

Pro: Swimming in Chlorinated Pools and Risk of Asthma We Can Now Carry On Sending Our Children to Swimming Pools!

“The *pool chlorine hypothesis* is the hypothesis that long-term attendance at indoor chlorinated swimming pools by children up to the age of about 6–7 years is a major factor in the rise of asthma in rich countries since the late twentieth century” (see the Wikipedia entry on the pool chlorine hypothesis [1]).

For many years, pediatricians and families have generally considered swimming as a healthy form of exercise for children. It is commonly believed to be the most appropriate sport for children with asthma, too, because it is less asthmagenic than other types of exercise and it may have beneficial effects on disease severity (2).

In the last decade, however, we have been reading warnings about a potential asthma risk for children swimming regularly in chlorinated pools (3–5), and an association has been suggested between the prevalence of childhood asthma and the number of pools per European inhabitant (6).

Should we reconsider our views? It was clearly important to take a closer look at the influence of swimming pool attendance on the burden of asthma and ensure that all parties concerned, including physicians, families, patients, professional operators, and regulatory authorities, are properly informed. Given the relevance of this issue to public health at international level, some reviews, including a meta-analysis, assessed the available literature on the subject (2, 7, 8): the opinion shared by the authors is that current evidence based on cross-sectional studies may be suggestive, but not conclusive. They consequently recommended prospective studies on large samples before any final conclusions can be drawn and public action taken, if necessary.

In this issue of the *Journal*, Font-Ribera and coworkers (pp. 582–588) provide a timely report on the first prospective study assessing the risk of new-onset asthma associated with swimming pool attendance in childhood (9). The authors followed up 5,738 British children (the ALSPAC Child Cohort) from birth to the age of 10 years and showed that attending swimming pools did not increase their asthma risk. Quite the reverse, this practice appeared to be associated with better lung function and fewer respiratory symptoms, particularly in children with asthma (9).

The value of these results is strongly supported by the study’s prospective design, which is a sort of “natural experiment” covering the first decade of the children’s lives, based on validated epidemiologic tools and laboratory investigations, including measurements of lung function, exhaled nitric oxide, and bronchial hyperresponsiveness.

Given the study’s dependable design, its findings cast this hot topic in a rather different light and challenge the messages coming from recent cross-sectional studies in favor of the pool chlorine hypothesis (3–5). The results of the Font-Ribera and coworkers’ analytical follow-up (9) appear to be consistent with earlier data from several cross-sectional investigations conducted in various countries around the world, which confirmed the benefits of swimming in childhood (2, 10, 11). Though the data from the Font-Ribera study (9) are quite reassuring for the general pediatric population, mostly consisting of recreational swimmers, the issue is

still debated for elite swimmers, who are notoriously more susceptible to asthma-like symptoms. For competitive swimmers, indeed, some studies have demonstrated chronic nasal symptoms (12) and a high prevalence of bronchial reactivity on exercise challenge tests (13). Studies on elite swimmers have reported neutrophilic airway inflammation (14), and it has been suggested more recently that a noncellular (possibly neurogenic) inflammation may be involved in airway dysfunction in competitive swimmers (15). The lack of any increase in exhaled nitric oxide in swimmers reported in previous studies (13, 14, 16) suggests that the combined exposure to chlorine and the physical exertion of swimming is presumably unassociated with any eosinophilic “asthma-like” inflammation, although other inflammatory patterns may be elicited. These findings are hardly consistent with the classic phenotype of childhood asthma, which is characterized mainly by eosinophilic airway inflammation, therefore poorly fitting the “pool chlorine hypothesis” for asthma burden. The differences in genetic background and their consequences on the effect of exposure to chlorinated pool environments may represent a crucial issue to consider when evaluating data from heterogeneous cohorts. In this regard, Font-Ribera and coworkers managed to correct for the most significant confounders, including family and individual risk of atopic diseases (9).

What else is worth noting in the study by Font-Ribera and coworkers? Despite a previous study (6) finding a few years ago that the association between the prevalence of wheezing and the availability of swimming pools was strongest in Northern Europe, the reassuring results of the ALSPAC study were recorded in the United Kingdom, where the climate is bound to make children use mainly indoor pools and therefore be heavily exposed to chlorinated products.

Although the findings in the ALSPAC cohort are distinctly reassuring as regards the safety of indoor swimming pools for children, we cannot disregard the health risks of excessive exposure to chlorine derivatives due to unnecessary overchlorination of the water or to acute chlorine inhalation caused by swimming pool accidents. Every effort should be made to minimize the potential hazards of higher than necessary disinfection by-product (DBP) levels (8).

Focusing on possible thresholds for exposure to DBPs, we also need to consider that individual response to chemical irritants may be influenced by a genetic variability, so it would be worth investigating inter-individual susceptibility to the detrimental effects of DBPs on the respiratory system with a view to identifying children who might be genetically liable or predisposed to lung damage.

Furthermore, airway damage in elite swimmers is still being debated in adolescents (13, 14), but has been well demonstrated in adults (14).

A deeper insight on the effects of chlorine exposure in children over time is therefore definitely warranted to better address the temporal nature of potential adverse effects of chlorine in swimmers.

In conclusion, discrepancies in experimental designs, such as the choice of populations and the intensity and timing of exposure, could account for the different results of currently

available reports. The findings in the ALSPAC cohort, the first prospective study focusing on the asthma risk related to chlorinated swimming pools, are reassuring, however, and suggest that recreational swimming in chlorinated pools does not raise the risk of asthma and allergic symptoms in children. The relevance of this topic to public health, nonetheless, means that further longitudinal studies are certainly warranted to reinforce the evidence in favor of the safety of children swimming in public pools.

At this point, we would encourage the authors of the *Wikipedia* page on the “pool chlorine hypothesis” (1) to reconsider their alarming report, possibly adopting a more positive and reassuring tone for recreational swimmers.

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Con: Respiratory Risks Associated with Chlorinated Swimming Pools

A Complex Pattern of Exposure and Effects

Chlorine used to disinfect swimming pools, and its derivatives, are well-known irritants of the skin, eyes, and of the upper respiratory tract. For a long time, the irritating effects of these substances have been regarded as a mere source of discomfort for swimmers and unlikely to cause adverse effects outside accidental exposures. In this issue of the *Journal* (pp. 582–588), Font-Ribera and coworkers report the results that support this view (1). These authors studied a cohort of 5,738 children born in 1991–1992 (the ALSPAC cohort) who were followed up until the age of 10 years. Data collected by questionnaire until the age of 7 years show no increase of ever-diagnosed asthma with the frequency of swimming, even when considering only children with atopy. In addition, no association was found with atopy screened at age 7–8 years, or with any current asthma or respiratory symptom that were recorded till the age of 10 years. There was even an improvement of lung function measured at

7–8 years, and at 10 years a decreased risk of asthma symptoms was seen in children with pre-existing respiratory conditions.

And yet, the idea that chlorination products (CPs) contaminating the air of swimming pools pose no risk to swimmers is increasingly challenged by reports of respiratory problems among swimming pool attendees. Studies conducted in France (2), in The Netherlands (3), and in Italy (4) clearly show that swimming pool workers, and in particular lifeguards and trainers, are at increased risk of developing irritation and asthma symptoms. The agent responsible for the effects is most probably trichloramine (also called nitrogen trichloride), the gas that gives indoor pools their typical smell and can induce occupational asthma in lifeguards (5). Regarding swimmers, it has been known for more than two decades that elite swimmers present a higher prevalence of asthma, rhinitis, and respiratory allergies than do other athletes (6–8). This poorer respiratory health of

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