Editorial

Role of aquatic therapy and speleotherapy as complementary therapies in the respiratory system

Theodoros Karampitsakos[1], Katerina Dimakou[1], Demosthenes Bouros[2]

[1]5th Department of Pneumonology, Hospital for Diseases of the Chest, "Sotiria", Athens, Greece
[2]First Academic Department of Pneumonology, Hospital for Diseases of the Chest, "Sotiria", Medical School, National and Kapodistrian University of Athens, Athens, Greece

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Correspondence:
Prof. Demosthenes Bouros MD, PhD, FERS, FAPSR, FCCP
Athens Chest Diseases Hospital 'Sotiria',
152 Messogion Av., Athens 11527, Greece
E-mail: debouros@med.uoa.gr, debouros@gmail.com

INTRODUCTION

Complementary therapies, either water-based or in subterranean environment, have been suggested as an option in disorders of various systems including the respiratory system. The use of water as complementary is probably as old as mankind. Egyptian, Roman, Persian, Chinese and Greek ancient cultures often used warm and cold water as treatment[1,2]. Hippocrates underlined the importance of water on body health in his book ''On Airs, Water and Places". Bathing represented a common therapeutic approach in the temples of Asclepius. Plato perceived water as one of four body humors, while Thales as the basis of everything[3,4]. Currently, aquatic therapy encompasses a broad range of therapeutic methods including hydrotherapy, balneotherapy, spa therapy and physiotherapy that take advantage of the physical properties of water for therapeutic purposes[3]. Definitions of aquatic therapeutic methods are frequently confused. The terms balneotherapy and hydrotherapy tend to be used interchangeably. Nonetheless, hydrotherapy represents a complementary therapy that uses water temperature and pressure as therapeutic agent[5]. On the contrary to hydrotherapy, balneotherapy uses thermal mineral water from natural springs, natural gases (CO_2, iodine, sulfur, radon, hydrogen sulfide) and edaphic remedies. Balneotherapy is often used synonymously for spa therapy, as it is usually practiced in spas[5]. Speleotherapy represents also another type of complementary therapy, which takes advantage of the subterranean environment[6]. This review summarizes the current state of knowledge regarding the effect of these approaches on the respiratory system.

EFFECT ON THE RESPIRATORY SYSTEM

A significant fact in favor of aquatic exercise for the respiratory system is that during aquatic treadmill running, oxygen consumption (VO_2) is 3 times greater at a given speed of ambulation in water than on land. Thus, a training effect may be achieved at a significantly slower speed than on land[7]. Studies investigating water immersion up-to shoulder levels at different temperatures (25°C, 34°C, and 40°C) showed increased metabolic

rate and VO2 only at 25°C[8]. Two main factors associated with oxygen transport during immersion are temperature and hydrostatic pressure[8]. Oxygen transport was improved above neutral temperature, due to increase in cardiac output resulting from the combined actions of hydrostatic counter pressure and body heating [8,9].The immediate effect of body's immersion in water up to the neck is a decrease in vital capacity (VC) by 7-9%; therefore, the applicability of water immersion exercise for patients with low values remains debatable[10]. However, values of vital capacity increase significantly after a six-month program[10]. Furthermore, VC seems to increase when bath temperature increases. Tidal volume (TV) also increases in cold or hot water compared to thermo neutral water (i.e., TV 40°C >34°C <25°C)[11]. Cold water immersion is also associated with a decrease in $paCO_2$[12]. In the context of inhalation of hot air, no significant impact on overall symptom severity has been detected[13].

Balneotherapy reduces also pain and improves respiratory muscles function[14]. With regards to speleotherapy, several components of the subterranean environment (normal biotic conditions, low mobility of air, low levels of dust, high rate of air ionization and radiation level) are considered beneficial for the respiratory system. Four forms of radiation can be used in patients with respiratory diseases - high level due to radon, moderate level - to potassium -40, normal level - to normal karst rock, and low level - to common salt rock (halite)[6].

Respiratory diseases had been widely considered a contraindication for aquatic therapy[3]. However, more recent evidence shows a beneficial role, if applied appropriately. Among respiratory disorders, the role of aquatic therapy is best studied in patients with asthma and chronic obstructive pulmonary disease(COPD). Therefore, results for these diseases are presented in detail. Furthermore, balneotherapy seems to be beneficial for patients with connective tissue disorders and especially for patients with rheumatoid arthritis; thus, this method might have a beneficial effect for patients with an underlying connective tissue disease-related-respiratory disorder[14]. Caution is required for hydrotherapy in patients with bronchiectasis, as recreational and therapeutic amenities involving the use of water might represent a potential source of Pseudomonas aeruginosa for susceptible patient groups[15].

With regards to the application of speleotherapy in respiratory diseases, this method has been most studied in patients with obstructive diseases and especially in patients with asthma[2,6]. There is also limited evidence supporting its role in patients with bronchiectasis[16]. Table 1 summarizes the most well studied complementary therapies in patients with respiratory diseases.

TABLE 1. The most well studied complementary therapies in patients with respiratory diseases

Authors	Disease	Main intervention	Year
Wadell	COPD	Beneficial role of high intensity water training 3 times per week for 12 weeks at 34 °C plus land training	2004
Kurabayashi	COPD	Beneficial role of breathing exercises at 38 °C water 30 mins per day, 5 days per week for 2 months	2000
Severino	COPD	Beneficial role of hydrotherapy combined with pulmonary rehabilitation	2007
Rae	COPD	Beneficial role of submaximal upper body muscle physical training in a waterpool temperature of 32 °C	2009
Vu	COPD	Spa Therapy reduces residual volume	2005
McNamara	COPD	Head out of water immersion improves exercise capacity and quality of life	2013
Baldi	COPD	Positive effect of mud bath therapy on respiratory muscles function	2015
Novotny	Asthma	3 week sessions of speleotherapy improve lung function	1994
Vu	Asthma	Spa therapy reduces bronchial sensitivity	2004
Moore	Bronchiectasis	Increased risk for Pseudomonas aeruginosa in pool-based therapies	2002
Falagas	CTDs	Beneficial role of balneotherapy for connective tissue disorders	2012

PATIENTS WITH ASTHMA

Asthma was considered a contraindication for hydrotherapy, thus there are limited studies in the field[17]. Hydrogen sulfide seemed to represent a risk factor for exacerbation of asthma[17]. Nonetheless, more recent data present debatable and conflicting results[18-20]. Furthermore, spa therapy seems to be beneficial in patients with asthma[21]. A study reported that spa therapy reduces bronchial sensitivity and could reduce corticosteroids dosage[21]. However, this result remains to be validated.

Speleotherapy, the use of subterranean environment, has been also investigated in patients with asthma and it was referred in Global Initiative for Asthma (GINA) guidelines as a possible complementary therapy[22]. Several components of the subterranean environment (absence of normal biotic conditions, low mobility of air, low levels of dust, high rate of air ionization, radiation level) have been suggested to play a role in the treatment of asthma[6]. The main curative factors of speleotherapy in caves and mines for patients with asthma are thought to be air quality, underground climate and radiation. A slight improvement of lung function and a significant difference in terms of MEF25% and MEF50% has been reported after a 3-week radon-based- speleotherapy[6]. However, currently there is insufficient evidence to assess reliably whether speleotherapy is beneficial for patients with asthma. Therefore, further studies are needed.

PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

Patients with COPD is the most well studied population in water-based interventions; yet, data for the effectiveness of therapeutic aquatic exercise interventions in patients with COPD are still limited and there is minimal high quality evidence of its efficacy. However, on the contrary to past speculations, accumulating body of evidence shows that aquatic therapy represents a safe procedure for patients with COPD, if applied appropriately[23,24]. Studies applied therapeutic aquatic exercise with an intensity ranging from 50% to 90% of VO_2max. Patients underwent sessions of 30-50 minutes 2 to 5 days per week for 8 to 24 weeks at water temperature between 29 °C and 38 °C.

Grade A recommendation was derived from a study showing that high intensity water training 3 times per week for 12 weeks, engaged with land training, improves muscle performance and health-related quality of life in patients with moderate to severe COPD[25].Furthermore, breathing exercises in a pool filled with 38 °C water 30 minutes per day, 5 days per week for 2 months is useful in the rehabilitation of emphysema[26].

With regards to **Grade B** recommendations, breathing exercises in water at 38 °C increase cardiac output and strengthen the diaphragm, resulting in a decreased dead space[5]. Hydrotherapy has been also associated with an increase in ejection fraction and FEV_1 and a decrease in PaCO2 in patients with COPD who do not present with very low baseline values[27]. Therefore, it was suggested that hydrotherapy in a pool at 38 °C for 30 min per day, 6 days per week, for 2 months could improve cardiac and respiratory function in patients with COPD. Furthermore, hydrotherapy combined with pulmonary rehabilitation seems to lead to better outcome in comparison to pulmonary rehabilitation alone[28].

Studies resulting in **Grade C** recommendations were rather heterogeneous according to functional and clinical variables used. A 15-min session of submaximal upper body muscle physical training in a waterpool temperature of 32 °C is feasible and safe for nonhypoxemic, normotensive COPD patients without heart failure[23,29].

With regards to **Grade D** recommendations, a study showed that complex spa therapy (swimming in a hot spring pool for 30 minutes 5 days per week and inhalation of 1 mL of iodine salt solution) reduces residual volume (RV)[30].

More recent studies have shown that aquatic therapy is a safe choice for patients with moderate to severe COPD, leading to better physical ability than land exercise[24,31]. Furthermore, **head out of water immersion** (HOWI), previously contraindicated for patients with COPD, seems to be safe and leads to improved exercise capacity and quality of life[32].

Recently published data showed that **mud bath therapy** (MBT) had a positive effect on endurance time and on parameters associated with respiratory muscles function, thus suggesting this method as a possible alternative[33]. Furthermore, **hydrogen sulfide** (H2S) had been widely considered detrimental for patients with asthma[19]; yetthere is evidence showing that long-term H2S exposure (even at the relatively high ambient concentrations found in areas such as Rotorua) is not associated with an increased risk for COPD and inhalation of gas containing thermal hydrogen sulfate lowers the viscosity of sputum[18].

Finally, studies investigating the effect of **speleotherapy** in patients with COPD are limited. Various case control studies have reported an improvement in quality of life, FEV_1, paO_2, $paCO_2$[2]. However, there is still lack of

high quality research in the field. Therefore, currently recommendation for speleotherapy in patients with COPD cannot be made.

Collectively, aquatic therapy is safe for patients with COPD, if applied appropriately. Patients with COPD might not afford land training and aquatic therapy represents an alternative, which could lead to better outcome regarding quality of life. Further studies investigating its efficacy are sorely needed.

CONCLUSION

Complementary therapies, either water-based or in subterranean environment, have been suggested in patients with respiratory diseases. Water has been widely used in the management of various diseases, since the earliest recorded history. The applicability of water-based therapies in patients with respiratory disorders had been debatable. However, more recent evidence shows that aquatic therapy is safe and could have a complementary role in the therapeutic management, if applied appropriately. Speleotherapy is best studied in patients with asthma and was previously reported in GINA guidelines. Nonetheless, data are still limited and there is minimal high quality evidence of its efficacy. Therefore, further studies investigating the effect of these complementary therapies on the respiratory system are anticipated.

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