REVIEW

Swimming pools water treatment ant its Health impact. State of the art

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ABSTRACT

Swimming and the various aquatic activities performed in indoor swimming pools are not only practised by thousands of individuals daily but are also highly recommended for rehabilitation in patients with musculoskeletal processes to aid mobility and muscle activation; furthermore, these activities are also useful in patients with exercise-induced asthma and some other respiratory diseases, since the warm, moist air is less likely to provoke an attack. However, in the last decade, concern has arisen on whether direct contact with the compounds used in water disinfection could alter bronchial reactivity in swimming-pool users and could also be a triggering factor for asthma in predisposed children. The present review evaluates research articles on this subject and, especially, discussions on these articles, to create an objective view of the state of the question. In particular, the final aim is to provide recommendations based on the experience of these studies to stimulate swimming pool users to avoid contamination and preserve their health and that of their children, to train monitors and trainers in these matters and, lastly, to increase awareness among the managers of installations of the impact of disinfecting compounds on health.

KEY WORDS: Water treatment. Closed swimming pool. Disinfecting compounds.

RESUMEN

La natación y las diversas actividades acuáticas realizadas en piscinas cubiertas, además de ser actividades deportivas practicadas por miles de individuos diariamente, son una herramienta de rehabilitación muy recomendada en pacientes con procesos limitantes del sistema musculoesquelético con el objeto de facilitar su movilización y su activación, y en pacientes con asma de esfuerzo y ciertas enfermedades respiratorias por su poca asmogenicidad al ser un ambiente cálido y húmedo. Sin embargo, en esta última década ha surgido la inquietud de si el contacto directo de los compuestos utilizados en la desinfección del agua pudiera no sólo ser un elemento importante en la alteración de la reactividad bronquial del usuario de la piscina, sino también ser un desencadenante de la aparición de asma en sujetos predispuestos en edad pediátrica. En la presente revisión se valoran los artículos de investigación y, sobre todo, las discusiones sobre ellos, con el objeto de crear una visión objetiva de dónde estamos hoy con respecto a este asunto. Pero sobre todo, el objetivo final es ofrecer recomendaciones basadas en la experiencia de esos estudios que estimulen al usuario de las piscinas a no contaminar y a preservar su salud y la de sus congéneres, a formar a los monitores y educadores de los practicantes en ese mismo sentido y, por último y no menos importante, a los responsables de la gestión de las instalaciones para concienciarlos de la importancia de su trabajo en el bien de los demás.

PALABRAS CLAVE: Tratamiento del agua. Piscina cubierta. Componentes de desinfección.

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Introduction

The hydrostatic balance offered by water can facilitate the movement of extremities and can decrease the effect of compression on the spinal column which in turn can allow for posture variation and different muscular group action. This is one of the reasons why swimming and other aquatic activities are considered to be so suitable for people who have difficulty for moving, be it due to a rheumatic-type inflammation, a neurological problem, injury or simply overweight. Swimming is also considered to be good for patients with asthma and certain respiratory diseases. As well being a more comfortable activity for people whose initial physical condition may not be quite as robust as others, the presence of a warm and humid atmosphere which prevents heat and humidity loss through air (fundamental stimulus for the onset of asthma), makes this initially a safe activity. We know that there are many asthmatic sports people at international levels whose sport is, or was, water-related.[1,2] However, practicing aquatic sports in a covered swimming pool means that, although the individual is breathing in a warm and humid atmosphere, he/she is also inhaling volatile compounds which are in the water. This requires treatment which is based fundamentally on chlorine and its derivatives, so as to avoid contamination and consequent infections. Chlorine is a yellowy-green gas with a characteristic smell. It is used in the sterilisation of our water supply and in swimming pools. It is a potent irritant of the mucous membranes, eyes and skin and exposure to it can cause pulmonary irritation. Its toxic effect has been known for over 100 years, with its use being widely known during the First World War in Ypres in 1915. The occasional exposure of humans to air with large quantities of chlorine has been written about in diverse medical literature.[3,4] Such situations occur in areas where work involves direct or indirect contact with these compounds, and inhalation is due most often to unfortunate accidents. Outside of such work places, the most common place for exposure to chlorine is in swimming pools. For many years, the most significant effects to chlorine exposure on swimmers has been the sudden occurrence of obstruction to a swimmer's airways,[5] together with increase in sensitivity to aeroallegens[6] and a high prevalence to bronchial hyperactivity in the presence of methacholine.[7] However, there are two main points to note for swimming pool users. Firstly, some studies have highlighted the significance of the respiratory apparatus coming into contact with these oxide compounds and they show concern over alterations recorded in the respiratory epithelium in young users of public swimming pools, associating these alterations to the onset of asthma and allergies in future life.[8-11] Secondly, studies have looked at the possible implication that contact with these compounds has a potentially carcinogenic effect on the future of the individual.[12]

Table I Benefits of swimming

Benefits for the body's development
Requires the use of large groups of muscles
Muscle toning
Improvement to the general physical state, stamina, power supply, flexibility
Improvement to articular movement
Improvement to body composition
Benefits to the development of motor coordination
Coordination of movement
Relaxation
Acquisition of new movement experiences
Improvement and development of coordination abilities such as rhythm, laterality, etc.
Benefits to the improvement of posture
Strengthening of the muscles in the vertebral column area
Releasing the load on the vertebral column
Benefits to the social sphere
Benefits to certain chronic diseases
Respiratory
Obesity
Muscular-skeletal
Acute: injuries, exacerbation of rheumatic and neurological disorders
Chronic: Rheumatoid disorder, neurological, osteoarthritis

These are some of the benefits attributed to practising organised and guided aquatic activities. As well as an improvement to a person's general physical condition, there are very beneficial aspects related to achieving hydrostatic balance in the water, above all for those people who have trouble getting around or moving their extremities for numerous causes.

Effects during childhood

The inhalation of irritant compounds at an early age has been considered by some investigators to have an inducing effect on the onset of asthma and respiratory disorders in individuals with a certain predisposition.[13,14] The respiratory system is a developing organ during the first years of life and is continuously adapting to the external environment from then on. Its basic function is to help with gas exchange so as to facilitate breathing. Direct contact with the external environment requires the respiratory system to have suitable defence mechanisms and be adapted sufficiently so as to cope with the substances and germs found in the external environment. Respiratory infections caused by intra and extra-

cellular microbes, and contact with environmental contaminants due to oxidative stress in the mucous membranes during the first years of life, have a modulating effect on inflammation and response to it in children who are predisposed to asthma or who suffer from allergies of some description, which can then lead to the onset of these illnesses in the future. Furthermore, in swimmers who are in contact with chlorine for various hours/day, many days a week they have an adaptive modification at a respiratory system defence-cell level[15] so as to cope with the continuous contact with chlorine derivatives. This is very different to the system in sports people who practice other sports, whether they are asthmatic or not. This alteration, known as the humoral system, is accompanied by an increase in bronchial response when assessed using unspecific methods, such as the response to methacholine[16,17].

However, a recent epidemiological study[18] refutes this and clears up certain doubts regarding the belief by some authors that chlorine in swimming pools provokes asthma in the next future. According to this meta-analysis, it is shown that swimming in infancy is NOT a factor which predisposes the swimmer to asthma. Only sports people who are swimmers and who train for many hours in the swimming pool from childhood, during their adolescence and throughout their competing years, have a higher predisposition to have bronchial hyperactivity which cannot be diagnosed as asthma right away.

Effects of chlorine on the respiratory tract

Explaining this can be done by looking at exposure to chlorine for long periods of time, continuously, from early ages and in those with a great respiration volume with high tidal volumes. In general, chlorine levels are low in the swimmingly pool environment where the swimmer is breathing and they are usually within the maximum established limits for a work place.[17] When we consider the volumes which are inhaled during a training session for a sports person of a certain level, we can see that the quantity of chlorine inhaled is the same or higher than the maximum allowed (and this occurs every day of the week, most days of the year.)[20]

Substances which release chlorine, bleaching soda and isocyanuric chlorine acid are frequently used in the disinfection of swimming pool water. Chlorine starts a reaction with the pollutants introduced by the swimmer (sweat, urine and various other dirt particles) and forms aldehydes, halogen hydrocarbons and chloramines. Some of these compounds can be transferred into the air around the swimming pool in the form of a gas or tiny drops of water. The irritant effects from these are attributed to the presence of the compounds which act as oxidants[21] on the mucous membranes (eyes, nose, throat or airways.)[22] The most volatile product and the one which is found in the highest concentrations in the respiratory area of the swimmer is the chloramines.[23] It is a highly irritating gas and without doubt, is one of the gases which is responsible for annoyance and irritation for the swimming pool attendants and users[24,25] and has been considered to be the cause of alterations in lung permeability when seen in high doses.[26-28]

To date, the effects have been assessed in an isolated manner, i.e. following intoxication or in a person's follow up in a study. At no point however, has the model of exposure been determined, and exposure of the respiratory tracts has been associated with the body's response. This is understood to be exposure of the respiratory tracts to compounds which are found within the permitted range as set out by current legislation.

In any case, the effect should not cause alarm as if high levels of sports hygiene are adhered to and guidelines are followed, the possible harmful effects of inhalation of the compounds found in the air will not have a negative effect, and all the beneficial effects of practising an aquatic-based sport are still valid.

Effects of these compounds on other organs and systems

The effects of the oxidants used for asepsis of swimming pool water can have a direct undesirable effect due to their oxidising effect on the epithelium of the person using the water. This has been shown to be the case for many years and can also be linked to infections caused by badly disinfected water.[29] It has been seen to alter skin and mucous membranes (oral, conjunctive, genital), the ear canal,[30,31] and even tooth enamel,[32,33] or the more delicate tissue such as the cornea.[34,35] However, in the case of skin sensitivity, it must be taken into account that almost 50% of humans have a certain hypersensitivity to particular substances,[36] and are generally sensitive to diverse, non-specific biocides.

In the case of mucous membranes being affected, as well as the direct chemical effect on the cellular tissue, over-cleaning of the area can eliminate good bacterium, leaving this area to be colonised by other types of bacterium. In the ear canal, as well as over-cleaning, elimination of wax protection, the effect of the oxidant compound, scrubbing with cotton wool and thereby eroding the skin of the ear canal thus easing access for

Table II Possible harmful effects of swimming in covered swimming pools due to contact with compounds commonly used in disinfecting the water

Alteration of the skin and appendages[a]
Eczema, delicate, dry or pruritic skin
Infections: furunculosis, conjunctivitis, otitis, sinusitis, epidermophytosis
Alterations to the characteristics of hair, modification to certain dye colour, etc.
Affect on the respiratory system
Respiratory difficulty
Facilitation of the development of asthma and allergies in those people who are already predisposed
Upper respiratory tract infection
Rhinitis and nasal obstruction

These are some of the harmful effects that can occur when practising aquatic activities for individuals that are predisposed or in installations with bad environmental conditions or that are incorrectly controlled.
[a]Appendages refers to the permanent body structures such as nails, hair, etc.

Table III Not scientific evidenced

With the aim of reducing the presence of disinfection compounds, the best way to do this is to try to minimise their presence. This can be done in the following ways:
- Always have a shower before getting in the swimming pool using a suitable soap
- Use soap when showering prior to swimming
- Use a clean swimming costume every day
- Urinate before showering and always before getting into the swimming pool
- Try to avoid going swimming if you have had an infection, most importantly, one of a digestive nature, until it is completely cured

Recommendations for the regular swimmer:
- Always shower before getting into the swimming pool using a suitable soap
- Get into the habit of applying hydrating cream or lotion to the skin, hair and nails after swimming
- Do not keep the same swimming kit in a sports bag for use on the following day/s
- When walking around the swimming pool areas, wear your own footwear. Keep it dry and clean it well at least once a week
- Use a clean towel each time to dry off

Indications for the swimmer with a respiratory condition (as well as the previous indications):
- Do not use the swimming pool when the respiratory process is exacerbated
- Do not use the swimming pool when suffering from an active respiratory infection
- Do not use the swimming pool with active rhinosinusal symptoms
- ALWAYS take any medication prior to exercising, following consultation with a specialist, even if there are no symptoms showing.

harmful germs, and the use of ear plugs which cause the area to become soaked due to excessive humidity, are all factors which can create inflammation and infection.

In this document we basically refer to the impact of chlorine on the health of the individual, but it is certain that other elements used in the asepsis of water can act in a similarly harmful way. Bromine also affects the skin and the appendages in sensitive individuals,[37] and can also affect the respiratory apparatus.[38] The direct effect of ozone on the respiratory epithelium is already known both for individuals who are exercising and those who are not.[39] This effect is undoubtedly more intense when the activity is also taking place where chlorine is present.[40]

Long term effects

Alterations to the epithelium can cause enough irritation to the individual to lead them to cease swimming activities for a period of time. The use of suitable protective creams, taking and applying probiotics[41] and the protection and care of ocular and auricular hygiene can ease recovery and avoid relapses. However, the best preventative measure is to not come into contact with the harmful compound, changing pool if it isn't possible for the properties of the water to be adequately changed.

One long term effect which has recently been assessed and has not been ruled out as having important epidemiological effects, is the generation of tumoural pathologies derived from the products used to disinfect the water when they are ingested in our drinking water supply.[42,43] Currently, it would be hazardous to claim that this risk, if it exists, is important for the recreational or occasional user of a swimming pool than the risk produced by drinking water with these compounds. Research into this aspect is currently ongoing and its exact impact will not be known for some time.[44,45]

Conclusions

- Swimming is healthy in many aspects when it is carried out in a safe environment with suitable guidance.
- The compounds used in the disinfection of water do not cause disorders in the human being if they are used in the right concentrations and the subject only remains in the water for a moderate amount of time. Only sensitive individuals are susceptible to present some symptoms in these conditions.

- Sensitive subjects or those with respiratory illnesses, allergies or dermatological problems tend to show the effects of excess of these compounds before others.
- Swimming in childhood does not produce asthma, and it is still to be determined whether or not it is true that individuals with a predisposition to asthma will show it at an earlier stage.
- In any case, currently, it can't be said that swimming is the ideal sport for the asthmatic, as it was said some years ago.
- Competitive swimmer who trains in the swimming pool for long periods of time and over many years tends to suffer more frequently from hypersensitivity in their respiratory apparatus with symptoms such as asthma, and it is treated in the same way. It is not asthma, and it disappears when the sporting activity ceases.
- Contact with swimming pool water does not cause cancer, nor make a person susceptible to it.

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