

Evidence-Based Review of Hydrotherapy Studies on Chronic Obstructive Pulmonary Disease Patients

**Rocio Martin-Valero, A.I. Cuesta-Vargas,
and M.T. Labajos-Manzanares**

The aim of this review was to summarize the level of evidence and grades of recommendation regarding therapeutic aquatic exercise interventions in chronic obstructive pulmonary disease (COPD) patients. We conducted a systematic search to identify relevant studies published from 1996 until 2010. Methodological quality of trials was assessed using the Delphi list and the grades of recommendation according to the DUODECIM (Finnish Medical Society Duodecim). The reviewed articles covered incremental therapeutic aquatic exercise with an intensity ranging from 50% to 90% of VO_{2max} with sessions of 30–50 min 2–5 days per week, for a total of 8–24 weeks at water temperatures ranging from 29 °C to 38 °C. The few clinical trials on patients with COPD showed no beneficial effects on lung function.

Chronic obstructive pulmonary disease, or COPD, is one of the leading causes of disability and mortality worldwide and increases in prevalence with age. Seven percent of people who were 40–45 years old and 15% of people who were 80–85 were diagnosed with COPD in 2003 (Royal Dutch Society for Physical Therapy, 2008). Knowledge regarding the disturbance of muscle function that occurs in patients with COPD is continuously increasing. Initially, muscular dysfunction was considered to be a self-limiting disease, resulting from inactivity and lack of exercise. More recent studies have shown that in addition to this factor, peripheral muscles such as the quadriceps seem to have some type of myopathy (Couillard & Prefaut, 2005). Although the presence of myopathy is still being debated, there is some evidence pointing to myopathy associated with oxidative stress (Rabinovich et al., 2001). Recent studies in COPD have highlighted the role of the ubiquitine proteasome system in the breakdown of skeletal muscle protein in COPD patients. Malfunctioning of the mitochondria has also recently been identified in these patients (Rabinovich & Vilaro, 2010).

The World Health Organization's Global Initiative for Chronic Obstructive Lung Disease (GOLD) consensus document uses the following definition:

R. Martin-Valero, A.I. Cuesta-Vargas, and M.T. Labajos-Manzanares are with the Faculty of Health Sciences, The Psychiatry and Physiotherapy Department at the University of Málaga in Spain.

Chronic obstructive pulmonary disease is a preventable and treatable disease with some significant extrapulmonary effects that may contribute to the severity in individual patients (Rabe et al., 2007). Its pulmonary component is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually both progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases. In addition to dyspnea, coughing, wheezing, sputum production, and recurrent respiratory infection, systematic consequences such as deconditioning, muscle weakness, weight loss and malnutrition are often observed. (Royal Dutch Society for Physical Therapy, 2008)

Therapeutic aquatic exercise intervention is a discipline that includes hydrotherapy, spa therapy, balneotherapy, and physiotherapy and is used for the prevention and treatment of diseases through water interventions (Geytenbeek, 2008). Hydrotherapy is defined as a complementary therapy that uses the temperature and pressure of water as a therapeutic agent at a given temperature (Geytenbeek, 2008). There is controversy in the scientific literature regarding the beneficial and harmful effects of water exercise for the respiratory system in people with respiratory problems. 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 the pool water decreases (Frontera, Herring, Micheli, & Silver, 2008). In addition, the diaphragm moves during diving due to compression by the abdomen, thus decreasing respiratory vital capacity (Greenleaf, 1984). On the other hand, patients with chronic obstructive pulmonary disease may benefit from the hydrostatic pressure exerted during immersion, which facilitates expiration and reduces the residual volume, decreasing the air trapped in this pathology (Asanuma, 1999; Choukroun, Kays, & Varène, 1989; Dahlback, 1975; Schoenhofer, Koehler, & Polkey, 2004).

Therapeutic aquatic exercise intervention is known for its ability to prevent and treat different conditions. This intervention is a specialized field of physical training and therapy, used to achieve certain physical and functional goals using the properties of water (Geytenbeek, 2008). In this paper, changes in the clinical (quality of life, disease severity) and functional (lung function, oxygen uptake) outcome measures in patients treated with this intervention are reviewed and assessed.

Anstey and Roskell's review of the literature (Anstey & Roskell, 2000) found insufficient evidence about the effectiveness of therapeutic intervention for COPD with further research into the restrictive and obstructive pulmonary influences of hydrotherapy being required. They also highlighted the need to carry out longitudinal studies with larger sample sizes to determine the clinical and functional effects of hydrotherapy in people with lung diseases. Therefore, the aim of this review was to summarize the levels of evidence and grades of recommendation regarding therapeutic aquatic exercise interventions in patients with COPD.

Method

Literature Search

A literature search was performed to identify all possible studies that could help answer the research question. The following databases were searched for relevant

trials: Web of Knowledge, CINAHL, PsycInfo, SportDiscus, SCOPUS, Oaister, DOAJ, Cochrane, EMBASE, Pedro and MEDLINE controlled trials register. A single reviewer searched the databases using combinations of the following keywords: COPD, respiratory disease, exercise, water, hydrotherapy and quality of life. The searches were limited to trials reported between 1996 and 2010.

Inclusion-Exclusion Criteria

Inclusion criteria were constructed using the PICO (population, intervention, control/comparison, and outcome) model. First, the population included samples of people independent in activities of daily living (ADL) with chronic obstructive pulmonary disease. Second, the intervention included all types of therapeutic aquatic exercise such as aqua-aerobics and aqua-jogging; spa therapy and balneotherapy (nonactive) were excluded from this review. Third, different types of randomized and nonrandomized, cohort and case studies were included. Finally, the outcomes included were physical fitness (e.g., six minutes walking distance or 6MWD, quadriceps strength), functional variables (e.g., lung function, oxygen uptake) and clinical variables (e.g., quality of life, disease severity). Studies were excluded if they dealt with drugs or other medical/surgical interventions.

Methodological Quality Assessment

Nineteen relevant articles were found in the main databases. Sixteen original studies were examined after subsequent selection based on review of the title and abstract. Two articles were excluded because they were written in Japanese and no translation was available. One article in German was excluded because it discussed spa therapy. The key aspects and results of the remaining 16 studies are summarized in Table 1.

We evaluated the methodological quality of the studies using the Delphi list developed by Verhagen et al. (1998). Two independent reviewers (i.e., investigators Cuesta-Vargas & Martín-Valero) carried out the assessment based on the Delphi score. The articles included in the review had a Delphi score ranging from 3 to 6 as shown in Table 1. The trials were considered to be of sufficient methodological quality if they had a score of at least 5 out of 9 points. This was based on the fact that tests with a score close to 4 do not employ a triple blind methodology (i.e., patient evaluator, evaluator, and providing treatment). This evaluation found two articles that were randomized controlled trials with a score of 6, which were considered to have sufficient methodological quality, five nonrandomized controlled trials, six cohort studies, one case study, one expert opinion, and one narrative review.

Evaluation of Clinical Relevance

In this study, effect size values were used to compare the different types of intervention on COPD. Effect size (ES) was calculated using the following formula of sixteen original studies: (mean posttest outcomes of type A intervention)–(mean posttest outcomes of type B intervention); (Cohen, 1988). Analysis of the effect size values was based on Cohen's work, which determined that values below 0.2 are considered to have no effect, those between 0.2 and 0.5 a small effect, between 0.5 and 0.8 a medium effect, and those above 0.8 are considered to have a large effect (Cohen, 1988). In some cases, effect size is zero due to the characteristics of

Table 1 Delphi Scores for Methodological Quality Assessment of Sixteen Studies

	(Kurabayashi et al., 2000)	(Wadell et al., 2004)	(Severino et al., 2007)	(Sato et al., 2007)	(Rae & White, 2009)	(Wadell et al., 2005b)	(Wadell et al., 2005a)	(Lotshaw et al., 2007)	(Kurabayashi, Machida, I& Kubota, 1998)	(Kurabayashi et al., 1998)	(Kurabayashi et al., 1997)	(Perk et al., 1996)	(Vu & Mitsunobu, 2005a)	(Kurabayashi et al., 1999)	(Vu & Mitsunobu, 2005b)	(Anstey & Roskell, 2000)
Randomization	/	/	/	/	X	X	X	X	X	X	X	X	X	X	X	X
Concealed treatment allocation	/	X	/	/	/	X	X	/	X	X	X	X	X	X	X	X
Baseline Similarity	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X
Eligibility Criteria	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X
Blinded outcome assessor	X	X	X	X	X	X	X	X	/	X	X	X	X	X	X	X
Blinded care provider	X	/	X	X	X	X	X	X	X	/	X	X	X	X	X	X
Patient blinded	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X+/-SD or MEAN +/-SE	/	/	/	/	/	/	/	X	/	/	/	/	/	/	X	X
Intention to treat	/	/	/	/	/	/	/	/	X	X	X	X	X	X	X	X
Total	6	6	6	6	5	4	4	4	4	4	3	3	3	2	0	0

the study. Notably, an effect size of 0.4 is considered to be the threshold for clinically significant change in the CRQ (Chronic Respiratory diseases Questionnaire; Jones, 2002). No estimated changes in the CRQ reached the minimum significant difference in effect size for this review.

The aim of this review was to summarize the levels of evidence and grades of recommendation regarding therapeutic aquatic exercise interventions in COPD patients. The grades of recommendation were assessed for each study according to the Duodecim (Finnish Medical Society Duodecim), a clinical practice guide

developed in Finland to improve the quality of health care (Burgers, Grol, Klazinga, Makela, & Zaat, 2003; Lugtenberg, Burgers, & Westert, 2009). First, grade A means that the recommendation is based on strong evidence. Second, grade B is based on sufficient evidence to make a clear recommendation. Grade C recommendations are based on limited evidence. Finally, grade D refers to recommendations for which there is no evidence based on clinical studies (Guerra, Martín Muñoz, & Santos Lozano, 2003).

Results

The 16 reviewed articles covered incremental therapeutic aquatic exercise with an intensity ranging from 50% to 90% of VO_{2max} with session durations of 30–50 min and a frequency of 2–5 days per week, covering a range from 8 to 24 weeks at water temperatures ranging from 29 °C to 38 °C. The results of this review are presented in Tables 1 and 2.

Discussion

Therapeutic aquatic exercise intervention is known for its ability to prevent and treat different conditions, although it is not considered part of standard pulmonary rehabilitation. The aim of this study was to summarize the levels of evidence and grades of recommendation of therapeutic aquatic exercise interventions in patients with COPD based on a systematic review. Without any doubt, there were few randomized clinical trials. Most studies found in this systematic review have recommendation grades B and C for patients with COPD.

The studies with a grade A recommendation showed changes in clinical and functional outcomes. Only Wadell, Sundelin, Henriksson-Larsen, and Lundgren (2004) showed that high-intensity physical group training in patients with moderate-to-severe COPD, who engaged in water and on land exercise three times per week (45 min per session) for 12 weeks, improved exercise performance and health-related quality of life, compared with a control group without intervention.

Effects of Aquatic Breathing Exercises

The studies with a grade B recommendation showed results with much heterogeneity, reflecting presumably differences in water temperatures. Breathing exercises during immersion in water at 38 °C could be recommended as physical therapy after a diagnosis of COPD. Elevation of the subperitoneal diaphragmatic pressure by the hydraulic pressure could help raise the diaphragm and assist in the evacuation of air during 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 sulfate lowers the viscosity of sputum (Asanuma, Fujita, Ide, & Agishi, 1971). Only three studies (Kurabayashi, Izumi, Hiroshi, Toru, & Kazuo, 1998; Kurabayashi et al., 2000; Perk, Perk, & Bodén, 1996) included breathing exercises in their therapeutic interventions.

Table 2 Reviewed Trials on the Effectiveness of Treatment of COPD in Water

Authors	Delphi Score, n	Evidence Type	R	Main Intervention	Intragroup Outcome	Effect Size (%) Functional Variables	Effect Size (%) Clinical Vbles
Kurabayashi et al., 2000	Delphi: 6/9 n = 17	Rand	A	38 °C 8 weeks 5 d/we 30 min/s 1.G Incremental Water W: walking, breathing out nose in water Rest: 25 °C for 30 min. 2.G Continuous Water	Peak Flow increases ss for GIW p = 0.039* PaO ₂ increases for GIW p = 0.010*; PaCO ₂ decreases GIW p = 0.040*	%CVF increase in favor of GIW p = 0.058*; %FEV1 in favor of GIW p = 0.018*	
Wadell et al., 2004	Delphi: 6/9 n = 43	Semi-Rand	A	34 °C 12 weeks 3 d/w 45 min/s PWR 80–90% 1.G Incre Water 2.G Incre Land 3. G control	GIW and GIL increases time cycled and load peak. GC deteriorated quality of life.*	ESWT: 0.68* ss in favor of GIW p = 0.003	0 CRQ: 0.11** activity in favor of GIW p = 0.018
Sato et al., 2007	Delphi: 6/9 n = 30	CCT	B	33 °C 24 weeks 50 min A G 1 d/we B G 2d/we C G control	Correlation HRQL-PCS r:0.452 p < 0.05ss HRQL-MCS r:0.382 p < 0.05ss	0	B ES moderate PCS (0.72) MCS (0.75) at 3 months. ES small at 6 months.
Severino et al., 2007	Delphi: 6/9 n = 10	CCT	B	12 weeks A G 1 d/we H +2 d/we PRP B G 3 d/we PRP	A: Sa O ₂ p = 0.008 A: BP p = 0.003 A: FR p = 0.046	0	Dyspnea: 0.28 nss A 33% better results than B

(continued)

Table 2 (continued)

Authors	Delphi Score, n	Evidence Type	R G	Main Intervention	Intragroup Outcome	Effect Size (%) Functional Variables	Effect Size (%) Clinical Vbles
Wadell et al., 2005b	Delphi: 4/9 n = 43	CCT	B	12 weeks 45 min TAE A G Water therapy 3 d/we B G Land therapy 3 d/we C G Control	A and B Improve knee flexion strength B and C Improve knee ext	BMI 0.043 for A	nss difference in activity level with Frändin & Grimby questionnaire
Kurabayashi et al., 1998	Delphi: 4/9 n = 24	CCT	B	Breathing water 38 °C A G 2 d/we 10 min/s 20 min/week B G 3 d/we 20 min/s x twice daily C G 6 d/we 20 min/s	GB ↑PaO ₂ ↓PaCO ₂ ss GB, C ↑FE ↑FEV1 ss	PaO ₂ in favor of GB p = 0.001 FEV1 in favor of GB p = 0.005	0 0
Vu & Mitsunobu, 2005a	Delphi: 3/9 n = 10	CCT	B	A with SPA therapy TAE B without SPA therapy	GA ↑%LAA nss ↓%DLco and ↓%VR nss G B: ↓%Dlco, ↑%VR p < 0.05	0	0
Kurabayashi et al., 1997	Delphi: 3/9 n = 22	Cohort	B	38 °C 8 weeks 30 min/s W: walking, breathing out slowly, mouth and nose in water. 3 periods 10 min with a rest of 5 min. P dressed rest: 25 °C for 30 min	%FEV ₁ ↑ ss ↓PaCO ₂	0	Quality of life by Hugh Jones improved in 5 P
Rae & White, 2009	Delphi: 5/9 n = 15	Cohort	C	29 °C 6 weeks 2 d/we TAE	PR good or very good	ISWT: 32 m*ss	Dyspnea: 4.9*ss

(continued)

Table 2 (continued)

Authors	Delphi Score, <i>n</i>	Evidence Type	R	G	Main Intervention	Intragroup Outcome	Effect Size (%) Functional Variables	Effect Size (%) Clinical Vbles
Lotshaw et al., 2007	Delphi: 4/9 <i>n</i> = 40	Cohort	C	C	6 weeks 3 d/we 90 min I: 60–80% HR A G Water B G Land	A and B SF36 <i>p</i> = 0.008 ss A and B 6MWD, 6RM knee, 6RM hip, 6RM shoulder <i>p</i> = 0.008 ss	0	0
Wadell et al., 2005a	Delphi: 4/9 <i>n</i> = 43	Cohort	C	C	A: 3 d/w 12 weeks 45 min B: 1 d/w 24 weeks 45 min PWR: 80–100%	9 months compared with baseline	ISWT: 31 m**ss <i>p</i> = 0.001	SF36 small effect 2.6 (<i>p</i> = 0.025) GA improved
Kurabayashi et al., 1998	Delphi: 4/9 <i>n</i> = 12	Cohort	C	C	38 °C 8 weeks 6 d/we 30 min TAE Rest: 25 °C for 30 min	↑ FE ss <i>p</i> < 0.01 ↑ FEV ₁ ↓ PaCO ₂ ss PaO ₂ did not improve	0	Quality of life by Hugh-Jones improved in 7 P
Perk et al., 1996	Delphi: 3/9 <i>n</i> = 20	Cohort	C	C	32 °C 12 weeks 15 min 3 periods submaximal upper body muscle training, each lasting 3 min + 3 periods to rest for 2 min	2% decrease SaO ₂ during vertical pulling exercise in water <i>p</i> = 0.05	VC <i>p</i> < 0.001 ss FEV ₁ <i>p</i> < 0.001 ss PEF <i>p</i> < 0.001 ss	Borg Scale Dyspnea <i>p</i> < 0.01 Borg Scale Effort <i>p</i> < 0.01
Kurabayashi et al., 1999	Delphi: 2/9 <i>n</i> = 22	Case Study	C	C	38 °C 8 weeks 3 d/we twice a day 20 min/s W: walking, breathing out slowly, mouth and nose in water. 2 periods 10 min with a rest of 5 min. P dressed rest: 25 °C for 30 min	%FEV ₁ ↑ ss for asthma; emphysema ↑ PaO ₂ ss ↓ PaCO ₂ ss	0	0

(continued)

Table 2 (continued)

Authors	Delphi Score, n	Evidence Type	R G	Main Intervention	Intragroup Outcome	Effect Size (%) Functional Variables	Effect Size (%) Clinical Vbles
Vu & Mitsunobu, 2005b	Delphi: 0/9	Expert Opinion	D	A G with SPA therapy B G with drug-treated Swim+mud: 5 d/w 30 min + Inhalation NaCl twice daily	%LAA %VR decrease p < 0.01 for G Water	0	0
Anstey & Roskell, 2000	Delphi: 0/9	Expert Opinion	D	Expert Review	0	0	0

Abbreviations: BMI: Body mass index; BP: bodily pain; C: Control; d: day; DLCO: carbon monoxide diffusion; ESWT: Endurance Shuttle Walking Test; Exer: exercise; F: physiotherapist; ES: effect size; FE: ejection fraction; FEV₁: forced expiratory volume in one second; FR: breathing frequency; G: group; GIW: Incremental Water Exercise Group; GIL: Incremental Land Exercise Group; LAA: lung areas of low attenuation; MCS: mental component summary; m: meters; min: minute; mo: month; SaO₂: oxygen saturation; s: session; Ss: statistical significance; nss: no statistical significance; P: patient; PCS: Physical component summary; PEF: peak expiratory flow; PaO₂: arterial oxygen pressure; PaCO₂: arterial carbon monoxide pressure; RMI: maximum resistance; RG: grades of recommendation; TAE: therapeutic aquatic exercise; VC: vital capacity; Vbles: variables; VD: dead space; VE: minute ventilation; VR: residual volume; Wmax: peak work rate; we: week; W: Work; 6MWD: six minute walking distance; 0: no data; %: percentage; * original resultsof the article; **Calculated result for table.

Effects of Temperature, Frequency, and Duration

Physical therapy for COPD requires a certain duration and frequency to improve clinical parameters. Wadell, Henriksson-Larsen, Lundgren, and Sundelin (2005a) indicated that training once per week (high intensity/low frequency) was not sufficient to sustain the improvements in physical capacity and quality of life achieved after a period of 3 months of high frequency aquatic exercise training with three sessions of 45 min each per week (high intensity/high frequency). High intensity physical training once per week for 6 months did seem to be enough to avoid deterioration compared with baseline. According to Kurabayashi's study, 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 (Kurabayashi, Izumi, & Kazuo, 1998). 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 one second and decrease in PaCO₂ with hydrotherapy (Kurabayashi, Izumi, & Kazuo, 1998). These results suggested that hydrotherapy in a pool with water at 38 °C for 30 min per day, 6 days per week, for 2 months was useful for improving cardiac function in patients with chronic pulmonary emphysema (Kurabayashi, Izumi, & Kazuo, 1998). Further studies are needed to confirm these recommendations.

The studies reviewed showed much heterogeneity with respect to the duration of treatment, ranging from 6 to 24 weeks. The typical duration of treatment was 8–12 weeks. Further studies should direct more attention to the specific duration, frequency, and accuracy of aerobic intensity thresholds. Other authors found that exercise in water tends to provide even greater benefits than similar frequency and duration exercise training on land (Wadell et al., 2004). The findings from the literature search discovered that studies with sample sizes between 10 and 43 subjects were not statistically powerful enough to detect significant differences with small effect sizes (Severino, Aguiar Pessoa Morano, & Sousa Pinto, 2007; Wadell, Sundelin, Lundgren, Henriksson-Larsén, & Lindström, 2005b). One exploratory trial with grade B evidence in a group of patients who used hydrotherapy with conventional pulmonary rehabilitation showed better physical condition (Severino et al., 2007). The group that combined therapy on land and in water tolerated larger loads on the upper limbs. Furthermore, COPD patients showed improved breathing and heart frequency at the end of the 3-month intervention. Therefore, the sample size of this study was very small and not statistically significant; however, this does not mean that treatment was ineffective but the study design and sample size may not have been suitable. Further research with a statistically powerful enough sample of COPD patients investigating how immersion affects diseased lungs may clarify this issue.

The studies showing grade C recommendations were rather heterogeneous according to functional and clinical variables used. The study conducted by Perk et al. (1996) was the only one to show improved exercise tolerance following water-based pulmonary exercise training, as demonstrated by increased maximum oxygen uptake. They concluded that a 15-min session of submaximal upper body muscle physical training in the pool with a water temperature of 32 °C is feasible

and safe for nonhypoxemic normotensive COPD patients without cardiac failure (Perk et al., 1996). With respect to aquatic exercise intervention, upper and lower body strengthening has not been adequately investigated, especially in terms of whether it can improve functional abilities and quality of life. It remains necessary to analyze the effects of hydrotherapy frequency on the health-related quality of life. According to Sato, “. . . the effect size between once and twice groups were moderate for physical component summary score (0.72) and mental component summary score (0.75) at three months and small (-0.27 and -0.27) at six months” (Sato, Kaneda, Wakabayashi, & Nomura, 2007). On the other hand, only one qualitative study included participants’ views on their experience in the practice of hydrotherapy (Rae & White, 2009). Their study did not compare the effect of hydrotherapy with conventional pulmonary rehabilitation and thus evidence of the benefits of hydrotherapy in COPD was not discussed (Rae & White, 2009).

Two primary documents gave a grade D recommendation (Anstey & Roskell, 2000; Vu & Mitsunobu, 2005b). Vu and Mitsunobu (2005b) reported that the percent of low attenuation area serves as an important tool in the assessment of COPD. There was also a statistically significant reduction in both residual volume (% predicted) and Max % low attenuation area (LAA) for the spa-treated group in contrast to the drug-treated group after therapy (Vu & Mitsunobu, 2005b). Knowledge from these studies provided evidence as to the indications, contraindications, and clinical influences of immersion. A study by Perk et al. (1996) showed that 15 min of submaximal physical training in a pool was safe and not associated with desaturation and discomfort in nonhypoxemic normotensive patients with COPD.

These clinical trials we reviewed on patients with COPD showed no beneficial effects on lung function. Most researchers examined upper body strengthening in terms of improving respiratory muscle strength and overall exercise tolerance. Such exercise is likely to slow the deterioration of lung function. Therefore, it is necessary to conduct future studies using, for example, cluster analysis to identify how subtypes of patients seem to respond to types of aquatic therapy.

Further studies are required to advance and strengthen the existing scientific evidence, which was both limited and varied in its findings. Therapeutic aquatic exercise intervention is probably more favorable for patients with lower functional characteristics. We noted three limitations in the practical application of aquatic interventions for people with COPD. The first was that researchers have used quite small samples sizes, which decreased the statistical power to detect treatment effects. The second limitation was that too often studies were designed with a supervised period of rehabilitation only and were not sustained over a sufficiently long period of time for treatment effects to be reliably demonstrated. It would be of great value to determine the optimal number of training sessions and length of time required to maintain improved levels of physical capacity and quality of life in patients with COPD. The third limitation we noted was that the reviewed studies did not include specific exercises for inspiratory and expiratory muscles that would allow the changes experienced by COPD patients to be analyzed in more detail. Paying attention to overcoming these limitations should open up important new lines of research.

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