagnosed or screened with the EIB test) and of elevated eNO, ranking immediately after atopy and family history of asthma or hay fever.

Although the risk of elevated eNO increased with CPA [odds ratio (OR) = 1.30; 95% confidence interval (CI), 1.10-1.43] independently of total or specific serum IgE, the probability of developing asthma increased with CPA only in children with serum IgE > 100 kIU/L (OR for each 100-hr increase in CPA = 1.79; 95% CI, 1.07-2.72).

All these effects were dose related and most strongly linked to pool attendance before 6-7 years of age.

Use of indoor chlorinated pools especially by young children interacts with atopic status to promote the development of childhood asthma.

These findings further support the hypothesis implicating pool chlorine in the rise of childhood asthma in industrialized countries.

Safety of Pediatric Aquatic Therapy—Lungs

Email: alfred.bernard@uclouvain.be

Exposure of the human population to chlorination products has considerably increased during the 20(th) century especially after the 1960s with the development of public and leisure pools. The present article summarizes current knowledge regarding the human exposure to chlorination products and reviews studies suggesting that these chemicals might be involved in the development or exacerbation of allergic diseases.

- Populations regularly in contact with chlorination products such as swimmers, lifeguards or workers using chlorine as cleaning or bleaching agent show increased risks of allergic diseases or of respiratory disorders frequently associated with allergy.
- Experimental evidence suggests that chlorination products promote allergic sensitization by compromising the permeability or the immunoregulatory function of epithelial barriers.
- These findings led to the chlorine hypothesis proposing that the rise of allergic diseases could result less from the declining exposure to microbial agents (the hygiene hypothesis) than from the increasing and largely uncontrolled exposure to products of chlorination, the most widely used method to achieve hygiene in the developed world.
- Giving the increasing popularity of water recreational areas, there is an obvious need to assess the effects of chlorine-based oxidants on human health and their possible implication in the epidemic of allergic diseases.


Email: mgoodm2@sph.emory.edu

In this meta-analysis, studies on swimming and asthma were divided into four groups: Group I compared frequency of asthma among elite swimmers to that of other athletes; Group II examined the association between asthma and swimming during childhood; Group III evaluated effects of swimming programs on asthma severity and pulmonary function; and Group IV compared immediate respiratory effects of swimming to those of other types of exercise.

- The summary results were expressed as meta-odds ratios (ORs) for binary endpoints such as presence of asthma, and meta-differences for continuous endpoints such as changes in post-exercise pulmonary function tests (PFTs).
- All summary measures of effect were calculated using random effects models accompanied by a corresponding 95% confidence interval (CI) and a test for heterogeneity.
- In the analysis comparing frequency of asthma among elite swimmers to that among other athletes (Group I), meta-ORs ranged from 2.3 to 2.6 with all 95% CIs excluding 1.0. The corresponding meta-ORs reflecting the association between asthma and swimming pool use during childhood (Group II) were in the 0.63-0.82 range and were not statistically significant.
- In comparison to swimming, running and/or cycling was associated with a statistically significant four-to six-fold increase in exercise induced bronchospasm.
- Although asthma is more commonly found among elite swimmers than among other high-level athletes, it is premature to draw conclusions about the causal link between swimming and asthma because most studies available to date used cross-sectional design, because the association is not confirmed among non-competitive swimmers, and because asthmatics may be more likely to select swimming as the activity of choice because of their condition.
### Safety of Pediatric Aquatic Therapy—Lungs

Email: yvonne.schoefer@gsf.de  
Swimming pool attendance and exposure to chlorination by-products showed adverse health effects on children. We assessed whether early swimming pool attendance, especially baby swimming, is related to higher rates of early infections and to the development of allergic diseases.  
| In 2003-2005, 2192 children were analysed for the 6-year follow-up of a prospective birth cohort study. Data on early swimming pool attendance, other lifestyle factors and medical history were collected by parental-administered questionnaire. Bivariate and multivariate logistic regression analyses were used to evaluate associations.  
Babies who did not participate in baby swimming had lower rates of infection in the 1st year of life (i) diarrhoea: OR 0.68 CI 95% 0.54-0.85; (ii) otitis media: OR 0.81 CI 95% 0.62-1.05; (iii) airway infections: OR 0.85 CI 95% 0.67-1.09.  
No clear association could be found between late or non-swimmers and atopic dermatitis or hay fever until the age of 6 years, while higher rates of asthma were found (OR 2.15 95% CI 1.16-3.99), however, potentially due to reverse causation.  
The study indicates that, in terms of infections, baby swimming might not be as harmless as commonly thought.  
Further evidence is needed to make conclusions if the current regulations on chlorine in Germany might not protect swimming pool attendees from an increased risk of gastrointestinal infections. In terms of developing atopic diseases there is no verifiable detrimental effect of early swimming.  
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Email: wenche.nystad@fhi.no  
To estimate the effect of baby swimming in the first 6 months of life on respiratory diseases from 6 to 18 months.  
| METHODS: We used data from The Norwegian Mother and Child Cohort Study (MoBa) conducted by the Norwegian Institute of Public Health in children born between 1999 and 2005 followed from birth to the age of 18 months (n = 30,870). Health outcomes: lower respiratory tract infections (LRTI), wheeze and otitis media between 6 and 18 months of age. Exposure: baby swimming at the age of 6 months. The effect of baby swimming was estimated by logistic regression analysis adjusting for potential confounders.  
RESULTS: About 25% of the children participated in baby swimming. The prevalence of LRTI was 13.3%, wheeze 40.0% and otitis media 30.4%. Children who were baby swimming were not more likely to have LRTI, to wheeze or to have otitis media.  
However, children with atopic mothers who attended baby swimming had an increased risk of wheeze, adjusted odds ratios (aOR) 1.24 (95% CI 1.11, 1.39), but not LRTI or otitis media.  
This was also the case for children without respiratory diseases before 6 months aOR 1.08 (95%CI 1.02-1.15).  
CONCLUSION: Baby swimming may be related to later wheeze. However, these findings warrant further investigation.  
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| bernard a, carbonnelle s, dumont x, nickmilder m. infant swimming practice, pulmonary epithelium integrity, and the risk of allergic and respiratory diseases later in childhood. pediatrics. 2007 jun;119(6):1095-103. |
| METHODS: Clara cell protein, surfactant-associated protein D, and total and aeroallergen-specific immunoglobulin E were measured in the serum of 341 schoolchildren aged 10 to 13 years, among whom 43 had followed an infant swimming program. Asthma was defined as doctor-diagnosed asthma and/or positive exercise-induced bronchoconstriction (15% decrease in postexercise forced expiratory volume). |
| RESULTS: There were no significant differences between the infant swimming group and the other children regarding the levels of exhaled nitric oxide and total or aeroallergen-specific serum immunoglobulin E. Children who swam as infants showed, by contrast, a significant decrease of serum Clara cell protein and of the serum Clara cell protein/surfactant-associated protein D ratio integrating Clara cell damage and permeability changes of the lung epithelial barrier. These effects were associated with higher risks of asthma and of recurrent bronchitis. Passive exposure to tobacco alone had no effect on these outcomes but seemed to interact with infant swimming practice to increase the risk of asthma or of recurrent bronchitis. |
| CONCLUSIONS: Our data suggest that infant swimming practice in chlorinated indoor swimming pools is associated with airways changes that, along with other factors, seem to predispose children to the development of asthma and recurrent bronchitis. |

| zwiener c, richardson sd, de marin i, grumm t, glauner t, frimmel fh. drowning in disinfection byproducts? assessing swimming pool water. environ sci technol. 2008 mar 1;42(5):1812. |
| Precursors of DBPs include human body substances, chemicals used in cosmetics and sun screens, and natural organic matter. Analytical research has focused also on the identification of an additional portion of unknown DBPs using gas chromatography (GC)/mass spectrometry (MS) and liquid chromatography (LC)/MS/MS with derivatization. Children swimmers have an increased risk of developing asthma and infections of the respiratory tract and ear. A 1.6-2.0-fold increased risk for bladder cancer has been associated with swimming or showering/bathing with chlorinated water. Bladder cancer risk from THM exposure (all routes combined) was greatest among those with the GSTT1-1 gene. This suggests a mechanism involving distribution of THMs to the bladder by dermal/inhalation exposure and activation there by GSTT1-1 to mutagens. DBPs may be reduced by engineering and behavioral means, such as applying new oxidation and filtration methods, reducing bromide and iodide in the source water, increasing air circulation in indoor pools, and assuring the cleanliness of swimmers. The positive health effects gained by swimming can be increased by reducing the potential adverse health risks. |
Airway irritants such as ozone are known to impair lung function and induce airway inflammation. Clara cell protein (CC16) is a small anti-inflammatory protein secreted by the nonciliated bronchiolar Clara cells. CC16 in serum has been proposed as a noninvasive and sensitive marker of lung epithelial injury. In this study, we used lung function and serum CC16 concentration to examine the pulmonary responses to ambient O3 exposure and swimming pool attendance.

The measurements were made on 57 children 10-11 years of age before and after outdoor exercise for 2 hr. Individual O3 exposure was estimated as the total exposure dose between 0700 hr until the second blood sample was obtained (mean O3 concentration/m3 times symbol hours). The maximal 1-hr value was 118 microg/m3 (59 ppb), and the individual exposure dose ranged between 352 and 914 microg/m3hr. These O3 levels did not cause any significant changes in mean serum CC16 concentrations before or after outdoor exercise, nor was any decrease in lung function detected.

However, children who regularly visited chlorinated indoor swimming pools had significantly lower CC16 levels in serum than did nonswimming children both before and after exercise (respectively, 57 +/- 2.4 and 53 +/- 2.8 microg/L vs. 8.2 +/- 2.8 and 8.0 +/- 2.6 microg/L; p < 0.002).

These results indicate that repeated exposure to chlorination by-products in the air of indoor swimming pools has adverse effects on the Clara cell function in children.

A possible relation between such damage to Clara cells and pulmonary morbidity (e.g., asthma) should be further investigated.


Email: wenche.nystad@fhi.no

To estimate the association between baby swimming and recurrent respiratory tract infections and otitis media in the first year of life in children of parents without and with atopy.

METHODS: Norwegian schoolchildren (n = 2862) was enrolled in a cross-sectional study of asthma and allergy using the questionnaire of the International Study of Asthma and Allergies in Childhood (ISAAC). The outcomes were parental retrospective report of recurrent respiratory tract infections and otitis media diagnosed by a physician in the first year of life. The exposure was baby swimming during the same period. Parental atopy reflects a history of maternal or paternal asthma, hayfever or eczema.

RESULTS: The prevalence of recurrent respiratory tract infections was higher (12.3%) among children who took part in baby swimming than among those who did not (7.5%). The prevalence of recurrent respiratory tract infections during the first year of life was 5.6% and 10.5%, respectively, in children of parents without and with atopy, whereas the prevalence of baby swimming was 5.6% and 5.1%, respectively, in the two groups. Stratified analysis using parental atopy as strata showed that the increased risk of recurrent respiratory tract infections was only present among children of parents with atopy [adjusted odds ratio (aOR) 2.08, 95% confidence interval (95% CI) 1.08-4.03]. A similar trend was present for otitis media (aOR 1.77, 95% CI 0.96-3.25).

CONCLUSION: The results of this study suggest that baby swimming and infant respiratory health may be linked. The findings need to be examined in a longitudinal study.

E-mail: j.h.jacobs@iras.uu.nl.

The association between swimming pool characteristics and activities of employees and respiratory symptoms in employees was studied.

Trichloramine levels were measured to evaluate relationships with pool characteristics and to estimate long-term exposure levels. Questionnaires were available from 624 pool workers and 38 swimming facilities. Chloramine levels were measured by area sampling over 2-h periods and analysed using ion chromatography. Work-related and general respiratory symptoms, and symptoms indicative of atopy and bronchial hyperresponsiveness were considered. Respiratory symptom prevalence among pool workers was compared with symptoms in a Dutch population sample. Chloramine levels were modelled with regression analysis. This model was used to estimate long-term average chloramine levels with greater frequency. Upper respiratory symptoms were statistically significantly associated with cumulative chloramine levels (odds ratio (OR) >1.4 for hoarseness, lost voice, sinusitis). General respiratory symptoms were significantly elevated compared with a Dutch population sample (OR ranged 1.4-7.2).

An excess risk for respiratory symptoms indicative of asthma was observed in swimming pool employees. Aggravation of existing respiratory disease or interactions between irritants and allergen exposures are the most likely explanations for the observed associations.


Email: kt01265702@blueyonder.co.uk

The first series of three workers who developed occupational asthma following exposure to airborne chloramines in indoor chlorinated swimming pools is reported.

Health problems of swimmers in indoor pools have traditionally been attributed to the chlorine in the water. Chlorine reacts with bodily proteins to form chloramines; the most volatile and prevalent in the air above swimming pools is nitrogen trichloride. Two lifeguards and one swimming teacher with symptoms suggestive of occupational asthma kept 2-hourly measurements of peak expiratory flow at home and at work, analysed using the occupational asthma system (OASYS) plotter, and/or had specific bronchial challenge testing to nitrogen trichloride, or a workplace challenge. Air measurement in one of the pools showed the nitrogen trichloride levels to be 0.1-0.57 mg m(-3), which was similar to other studies. Two workers had peak expiratory flow measurements showing occupational asthma (OASYS-2 scores 2.88 and 3.8), both had a positive specific challenge to nitrogen trichloride at 0.5 mg m(-3) with negative challenges to chlorine released from sodium hypochlorite. The third worker had a positive workplace challenge.

Swimming-pool asthma due to airborne nitrogen trichloride can occur in workers who do not enter the water because of this chloramine. The air above indoor swimming pools therefore needs to be assessed and managed as carefully as the water.