Review Article of GARD Section

# Balneotherapy and hydrotherapy in chronic respiratory disease

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**Abstract:** Chronic respiratory diseases (CRD) belong to major noncommunicable diseases (NCD) targeted by World Health Organization (WHO) NCD Action Plan and United Nations (UN) Sustainable Development Goal (STG) 3.4 to achieve 30% decline of mortality by the year 2030. Strong evidence is now available in the literature for therapeutic aquatic exercise interventions in improving health status of chronic obstructive pulmonary diseases (COPD) patients. However, gym-based exercises can be difficult for patients with COPD who are mainly elderly and often have co-morbidities—such as severe arthritis and obesity—which may impair their ability to exercise at an adequate intensity. Besides improving respiratory function and health status in COPD, exercise in water helps overcoming patient's fears and promote socialization, contrasting the risk of depression, which is a major condition often associated with long term COPD condition. Susceptibility to respiratory infections plays a role in exacerbations of COPD. Sulphur-rich water inhalations improve muco-ciliary clearance, reduce inflammatory cytokines production and inflammatory mucosal infiltration, reduce elastase secretion by neutrophils, preserving elastic properties of pulmonary interstitium and thus facilitating expectoration. Repeated cold water stimulations in COPD also reduce frequency of infections. Finally, sauna bathing reduces the risk of pneumonia. On the other side, hydrotherapy/balneotherapy also help obesity control, which is one of the most difficult NCD risk factors to modify and consequently is an important component of the WHO preventive strategy to achieve STG 3.4. Along with high prevalence and mortality, CRD cause increasing pharmaceutical and hospital costs. In this perspective, Health Resort Medicine should not be ignored as a resource in the WHO NCD strategy and Universal Health Coverage, providing a multi-stakeholder platform (including the network of health resorts and their facilities) able to give a real help to the achievement of UN goal STG 3.4 by the year 2030.

**Keywords:** Balneotherapy; hydrotherapy; chronic respiratory disease (CRD); prevention; World Health Organization (WHO)

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## Introduction

Noncommunicable diseases (NCD) are responsible for 71% of global mortality or 41 million of deaths per year which occur globally. NCD are mainly cardiovascular diseases (CVD), cancer, chronic respiratory diseases (CRD), and diabetes. These four disease categories are largely preventable through public policies that tackle their common risk factors: tobacco use, unhealthy diets, harmful use of alcohol, physical inactivity and air pollution. Global CRD burden remains unacceptably high. In 2016 these diseases were responsible for 3.8 million deaths, 9% of all NCD deaths and 7% of all global deaths. Seventy-five percent of these deaths occur in those aged 30–69 years demonstrating that CRD are not solely a problem for the elderly (1).

The use of natural mineral waters, gases and peloids in form of bathing, drinking, inhalation, etc. is now internationally called balneotherapy. The use of water (regardless its chemical/physical characteristics and its geological origin) for therapy is referred to as hydrotherapy (2).

The appropriate therapeutic use of mineral waters specific in terms of chemical composition, physical properties and microbiome (the genetic material of all the microbes—bacteria, fungi, protozoa and viruses-that live on and inside the human body) is in fact one of the most profitable procedures that can be administered in combination or sequentially to conventional drug therapies to reduce the intense inflammatory background that characterizes these diseases and, in summary, to help secondary prevention, in the virtual absence of undesired effects (3).

CRD prevention and control is an important part of the WHO Global NCD Action Plan for the Prevention and Control of NCD 2013–2020 adopted by World Health Assembly (WHA) in 2013 (4,5). Life style modifications focused on the risk factors include reduction in the harmful use of alcohol, reduction of insufficient physical activity, reduction in mean population intake of salt/sodium, saturated fatty acids, elimination of industrially produced trans-fatty acids and reduction of current tobacco use. If met, these life style modifications, along with appropriate treatment programmes, would ensure achievement of 25% reduction mortality from NCD by the year 2025. These targets are aligned to those for NCD included in the 2030 Agenda for Sustainable Development "*by 2030, reduce, by one third, premature mortality from NCD through prevention and treatment, and promote mental health and well-being*" as specified in Sustainable Development Goals (STG) target 3.4 adopted at the United Nations Summit on Sustainable Development in September 2015 (6,7) and the World Health Organization (WHO) 13$^{th}$ General Programme of Work 2019–2023 adopted by the WHA in May 2018 (8,9). Medical hydrology/balneology have a great potential for healthy life style modifications through information/education concerning primary and secondary prevention of NCD and by itself as an independent medical competence. While the impact of medical hydrology/balneology on rheumatic conditions, CRD and rehabilitation (10,11) is quite evident, its impact on other above mentioned NCD might result less obvious (12-15), but could be mediated by the modification of several risk factors NCD have in common, like for instance physical inactivity and/or obesity (16-19). Regretfully, this discipline suffers from a sort of skepticism at the international and often national levels, whose real origin should be discussed in the general interest of public health and in the absence of potential conflicts of interests. It is our opinion that published data now demonstrate that these medical therapeutics represent powerful measures not only for health and well-being in general, but also for the prevention and control of NCD (2). Just to mention, balneotherapy has recently been demonstrated to ameliorate biochemical parameters in exhaled condensate in heavy smokers (20).

This would allow balneotherapy to become a useful part of the WHO NCD prevention and control strategy (4,8) and of the Universal Health Coverage (UHC) 2030 global movement to reinforce health systems for UHC, providing a multi-stakeholder platform including the network of health resorts and their facilities to collaborate with public health systems in developed and developing countries to reduce NCD/CRD mortality, and—more in general—to reduce chronicity and related costs (21,22).

In this review, we analyzed the role of Health Resort Medicine (HRM) and in particular balneotherapy and hydrotherapy in CRD prevention and control. Well understanding their advantages and limitations in the prevention and management of allergic conditions and bronchial asthma, we stress the role of balneotherapy and hydrotherapy in the prevention and management of chronic obstructive pulmonary disease (COPD), which is the most prevalent CRD characterized by the highest mortality (23). We intend to demonstrate how HRM (an old medical practice which would have probably disappeared if ineffective) respond to modern global requirements regarding NCD prevention and control, and particularly to WHO Global Strategy and Action Plan for the Prevention and Control of NCD through primary health care (PHC) (4,8), and UHC global movement for the achievements of STG 3.4.

## Definitions and classifications

Health Resort Medicine is an important component of UHC since it comprises "*all medical activities originated and derived in health resorts based on scientific evidence aiming at health promotion, prevention, therapy and rehabilitation*". Key elements of health resort interventions in health resorts are balneotherapy, hydrotherapy, and climatotherapy. The use of natural mineral waters, gases and peloids in form of bathing, inhalation, drinking, etc. is now internationally called Balneotherapy, while the use of tap water for therapy (like, for example, in water-based musculo-skeletal rehabilitation) is called Hydrotherapy. While increasing biological data reveal more and more the effects of mineral waters on cells and tissues, for the global clinical effects of HRM it is important to take also environmental factors into account. These can be classified within the framework of the International Classification of Functioning, Disability and Health (ICF) (24). Examples comprise receiving health care by specialized doctors, being well educated (ICF-domain: e355), having an environment supporting social contacts (family, peer groups) (cf. ICF-domains: d740, d760), facilities for recreation, cultural activities, leisure and sports (cf. ICF-domain: d920), have access to a health-promoting atmosphere and an environment close to nature (cf. ICF-domain: e210).

CRD are a group of chronic diseases affecting the airways and the other structures of the lungs. Out of more than 20 diseases and conditions, most common are: COPD, asthma and respiratory allergies, and occupational lung diseases as they appear in ICD-10.J44, J45, J30, and J60-63 (25).

COPD is a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar alterations usually caused by significant exposure to noxious particles or gases (26). Based on multiple large-scale epidemiological studies global prevalence of COPD was estimated as 11.7% in 2010, with the number of cases of 384 million (27). There are around three million COPD deaths every year (28) making it the third leading cause of death worldwide, and numbers are increasing (29). With the growing prevalence of smoking in developing countries and population aging in high-income countries, the prevalence of COPD is expected to rise over the next 30 years and by 2030 there might be more than 4.5 million deaths per year from COPD and related conditions (30,31). COPD therefore is a major public health problem globally in subjects over 40 years of age (32) and is the prevalent CRD responsible for high mortality. In most patients, COPD is associated with significant concomitant disease conditions, which increase morbidity and mortality (33). Pharmacological therapy is used to reduce symptoms, reduce the frequency and severity of exacerbations, and improve health status and exercise tolerance (26). All COPD patients with breathlessness when walking at their own pace on ground level appear to benefit from rehabilitation and maintenance of physical activity.

Pulmonary rehabilitation (PR) is the most effective intervention to improve the quality of life (QOL) in established COPD, and therefore it is an integrated component of the disease management strategy. PR up to 12 weeks can reduce readmissions and mortality in patients following a recent exacerbation (≤4 weeks from prior hospitalization). Of course, exercise training is a key element of PR (26,34).

## Hydrotherapy and PR in COPD patients

Therapeutic aquatic exercise intervention led by physical therapists includes either hydrotherapy or balneotherapy, and is used for the prevention and treatment of diseases through water interventions (35). It represents a specialized field of physical training and therapy, used to achieve functional recovery using the properties of water (35,36).

The beneficial effects of water exercise for the respiratory system in people with respiratory problems are controversial. Previous studies have shown that hydrostatic pressure exerts resistance against inspiratory muscle strength and limits chest expansion; this effect is enhanced as the temperature of water decreases (37). Additionally, the diaphragm moves during diving due to abdomen compression, decreasing by this way respiratory vital capacity (38). On the other hand, patients with COPD may benefit from the hydrostatic pressure exerted during immersion, which facilitates expiration and reduces the residual volume, decreasing air trapping (39,40). Martín-Valero *et al.* (3) summarized the levels of evidence and grades of recommendation concerning therapeutic aquatic exercise interventions in patients with COPD. The grades of recommendation were assessed for each study according to the Duodecim (Finnish Medical Society Duodecim), a clinical practice guide. Sixteen studies have been included in the analysis. The analyzed articles covered incremental therapeutic aquatic exercise with an intensity ranging from 50% to 90% of $VO_2$max with sessions of 30–50 min 2–5 days per week, for a total of 8–24 weeks at temperatures of water ranging from 29 to 38 ℃. Grade A indicated recommendations based on strong evidence; grade B indicated sufficient evidence to make a clear recommendation. Only Wadell *et al.* study (41) corresponded to grade A level, showing changes in clinical and functional outcomes. Authors showed that high-intensity water-based physical training in patients with moderate-to-severe COPD three times per week (45 min per session) for 12 weeks, improved exercise performance and health-related QOL, compared to a control group without intervention. The authors concluded that high intensity physical training in water is of benefit for patients with COPD. It was also shown that training once per week (high intensity/low frequency) was not sufficient to sustain the improvements in physical capacity and QOL achieved after a period of 3 months of high intensity/high frequency aquatic exercise (42). However, high intensity physical training once per week for 6 months seemed to be sufficient to avoid respiratory function deterioration compared to baseline, and to reach a significant functional improvement of respiratory muscles performance (43).

The studies with a grade B recommendation showed more heterogeneous results, possibly reflecting differences in water temperatures or saline composition.

Breathing exercises during immersion in water at 38 ℃ might be recommended as physical therapy after a diagnosis of COPD. Elevation of the abdominal diaphragmatic pressure helps raising the diaphragm and assist in complete air exhalation, resulting in a decrease in dead space. In addition, hydraulic pressure was reported to increase cardiac output, resulting in an improvement in blood gas exchange in lung capillaries. Besides these effects, inhalation of gas containing thermal hydrogen sulfide ($H_2S$) lowers the viscosity of sputum (44). Perk *et al.* (45) and Kurabayashi *et al.* (46-48) included breathing exercises in their therapeutic protocols in COPD patients.

### *Effect of temperature and duration*

High intensity physical training in water once per week for 6 months did seem to be enough to prevent respiratory functional deterioration compared with baseline (49). According to another study (50), 6 consecutive days of exercise per week would be preferable to 3 alternative days of exercise per week, even if the cumulative exercise time was the same. In spite of patients who began with very low baseline values, this study found the following functional outcomes: increase in ejection fraction and forced expiratory volume in 1 second (FEV1) and decrease in $PaCO_2$ with hydrotherapy. These results suggested that hydrotherapy in a pool with water at 38 ℃ for 30 min per day, 6 days per week, for 2 months was useful for improving cardiac function in patients with COPD.

## Hydrotherapy and COPD at PHC

PHC should provide a frontline service to NCD/CRD patients according to the NCD Action Plan (4). An observational study was conducted to assess the feasibility and acceptability of swimming pool-based exercise for PR of COPD patients. One hundred and one patients with mild or moderate COPD registered at South London General Practice were invited to a swimming pool-based PR programme. The mean number of sessions attended was 10.6 out of 12 over 6 weeks (two sessions per week) at 29 ℃ pool temperature. Significant improvements in dyspnea score and walking distance were observed, and all other findings were in the direction of improvement. Most patients enjoyed exercising in water, overcame their fears, valued learning about COPD and socializing with fellow sufferers, and were positive about their physical improvement (51). Authors consider the swimming pool is a feasible and positive alternative venue for PR for COPD patients in PHC. In this way hydrotherapy reinforces health systems in addressing CRD through patient-centered PHC. This is an important observation, as gym-based exercises may be difficult for some patients with COPD who are elderly and may have co-morbidities (52) such as arthritis which may impair their ability to exercise at a high enough intensity. Experience in rheumatoid arthritis, fibromyalgia and heart failure, suggests that using water as the medium for exercise in PR broadens its appeal, acceptability, and effectiveness. Furthermore, in many countries swimming pools may be more accessible venues for PR than gyms since they are open to the community.

## Health resorts treatment and depression in COPD patients

Exercise in water is also interesting from the view point of overcoming patients fears and their socialization, since depression is a major confounding COPD condition (53). Promoting mental health is in fact an important component of SDG 3.4 2030 (6,7). The causes of depression and anxiety in patients with COPD are multifactorial and include behavioral, social and biological factors. Depression/anxiety are frequent co-morbidities in COPD, often under-diagnosed, and associated with poor health status and prognosis (26). The anxiety-depressive disorders were diagnosed in 59.2% out of 142 COPD grade I–III patients; treated at the health resort facility located on the southern coast of Crimea. Depression intensity correlated with the severity of COPD. It was shown that a course of the spa and health resort-based treatment produced beneficial effect on the psycho-functional status of the patients with COPD that was especially well seen in those with the mild form of COPD (54).

 

## Water based exercise compared with land-based exercise

McNamara *et al.* (55) studied COPD stage II patients with coexisting obesity or musculoskeletal or neurological conditions. Their randomized controlled trial aimed to measure the effectiveness of water-based exercise training in improving exercise capacity and QOL compared to land-based exercise training and control (without exercise) in people with COPD and co-morbidities. High dropout rates from land-based exercise training ranging from 14% to 66% were reported, as completion of land-based exercise training is often difficult or impossible for patients with co-morbidities (56). Fifty-four participants referred to PR were randomly allocated to a water-based exercise, land-based exercise or the control group. The two exercise groups trained for 8 weeks, completing three 60 min sessions per week led by the same experienced physiotherapist. The water-based exercise training group exercised in a hospital hydrotherapy pool with water temperature of 34 ℃, air temperature of 30 ℃ and relative air humidity of 30%. Water-based exercise training participants were able to choose the most comfortable level of water immersion in the standing position to perform the majority of exercises, which was always between the xiphisternum and the clavicles for each participant The unique water properties of buoyancy to support body weight, combined with resistance and turbulence to increase exercise intensity, as well as the proposed effects of warm water on blood flow to muscle (57) may have enabled our population of patients with COPD and physical co-morbidities to exercise at a higher intensity by reducing the impact of their physical co-morbidity on exercise. Water-based exercise training generated important outcomes for daily life in patients with COPD, with a reduction in dyspnea and fatigue, improving health-related QOL and integrated management of COPD. It has been proposed previously that immersion in water may not be tolerated by people with COPD as the hydrostatic pressure placed on the chest wall may increase the breathing work (45). However, people with COPD tolerated the water environment well with a high attendance rate, fewer drop-outs than the land-based exercise training group and the ability to train at the desired intensity. Furthermore, as the majority of participants in this study were classified as GOLD stage II, these results may not apply to people with severe COPD in view of this further investigation is needed.

## Water based exercise and obesity control

Special attention should be given to obesity as COPD co-morbidity and also as a risk factor for other major NCD which need to be controlled (58). Obesity in COPD has been associated with increased symptoms of dyspnea, poorer health-related QOL, elevated levels of fatigue and exercise performance limitations, comprising a decreased tolerance to weight-bearing exercise such as walking (59). A group of 24 obese (defined as body mass index ≥32 kg/m$^2$) individuals with moderate COPD (60) were randomized to either 8 weeks water-based exercise (n=8), land-based exercise (n=8) or control (without exercise) (n=8). Within-group comparisons showed that participants in the water-based exercise group lost the greatest amount of weight over the eight-week period (P=0.02). Between-group comparisons using independent group *t*-tests demonstrated a significant difference in weight change between the water-based exercise group and the control group (P=0.038). No nutritional or lifestyle interventions were provided as part of this study (60). Thus, water-based exercise significantly broad the potential of effective physical training in COPD patients as compared to land-based exercise or no exercise. This approach also favored obesity control, which is one of the most difficult NCD risk factor to modify (3,58,61), and promoted mental health, which is a relevant aim of STG 4 to achieve by the year 2030 (7). However, it should be noted that exposure to chlorinated water in swimming facilities may aggravate preexisting asthma or cause new onset asthma. This may be a particular problem for individuals who spend prolonged time at swimming facilities (62,63). This problem is overcome by balneotherapy, in which mineral water is not chlorinated (to preserve their natural chemical composition) and patients are treated individually.

## Balneotherapy, infection and CRD

A history of severe childhood respiratory infection has been associated with reduced lung function and increased respiratory symptoms in adulthood (64).

On the other hand, susceptibility to infections plays a role in exacerbations of COPD triggered by respiratory infections with bacteria or viruses (which may also coexist), justifying preventive use of influenza and pneumococcal vaccinations (26,65). Balneotherapy including $H_2S$ containing water and bromide-iodine thermal water have antibacterial and anti-inflammatory effect. Exogenous $H_2S$ is effective in reducing acute mycoplasma induced inflammation (66,67). Sulphur-rich water inhalations improve muco-ciliary clearance, reduce inflammatory cytokines production and inflammatory mucosal infiltration, reduce elastase secretion by neutrophils, preserving elastic properties of pulmonary interstitium and facilitating by this expectoration (68). Treatment with inhaled salt-bromide-iodine thermal water has a mild anti-inflammatory effect on the airways in COPD patients (69). Thus, prevention of respiratory infection is a relevant component of the prevention of the COPD exacerbations and COPD mortality. Sauna bathing can reduce the risk of pneumonia, based on the results of a long-term prospective cohort study in Finland (70). A population-based prospective cohort of 1,935 middle-aged (42–61 years) Caucasian men in Kuopio, who had no apparent pre-existing respiratory diseases at baseline (COPD, asthma or pneumonia), was followed-up for 25.6 years in 379 hospitals, and all diagnoses of respiratory diseases (COPD, asthma, or pneumonia) were recorded. Results showed that frequency of sauna bathing is inversely associated with future risk of respiratory diseases. Participants who had 2–3 and ≥4 sauna sessions per week respectively had a lower risk of CRD compared with participants who had ≤1 sauna session per week. The association remained robust after adjustment for several risk factors for these respiratory conditions, as well as the duration and temperature of sauna baths. The association between frequency of sauna bathing and respiratory diseases was not modified by smoking status. A subsidiary analysis showed frequency of sauna bathing to be inversely associated with the risk of pneumonia. The ability of sauna baths to decrease the risk of respiratory diseases may be explained by its ability to reduce oxidative stress (71). The heat associated with sauna baths may also have direct effects on the lung tissue by reducing pulmonary congestion and increasing tidal volume, vital capacity, ventilation, and forced expiratory volume of the lungs (72). On the other hand repeated cold water stimulations in COPD patients after 10 weeks treatment with 3 cold effusions and 2 cold washings of the upper part of the body (self-treatment) reduced frequency of infections; increased peak expiratory flow, lymphocyte counts, and expression of gamma-interferon; modulated interleukin (IL) expression; and improved QOL in COPD patients (73).

## Clinical impact of spa therapy on COPD

Inhalation therapy with sulphurous and salsojodic mineral waters improve symptoms as cough and sputum and functional indices as FEV1 in COPD. Spa therapy of COPD is based on the inhalation of sulphurous and salsojodic mineral water. Sulphurous mineral waters have vasodilating activity on bronchial mucosa, improving its trophic state, and increase the production of secretory IgA and muco-ciliary clearance; they have fluidificant activity on bronchial secretion. Clinical trials showed improvement of cough, sputum and functional indexes as FEV1 and exhaled carbon monoxide (CO). Salsojodic mineral waters increase the fluidity of the bronchial mucus and muco-ciliary clearance. Inspiratory resistive breathing (IRB) challenges affect respiratory muscle endurance in healthy individuals, which is considered to be an IL-6-dependent mechanism. Baldi *et al.* (74) compared the effects of 12 sessions of the mud bath therapy (MBT) on endurance time (ET) and plasma IL-6 concentration following an IRB challenge in forty-two patients (aged 42–76 years) suffering from mild to severe COPD in a thermal spa center in Italy. Plasma mediators and ET and endurance oxygen expenditure ($VO_2$Endur) were measured following IRB challenge at 40% of maximum inspiratory pressure. MBT model was safe and improved ET upon a moderate IRB challenge, indicating the appearance of a training effect in COPD patients

## Conclusions

CRD is a major NCD targeted by WHO NCD Action Plan and UN STG 3.4 to achieve 30% decline of mortality by the year 2030 thanks to progress in pharmacological treatments and life-style modifications. Therapeutic aquatic exercise intervention both at health resort facilities and public swimming pools has evidence of improving health status of COPD patients. This could be a feasible and positive alternative venue for PR for COPD patients in primary care. Balneotherapy in spa facilities and swimming pools will strengthen health systems (75) to address CRD through patient-centered PHC and UHC. This is an important observation as gym-based exercises may be difficult for many patients with COPD who often are mainly elderly and who may have other co-morbidities such as severe arthritis and obesity which may impair their ability to exercise at a high enough intensity. The use of water as the medium for exercise in PR should widen its, acceptability, and effectiveness. COPD patients (in particular those with co-morbidities) find exercise in water more suitable. Exercise in water is also interesting from the view point of overcoming patient's fears and their socialization since depression is a major confounding COPD condition. It was shown that a cycle of balneotherapy produced beneficial effects on the psycho-functional status of the patients with COPD. Water based exercise significantly broad the potential of effective physical training in COPD patients as compared to land-based exercise or no exercise. This approach facilitates obesity control, which is one of the most difficult NCD risk factor to modify, and promotes mental health which is an important component of STG 3.4. Susceptibility to infections plays a role in exacerbations of COPD triggered by respiratory infections with bacteria or viruses, justifying the preventive use of vaccinations and balneotherapy. Prevention of respiratory infection is in fact a vital component of the prevention of the COPD exacerbations and COPD mortality. Sauna bathing reduces the risk of pneumonia. On the other hand, repeated cold-water stimulations in COPD patients could also reduce frequency of infections and improve QOL. Along with high prevalence and mortality, CRD is a cause of increasing pharmaceutical and hospital costs: in view of this HRM should not be ignored as a potential resource in the WHO NCD strategy and UHC which provides a multi-stakeholder platform including network of health resorts and their facilities which promote achievement of STG 3.4 by the year 2030.

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