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High intensity physical group training in water—an effective training modality for patients with COPD

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Summary The aim of this study was to examine the effect of high intensity physical group training in water and on land for patients with COPD with regard to physical capacity and health related quality of life (HRQoL). A controlled, semi-randomised study was conducted where 30 patients were randomised to training either in water or on land. Thirteen patients constituted a control group. Forty-three outpatients, with moderate to severe COPD (27 w/16 m), from two local hospitals in northern Sweden, were included in the study. High intensity physical group training in water (water group) or on land (land group) was performed for 12 weeks, three times per week, 45 min per session. The control group received no intervention. Pre- and post-intervention, all patients performed incremental and endurance shuttle walking tests (ISWT and ESWT), cycle ergometer tests and responded questionnaires about HRQoL (St. Georges Respiratory Questionnaire—SGRQ and SF-36). The patients trained with a mean heart rate of 80–90% of peak heart rate. Both training groups increased the distance walked, i.e. land group in ISWT (25 m) and water group in ESWT (179 m). The water group increased the distance in ESWT significantly more that both the land and the control groups. Both training groups increased the time cycled (40–85 s) and work load (10–20 W) in the cycle ergometer test. The control group deteriorated in HRQoL according to total score in SGRQ while the training groups remained constant. The water group improved their activity score in SGRQ and their physical health score in SF-36 and those improvements were significant as compared to the land and the control groups. In conclusion, high intensity physical group training in water is of benefit for patients with COPD. It was in some areas found to be even more effective regarding improvements in physical capacity and experienced physical health compared to the same kind of training on land.

Introduction

Patients with chronic obstructive pulmonary disease (COPD) often complain of disabling breathlessness and reduced exercise capacity.[1] Despite optimal medical treatment patients often experience a functional deficit associated with dyspnea and deconditioning as well as decreased health related quality of life.[2]

There is currently compelling evidence that exercise training induces considerable physiological effects and improves measures of exercise tolerance. As such, exercise training represents a

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cornerstone of the interdisciplinary management of COPD patients as it has been shown to improve the patients exercise tolerance and symptoms of dyspnea.[1] Also, pulmonary rehabilitation including exercise training has in many studies been shown to improve the patients health related quality of life.[3–5]

Different training modalities have been evaluated to uncover the most effective way of training patients with COPD. More than a decade ago, Casaburi et al.[6] showed that training at high intensity (80% of baseline peak work-rate) was superior to low intensity training (50%) regarding physiologic training responses. In a recent study interval training was found to be as effective as continuous training.[7] Also recently resistance training was shown to have similar effects on peripheral muscle force, exercise capacity and health-related quality of life as did endurance training.[8] Ortega et al.[9] concluded that combined strength and endurance training is more effective than each of these training programmes alone. Exercise training as a component to outpatient pulmonary rehabilitation programmes, has been shown to be cost effective and is likely to result in financial benefits to the health service.[10,11]

Even though much research has been done on different training methods, there is still a need for evaluating new training modalities for this increasing group of patients. Since the number of COPD patients increases it is also important to find methods that are cost effective. In most previous exercise studies the patients have performed the endurance training individually on either a treadmill or on a cycle ergometer.[7,8] The strength training has also been performed individually with weights, expanders or in different apparatus.[8,9] Group training in a gymnasium has been used for a long time in health promotion and has been found to be effective in patients with asthma,[12] cardiac[13] and different musculoskeletal[14,15] disorders, though it has not yet been evaluated in patients with COPD. Besides the psychological and psychosocial benefits of getting patients together in a group, specific equipment is not required, and up to twenty patients can train under supervision from one leader. Another aspect is that this kind of training is available in the society and can be adjusted to fit patients with specific needs.

Water exercise is another form of training that has been used for decades in the areas of physiotherapy, physical medicine, and rehabilitation. The buoyancy of the water is of relevance for individuals seeking ways to improve fitness without the inherent risk of musculoskeletal injuries accrued with continuous impact on the skeletal system.[16] Training in water was shown to be effective in healthy persons (young and elderly)[16,17] and in different patients groups such as asthmatics,[12] patients with poliomyelitis,[18] fibromyalgia syndrome[19] and rheumatoid arthritis.[20] Perk et al.[21] concluded that training in water was applicable and safe in patients with COPD. It may be an attractive alternative as it combines elements of strength, endurance and mobility training as well as psychosocial and low-cost benefits of group training. To our knowledge no studies have evaluated the effect on physical capacity and quality of life after a period of aerobic group training in water or on land among patients with COPD.

The aim of this study on COPD patients was therefore to compare the effect of high intensity physical group training in water and high intensity physical group training on land to a non-training control group with regard to physical capacity and to health related quality of life.

Materials and methods

Patients

Forty-three patients (27 women and 16 men) with stable, moderate to severe COPD, according to GOLD criteria,[22] were included in the study. The subjects were recruited from previously diagnosed outpatients, under treatment at two hospitals in Northern Sweden. The inclusion criteria were $FEV_1 < 80\%$ of predicted, $FEV_1/VC < 70\%$, stable medication and no infection during the last month before entering the study. Patients with cardiac, orthopaedic, neurological, or psychological disorders that might have interfered with exercise performance were excluded. Before entering the study all patients performed a spirometry test (Spirolab, Medical International Research, Roma, Italy) and an exercise electrocardiogram test on a cycle ergometer (Rodby™, RE 829, Enhörna, Sweden). All patients gave their informed consent prior to the study and the Ethics Committee of Umeå University, Sweden, approved the study. Base line characteristics of the patients are shown in Table 1.

The climate, pollution and environmental factors were the same in the areas from where the patients were recruited. All patients were offered pneumococcal and influenza vaccination in order to avoid drop-outs during the study since the intervention proceeded during the influenza season.

Table 1 Characteristics of the patients included in the study.

	Control ($n=13$)	Water ($n=15$)	Land ($n=15$)	*P*-value
Sex (f/m)	6/7	11/4	10/5	
Age	63 (7)	65 (4)	65 (7)	ns
Height (m)	1.70 (0.10)	1.64 (0.07)	1.63 (0.07)	ns
Weight (kg)	75 (12)	80 (15)	70 (11)	ns
FEV_1 (l)	1.34 (0.40)	1.31 (0.31)	1.26 (0.34)	ns
FEV_1 % pred.	49 (12)	56 (11)	53 (12)	ns
FVC (l)	3.18 (0.74)	2.73 (0.76)	2.78 (0.77)	ns
FVC % pred.	93 (14)	94 (17)	96 (21)	ns
FEV %	41 (15)	46 (8)	42 (10)	ns
Work $rate_{peak}$ (W)	85 (31)	76 (26)	71 (31)	ns

Kruskal–Wallis was used for comparison between groups.
Values presented as mean (SD).

Study protocol

The study design was controlled and semi-randomised. Thirty patients, living within 60 km from the hospital where the study took place, were randomised to physical group training either in water (water group) or on land (land group). At randomisation the patients were stratified according to sex, FEV_1 and working capacity. Patients living 60–130 km from the study hospital (13 patients) were included in the control group.

Outcome measurements

Before and after the intervention period the patients completed a set of tests.

Walking tests: The Incremental Shuttle Walking Test (ISWT)[23] and the Endurance Shuttle Walking Test (ESWT)[24] were used. Before and after the walking tests the patients rated their dyspnea and leg fatigue according to Borg (CR10, category ratio scale).[25] Heart rate and oxygen saturation (SpO_2) were measured at rest and directly after tests with a pulse oximeter (Omeda Biox 3700e, Louisville, KY, USA). Instructions during the tests were standardised and no encouragement was given.

Cycle ergometer test: An incremental symptom-limited test on cycle ergometer (Rodby™, RE 829, Enhörna, Sweden) with ECG-registration was performed with the measurement of lactate from a venous cannula in the arm. A ramp protocol was used, i.e. all patients started at 20 W and the load was increased by 20 W every third minute until exhaustion. The patients SpO_2 and Borg ratings for dyspnea (CR10) and for rated perceived exertion (RPE)[25] were monitored at the end of every load. During the maximal test the patient's oxygen uptake (VO_2), carbon dioxide production (VCO_2) and ventilation (VE) were measured with a metabolic stress test system (MetaMax II, Cortex, Biophysik GmbH, Leipzig, Germany). Instructions during the tests were standardised and no encouragement was given.

Questionnaire: Health related quality of life (HRQoL) was evaluated with the disease specific St. Georges Respiratory Questionnaire (SGRQ)[26] and the generic Short Form 36 (SF-36).[27] The results in SF-36 were compared with normal values for a healthy Swedish population over 65 years of age.[28] Once a month, during the study period, all patients answered an activity level questionnaire[29] and some questions about health status and the use of medical care. The intervention in the study was not to be taken into account when answering the activity level questionnaire.

Spirometry: FEV_1, VC and FVC were measured with a spirometer (Spirolab, Medical International Research, Roma, Italy).

Intervention

The intervention was physical group training either in water (water group) or on land (land group) according to randomisation. The training programme for both intervention groups consisted of outpatient aerobic group training for 45 min (including warm-up and cool-down) three times per week for 12 weeks. Physiotherapists led the training. The programmes in water and on land were designed to have the same intensity profile, presented in Fig. 1. The sessions started with warm-up and flexibility exercises for 9 min. The session was then performed in the following order: 4 min endurance exercises, 3 min strength exercises for the legs, 4 min endurance exercises, 3 min strength exercises for the arms, 4 min endurance

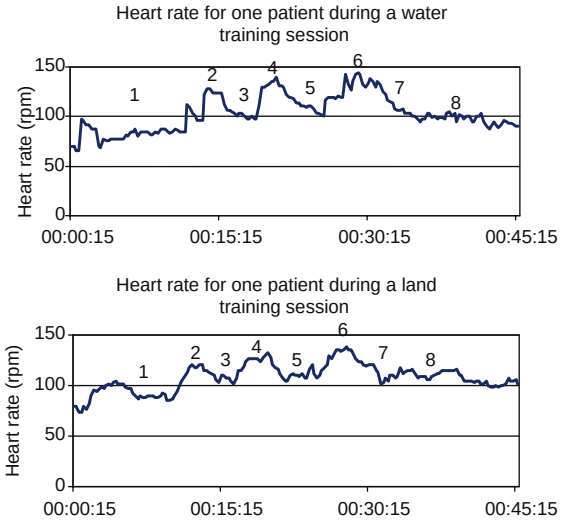

Figure 1 The intensity profile during the training sessions in water and on land, demonstrated with the heart rate of one patient from each training group. (1) Warm-up, (2) endurance exercises, (3) leg strength exercises, (4) endurance exercises, (5) arm strength exercises, (6) endurance exercises, (7) exercises for strength in torso, (8) cool-down.

exercises, 3 min strength exercises for the torso, 3 min flexibility exercises and finally cool-down and stretching exercises for 12 min. The intensity increased for each successive endurance exercise portion. The endurance parts of the session consisted of varied repetitive large-muscle exercises intending to increase the load on the cardiovascular system and increase heart rate. The complete programme was supported by music, which guided the intensity of the performance during the session. The water temperature was 33–34°C. The land training was performed in a gymnasium.

The intensity during the training sessions was monitored using heart rate registration (Polar Accurex Plus™, Polar Elektro Oy, Kempele, Finland) once weekly and the patients rated their dyspnea (CR10) and perceived exertion (RPE) according to Borg score[25] after each training session. The intensity target was to achieve a mean heart rate on 80–100% of peak heart rate according to maximal test on cycle ergometer and the patients were encouraged to reach Borg score 5 for dyspnea and 15 for rated perceived exertion. The blood pressure at rest was measured once a month.

Statistical analysis

The data were analysed using SPSS (version 10.0). Non-parametric methods were used and the data are presented as medians along with minimum and maximum values unless otherwise stated. An intention to treat analysis was applied (i.e. all patients completing pre- and post-tests were taken into the analysis). A lower limit of training compliance was set to 50% of the training sessions. The patients who fulfilled that criterion were also analysed separately as on treatment group. Differences between groups were analysed with the non-parametric Kruskall–Wallis one-way ANOVA (analysis of variance). When the ANOVA showed significant differences between groups, the Mann–Whitney *U*-test was used for pairwise comparisons between groups. The level of significance was defined as $P<0.05$. Changes within groups were compared with Wilcoxon matched-pairs signed-ranks test. Effect-size values (ES) were calculated to describe overall treatment effects.[30] It is calculated as the difference between before treatment (*T*1) and after treatment (*T*2) divided by the combined standard deviation for the total patient group before treatment (SD1). ($ES = (T1-T2)/SD1$). ES values are preferably calculated so that a positive change gives a positive value. The most common criteria for what is considered to be a large or a small treatment effect are based on Cohen's work. Values below 0.2 are considered as no effect, between 0.2 and 0.5 a small effect, between 0.5 and 0.8 a medium effect and values above 0.8 are a large effect.[30] Sample size was determined by power analysis (nQuery Advisor® 3.0) based on the minimum clinically important difference (MCID) in the ISWT.[31] A sample size of 30 subjects (10 subjects per group) was recommended to attain a power $>80\%$ with a α-level of 0.05. To adjust for potential drop-out 30 subjects in the intervention group and 13 patients in the control group (i.e. a total of 43 patients) were enrolled.

Results

Two patients (one woman in the control group and one woman in the land training group) did not attend the follow up tests and thus were regarded as drop-outs. Forty-one patients completed all follow up tests and were included in the intention to treat analysis. Twelve patients in each training group fulfilled the criteria of attending at least 50% of the training sessions (on treatment). The median attendance rate among the patients fulfilling the criteria was in the water group 31.5 (min = 18, max = 36) and in the land group 30.5 (min = 23, max = 35) of a total of 36 sessions (88% and 85%, respectively). There were no significant differences at baseline in any of the studied parameters

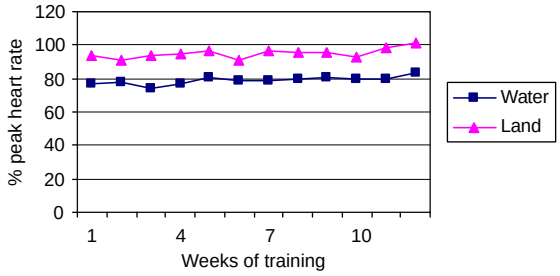

Figure 2 Percent of peak heart rate during the training sessions in both training groups. (Peak heart rate achieved during maximal cycle ergometer test pre training).

between the groups or between the patients fulfilling the training criteria and those who did not.

The mean heart rate during the training sessions in both training groups is shown as percent of peak heart rate in Fig. 2. The ratings of dyspnea (0–10) and perceived exertion (6–20) reached on average 4 and 14, respectively, for both training groups.

Both training groups increased their distance walked in ISWT (significant in the land group) and ESWT (significant in the water group) while the control group decreased (not significant) the distance. The difference after training was slightly larger for the on treatment group compared to the intention to treat group. The difference in ISWT between the control group and the training groups was significant when looking at the on treatment patients but not the intention to treat patients. The differences in ESWT between the groups were significant in both comparisons (Table 2).

During the incremental symptom-limited cycle ergometer tests both the water and the land training groups significantly increased the time cycled. A significant increase in mean workload was found, 6.7, 9.3 and 10.0 W for the control, water and land groups, respectively. All groups increased their $VO_{2\ peak}$ during the cycle ergometer test and the increase was significant in the water and the control group (Table 3). The water group showed a small but significant increase in peak heart rate ($+3$ rpm). No changes were found in any of the groups in peak ventilation or peak lactate during the cycle ergometer tests.

The mean total score in SGRQ at baseline for the control, water and land groups were 33.3 (SD 13.5) units, 40.5 (20.2) units and 44.8 (18.1) units, respectively. The difference between groups was not significant at baseline. Figure 3 presents the change in units after intervention with intention to treat analysis. The water group showed a slight, non-significant, decrease in total score (improvement, -3.6 units) in SGRQ. The control group showed a significant increase in total score (deterioration, $+5.3$ units), and that change was also significant compared to the training groups, $P=0.034$. The water group showed a significant decrease in activity score (-5.1 units), which was also a significant improvement compared to the other two groups ($P=0.009$) (Fig. 3).

The water group showed a significant improvement in physical health—PCS (physical component score) from 33 to 39 in SF-36, and this change was significant compared to the two other groups, $P=0.041$ (intention to treat analysis). The change in the patients who fulfilled the criteria of training attendance was slightly greater, from 34 to 42. Figure 4 presents the results in the PCS together with normal values for a healthy Swedish population over 65 years of age. In the mental health score all groups were on the same level as the healthy population at baseline and no change appeared after intervention.

The effect-size values (ES) for the walking tests, SGRQ and SF-36 in the intention to treat groups are presented in Table 4. According to these calculations the land group showed a small positive effect in ISWT (0.33) and the water group showed a medium positive effect in ESWT (0.68). In SGRQ the control group showed negative ES values for all dimensions and the symptoms, activity and total scores are considered as small changes (-0.3 to -0.46). On the opposite the water group showed small positive ES values in the activity, impact and total scores (0.2–0.28). In the between group comparisons the difference was significant in the activity score ($P=0.056$ in the total score). In SF-36 the water group achieved an effect which was considered to be a medium positive change in PCS (0.61). In the between group comparisons there were no significant differences ($P=0.062$ in PCS).

The results from the activity level questionnaire indicated that the control group had lowered their level of daily activity during the study period. The questions about health status indicated that both training groups had more exacerbations that demanded treatment with antibiotics during the intervention period compared to the control group.

Discussion

In most previous training studies on patients with COPD the participants had individually designed training programs.[7–9] This study showed that 12 weeks of physical group training in water as well as on land led to an improved exercise performance in

Table 2 Results from the walking tests at baseline and after 3 months intervention in the control group and the training groups. Analysis of all patients in the study (Intention to treat) and analysis of patients fulfilling the training attendance criteria (On treatment) are presented. Median values (min–max) at baseline, at 3 months follow up, and the differences are given. Comparisons within and between group are outlined. Ns; no significance.

		Control group	Water group		Land group		
		($n=12$)	Intention to treat ($n=15$)	On treatment ($n=12$)	Intention to treat ($n=14$)	On treatment ($n=12$)	Between group comparisons
ISWT (m)	Baseline	345 (180–550)	270 (200–540)	270 (200–540)	350 (130–570)	380 (130–570)	ns
	3 months	320 (200–500)	340 (150–540)	345 (260–540)	390 (140–590)	420 (140–590)	
	Within group comparison	ns	ns	ns	$P=0.008$	$P=0.003$	
	Difference Baseline/3 mo	−5 (−110–80)	20 (−140–110)	55 (−90–110)	20 (−20–130)	25 (0–130)	$P=0.03$[a] $P=0.008$[b]
ESWT (m)	Baseline	1047 (116–1538)	458 (133–1364)	562 (133–1364)	576 (85–1905)	686 (85–1905)	ns
	3 months	599 (176–1446)	1060 (315–1846)	1319 (315–1846)	512 (209–1905)	747 (209–1905)	
	Within group comparison	ns	$P=0.001$	$P=0.002$	ns	ns	
	Difference Baseline/3 mo	−40 (−890–444)	164 (8–1454)	179 (8–1454)	53 (−473–704)	53 (−473–704)	$P=0.001$[c] $P=0.009$[d] $P=0.001$[e] $P=0.007$[f]

Wilcoxon Signed Ranks test was used for comparisons within groups. Kruskal–Wallis and Mann–Whitney *U*-test was used for comparisons between groups.
[a]Control and water group—on treatment.
[b]Control and land group—on treatment.
[c]Control and water group—intention to treat.
[d]Water and land group—intention to treat.
[e]Control and water group—on treatment.
[f]Water and land group—on treatment.

Table 3 Results from the cycle ergometer tests at baseline and after 3 months intervention in the control group and the training groups. Analysis of all patients in the study (Intention to treat) and analysis of patients fulfilling the training attendance criteria (On treatment) are presented. Median values (min–max) at baseline, at 3 months follow up, and the differences are given. Comparisons within and between groups are outlined. Ns; no significance.

		Control group	Water group		Land group		
		($n = 12$)	Intention to treat ($n = 15$)	On treatment ($n = 12$)	Intention to treat ($n = 14$)	On treatment ($n = 12$)	Between group comparisons
Time cycled (s)	Baseline	495 (230–1260)	520 (360–720)	520 (380–720)	540 (260–1170)	540 (350–1170)	ns
	3 months	525 (240–1440)	580 (380–900)	595 (390–900)	575 (270–1300)	595 (390–1300)	
	Within group comparison	ns	$P = 0.004$	$P = 0.008$	$P = 0.033$	$P = 0.016$	
	Difference Baseline/3 mo	20 (−110–180)	40 (−30–180)	85 (−30–180)	25 (−50–170)	40 (−30–170)	ns
$Load_{peak}$ (W)	Baseline	60 (40–140)	60 (40–80)	60 (60–80)	60 (40–140)	60 (40–140)	ns
	3 months	60 (40–160)	80 (60–100)	80 (60–100)	80 (40–160)	80 (60–160)	
	Within group comparison	$P = 0.046$	$P = 0.008$	$P = 0.014$	$P = 0.008$	$P = 0.008$	
	Difference Baseline/3 mo	0 (0–20)	0 (0–20)	10 (0–20)	10 (0–20)	20 (0–20)	ns
$VO_{2\ peak}$ (ml/kg · min)	Baseline	16.6 (10.8–24.9)	15.6 (13.0–23.1)	15.5 (13.2–23.1)	17.7 (13.3–27.3)	18.9 (14.6–27.3)	ns
	3 months	18.0 (11.5–28.7)	16.9 (14.0–26.4)	16.9 (14.0–26.4)	17.7 (13.3–34.1)	19.8 (13.9–34.1)	
	Within group comparison	$P = 0.018$	$P = 0.008$	$P = 0.004$	ns	ns	
	Difference Baseline/3 mo	0.7 (−0.7–3.8)	1.5 (−1.9–3.5)	2.1 (−0.5–3.5)	0.6 (−3.9–6.8)	0.6 (−3.9–6.8)	ns

Wilcoxon Signed Ranks test was used for comparisons within groups. Kruskal–Wallis and Mann–Whitney *U*-test was used for comparisons between groups.

both walking tests and cycle ergometer tests. The two different training groups also showed a preserved quality of life according to the SGRQ as compared to the control group who deteriorated. Furthermore the group training in water improved the endurance according to the ESWT even more than the group training on land. The water group also improved their activity score in the SGRQ and their physical health according to the SF-36 and that was significant compared to both the control and the land training group.

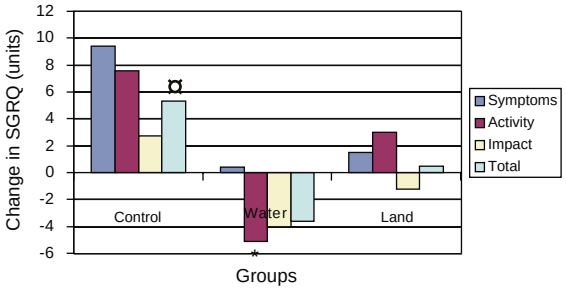

Figure 3 Change in St. George's Respiratory Questionnaire (SGRQ) after intervention. Intention to treat analysis. Mean values presented. ¤, significant within group, $P = 0.015$, *, significant within group, $P = 0.046$.

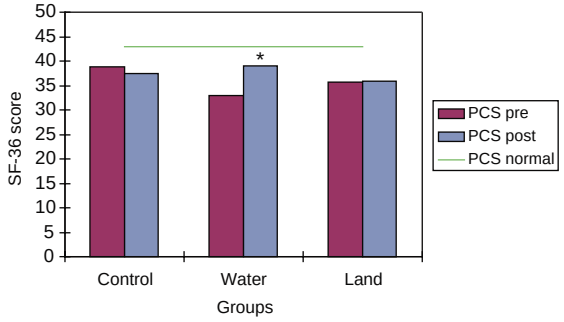

Figure 4 Physical health according to SF-36 (PCS—physical component score) before and after intervention compared to a normal population. Intention to treat analysis. Mean values presented. *, significant within group, $P = 0.015$.

The finding that physical training is effective in COPD patients is in accordance with previous studies, that have shown that strength training as well as endurance training should be included in the training programmes[8,9] and that interval training is of benefit.[7] The programmes in our study included both strength and endurance exercises and the sessions were designed with intervals in accordance with the music and as described in the methods.

The reason why the land group, not the water group, increased the distance walked in ISWT, and why the water group, not the land group, increased the distance walked in ESWT is not clear. The design of the training programme was the same in the two training groups with the same amount of endurance, strength and mobility exercises. Physiotherapists led the training and, as far as possible, the same physiotherapist led both land and water training to avoid the impact of different leader personalities. The mean heart rate during the training sessions (Fig. 2) shows that the intensity level complies with the goal 60–90% of HR_{max} set by the American College of Sports Medicine (ACSM) for improving aerobic fitness.[32] The design of the walking tests could possibly be one explanation to

Table 4 Mean effect-size values (ES) and 95 % CI for walking tests (ISWT, ESWT) and health related quality of life, HRQoL (SGRQ, SF-36) in the three groups. The *P*-value presents the between group differences. Ns; no significance.

Outcomes	Control ($n = 12$)		Water ($n = 15$)		Land ($n = 14$)		*P*-value
	ES	95 % CI	ES	95 % CI	ES	95 % CI	
Walking tests							
ISWT	−0.08	(−0.35–0.19)	0.16	(−0.16–0.49)	**0.33**	(0.09–0.56)	ns
ESWT	**−0.30**	(−0.78–0.17)	**0.68**	(0.22–1.14)	0.06	(−0.23–0.35)	0.003
SGRQ							
Symptoms	**−0.37**	(−0.88–0.14)	−0.02	(−0.56–0.52)	−0.06	(−0.51–0.39)	ns
Activity	**−0.42**	(−0.88–0.05)	**0.28**	(0.00–0.55)	−0.17	(−0.52–0.19)	0.018
Impact	−0.14	(−0.33–0.05)	**0.21**	(−0.16–0.57)	0.07	(−0.35–0.48)	ns
Total	**−0.30**	(−0.50–−0.09)	**0.20**	(−0.13–0.53)	0.03	(−0.36–0.30)	ns
SF-36							
PCS	−0.14	(−0.62–0.34)	**0.61**	(0.10–1.13)	0.02	(−0.48–0.52)	ns
MCS	0.00	(−0.37–0.36)	−0.07	(−0.60–0.46)	−0.10	(−0.54–0.18)	ns

The effect-size values of clinical relevance are indicated with bold style.

the results. The speed in the ESWT was decided from the result of the ISWT, it should correspond to 85% of the predicted VO_2 achieved in ISWT. An improvement in ISWT could lead to a higher walking speed in ESWT, which in it self is an improvement, but may have lead to difficulties for the patient to manage for a longer period.

The patients training in water in the present study attained lower heart rates compared to the land group throughout the training period (Fig. 2), although they rated their dyspnea and perceived exertion as high as the land group (4 and 14 on the Borg score). Head-out immersion in water leads to a central shift of blood volume from the peripheral to the intrathoracic vascular bed and studies have reported lower heart rates in water compared to the same exercise intensity on land.[33,34] Agostini et al.[35] found that the functional residual capacity (FRC) is decreased by almost the half, the vital capacity (VC) is decreased with 9% and the residual volume (RV) is decreased with about 16% during head-out water immersion. In patients with COPD the FRC and RV are often increased due to pathological changes in the lungs. This increases the work of breathing and contributes to the increased dyspnea that many of the patients suffer from. The fact that FRC and RV are decreased during head-out water immersion could possibly decrease the sense of dyspnea and facilitate the accomplishment of physical exercises in water. Further studies are desirable to investigate if this effect explains the difference in results between the water group and the land group.

The significant increase of 25 m in ISWT in the land group is not considered to be of clinical relevance since the minimum clinically important difference (MCID) for ISWT is 48 m.[31] On the other hand, the increase in ESWT for the water group (179 m) is of such a magnitude that it could be considered as a clinically important difference, although comparable data for ESWT is not yet available. The water and land groups increased their peak workload during the cycle ergometer test with mean values of 9.3 and 10.0 W, respectively, which is above the limit of clinical relevance in patients with COPD (8.3 W) as suggested by Lacasse et al.[36] The control group significantly increased their workload with a mean value of 6.7 W and their VO_{2peak} with 0.7 ml/kg min but it can be questioned if these increases are clinically important.

A clinically important difference was also achieved in the water group in the activity score in SGRQ where the group lowered the score by 5.1 units. Four units is considered to be the threshold of clinically significant change.[37] The control group increased their total score with 5.3 units, which consequently is a clinically important reduction in the health related quality of life. Compared to other groups of COPD patients presented in previous studies[26,38] the results in SGRQ at base line seem to be slightly better in our study group. When comparing the studied group of COPD patients with a normal Swedish population over the age of 65 years,[28] we found that the patients had similar mental scores but decreased physical scores according to the generic SF-36 questionnaire. The increase of 6 points in the water training group (8 points in the on treatment group) could be compared with the results from Kosinski et al. who found that an increase of 4.4 points in PCS (SF-36) is a minimum clinical important difference in patients with rheumatoid arthritis.[39]

When analysing the effect-size values we found that these values agree quite well with the actual test results (Table 4). The water group achieved effect-sizes between 0 and 0.7, the land group between 0 and 0.3, and the control group presented effect-sizes between 0 and −0.4. These results can be compared with the meta-analysis from Lacasse et al. who presented effect-sizes in exercise capacity and HRQoL between 0.3 and 0.8 after pulmonary rehabilitation[36] and with a research synthesis from Cambach et al.[40] who presented effect-sizes between 0.4 and 1.2. The somewhat lower effect-sizes found in the present study might be explained by the difference in intervention, which in this study consisted of physical training only, and not multidisciplinary rehabilitation programmes which were focused on in Cambach et al.'s meta-analysis.

According to the activity level questionnaire the patients in the control group tended to decrease their activity level during the intervention period. Aside from the deterioration of a chronic disease, one explanation could be the climate, which tends to worsen during the time of year of the study (September–November) and does not stimulate outdoor activities. This decrease in activity level could possibly correspond to the decrease in quality of life according to the SGRQ. Regarding the questions about health status it was shown that the patients in the training groups tended to have a higher rate of exacerbations and use of antibiotics compared to the control group. One hypothesis is that infections are more easily spread in groups as when patients gather together for training, but this has to be further elucidated. Despite the higher number of exacerbations the patients in the training groups managed to increase their physical capacity and keep or improve their health related quality of life during the period.

In individually tailored exercise programs, which most previous studies have focused on,[7–9] the number of cycle ergometers, treadmills or strength exercises machines available at the rehabilitation centre restricts the number of patients training at the same time. The results from the present study show that group training, with 15 patients in each group led by one physiotherapist, is effective. The patients can keep the intensity, measured by Borg ratings and heart rate, on an acceptable level.

Although no calculations on costs were made, this kind of training can be considered to be cost effective, since several patients train together under supervision from one leader, without the need of equipment other than the halls. Furthermore the psychosocial aspects of patients getting together in a group activity could not be ignored as a positive factor.

In this study high intensity physical group training was shown to be of benefit for patients with COPD. A new finding with the present study is that, with comparable exercise intensity, group training in water shows additional benefits in physical capacity and experienced physical health compared to group training on land. These positive results achieved by the water group may contribute to a new effective training modality for the increasing number of COPD patients.

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