Ground-based walking training improves quality of life and exercise capacity in COPD

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ABSTRACT This study was designed to determine the effect of ground-based walking training on health-related quality of life and exercise capacity in people with chronic obstructive pulmonary disease (COPD).

People with COPD were randomised to either a walking group that received supervised, ground-based walking training two to three times a week for 8–10 weeks, or a control group that received usual medical care and did not participate in exercise training.

130 out of 143 participants (mean±SD age 69±8 years, forced expiratory volume in 1 s 43±15% predicted) completed the study. Compared to the control group, the walking group demonstrated greater improvements in the St George's Respiratory Questionnaire total score (mean difference -6 points (95% CI -10– -2), $p<0.003$), Chronic Respiratory Disease Questionnaire total score (mean difference 7 points (95% CI 2–11), $p<0.01$) and endurance shuttle walk test time (mean difference 208 s (95% CI 104–313), $p<0.001$).

This study shows that ground-based walking training is an effective training modality that improves quality of life and endurance exercise capacity in people with COPD.

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Introduction

Pulmonary rehabilitation has been shown to improve health-related quality of life (HRQoL) [1] and exercise capacity, as well as reduce hospital admissions and length of stay in people with chronic obstructive pulmonary disease (COPD) [2–4]. Globally, the demand for pulmonary rehabilitation far outweighs the availability of programmes [5–10]. Exercise training is considered to be the most important component of pulmonary rehabilitation, with endurance training most commonly undertaken on a treadmill or stationary cycle ergometer [1].

A simpler form of training requiring no equipment is ground-based walking. Although guidelines recommend that walking training can be incorporated within pulmonary rehabilitation programmes [1], there is limited scientific evidence to support the use of ground-based walking training as the sole endurance training mode. Previous studies that have evaluated supervised, ground-based walking training have been limited by low participant numbers [11] and the lack of a control group that received no exercise intervention [12]. Establishing the effectiveness of ground-based walking as the sole exercise modality to improve exercise capacity and HRQoL, would increase the accessibility of exercise training for people with COPD, especially in rural and remote locations where access to exercise equipment is limited.

The primary aim of this study was to determine the effects of a short-term, supervised, ground-based walking training programme on HRQoL compared to usual medical care in people with COPD. A secondary aim was to determine the effects of ground-based walking training on endurance, as well as functional and peak exercise capacity compared to usual medical care. We hypothesised that a supervised, ground-based walking training programme would result in significant improvements in HRQoL and exercise capacity compared with usual medical care in people with COPD.

Methods

Participants

Participants were recruited from referrals to outpatient pulmonary rehabilitation programmes in two Australian cities (Sydney and Perth). Participants were included in the study if they had a medical diagnosis of moderate, severe or very severe COPD according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) spirometric classification [13] (forced expiratory volume in 1 s (FEV_1)/forced vital capacity (FVC) <0.7 and FEV_1 $<80\%$ predicted [14]), were in a stable clinical state and had a smoking history of >10 pack-years. Exclusion criteria were prescription of long-term oxygen therapy, morbid obesity (body mass index >35 $kg \cdot m^{-2}$), use of a walking aid, comorbidities likely to adversely affect exercise performance, or participation in supervised exercise training in the past 12 months. Written informed consent was obtained from all participants.

Study design

This study was a prospective, blinded (assessor and statistician), multicentre, randomised controlled trial with concealed allocation. Following baseline assessment participants were randomised *via* an independent telephone randomisation service using computerised random number generator sequencing to either the walking group or control group. Randomisation was stratified according to baseline lung function (FEV_1 $<40\%$ or $\geqslant 40\%$ predicted), HRQoL (St George's Respiratory Questionnaire (SGRQ) total score <45 or $\geqslant 45$), exercise capacity (6-min walk distance (6MWD) $<70\%$ or $\geqslant 70\%$ predicted) and study centre. Randomisation was biased towards the walking group with a 2:1 ratio for the purposes of a long-term follow-on study to 12 months. The study was approved by the ethics committees of Sydney South West Area Health Service (Sydney, Australia), The University of Sydney (Sydney), Curtin University (Perth, Australia), Sir Charles Gairdner Hospital (Nedlands, Australia) and Bentley Hospital (Perth). The trial was registered in the Australia and New Zealand Clinical Trials Registry (identifier ACTRN 12609000472279).

Intervention

Participants in the walking group performed ground-based walking training while participants in the control group did not participate in any exercise training and were not given any instructions regarding exercise. A letter was sent to the general medical practitioner of each participant to advise them of their patient's involvement in the study and to encourage optimal medical management. The letter included the Australian COPD best practice management guidelines [15] and a COPD action plan that recommended individualised medication use when stable and during an exacerbation [15].

Walk training

Participants in the walking group attended walking training sessions three times a week for 8 weeks. Walking training was performed on a flat indoor track within the participating hospitals and was supervised by physiotherapists experienced in providing pulmonary rehabilitation for people with COPD. The ground-based

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walking training commenced at 30-mins duration with the speed set at 80% of the average speed achieved during the 6-min walk test (6MWT) [16]. Ground-based walking training was increased by 5 min after every sixth training session to a maximum of 45 min. Participants were instructed to walk at a pace which elicited a dyspnoea score of 3–4 on a modified 0–10 point category-ratio dyspnoea scale [17]. Walking speed (intensity) was advanced on an individual basis depending on each participant's ability. If speed could not be increased due to a limitation in stride length and the participant was scoring <3 on the dyspnoea scale, weight belts were worn during training. The starting weight was 2.5 kg and was increased by 1 kg after every third session if the participant reported a dyspnoea score <3 at the end of the training session.

Immediately prior to and at the end of all supervised walking training sessions, heart rate and oxygen saturation measured by pulse oximetry (S_{pO_2}) were recorded using a finger probe connected to either a Masimo Rad 5 (Masimo Corporation, Irvine, CA, USA) or a Novametric (Respironics, Murrysville, PA, USA) oximeter. Rest breaks were allowed during training in the event of intolerable symptoms, and heart rate and S_{pO_2} were assessed during rest breaks using a pulse oximeter. Participants were encouraged to recommence walking training as soon as they felt able and rest time was not included in the duration of the training session.

If a participant was unable to attend three times per week, they were required to attend twice a week and complete one unsupervised session of walking training per week or attend twice a week for 10 weeks. The aim was to ensure that at least 20 walking training sessions were completed within 8–10 weeks. In the event of a participant having an exacerbation of COPD or being unable to attend due to illness, the exercise training was extended by a maximum of 2 weeks. Training compliance was measured by the number of completed training sessions.

Lung function tests

Spirometry (FEV_1 and FVC) was completed at baseline and on study completion using a calibrated portable spirometer (EasyOne spirometer; ndd Medical Technologies Inc., Andover, MA, USA) according to standard procedures [18]. Lung volumes (body plethysmography) and diffusion capacity of the lung for carbon monoxide were measured at baseline only, according to standard protocols [19, 20]. Obtained measurements were compared to normative data [14, 21, 22]. Disease severity of each participant was classified according to the GOLD spirometric criteria [13].

Outcome measures

All outcomes were measured at baseline and at study completion. The primary outcomes were HRQoL measured by the SGRQ and the Chronic Respiratory Disease Questionnaire (CRQ). Secondary outcomes were endurance exercise capacity measured by the endurance shuttle walk test (ESWT) time, functional exercise capacity measured by the 6MWT and peak exercise capacity measured by the incremental shuttle walk test (ISWT).

Measurement of HRQoL

HRQoL was measured with the SGRQ [23] and the interviewer-administered CRQ with an individualised dyspnoea domain [24]. The SGRQ has 53 items examining the impact of respiratory disease across three domains (symptoms, activity limitations and impact of disease) of HRQoL. The CRQ is a COPD-specific measurement tool that has 20 questions examining four domains of HRQoL (dyspnoea, fatigue, emotional function and disease mastery). During follow-up interviews, respondents were reminded of their responses to the most recently completed CRQ and asked if they felt the same, better or worse.

Measurement of exercise capacity

Participants completed two ESWTs, two 6MWTs and two ISWTs over two visits within a 7-day period. On the first visit, both ISWTs were completed prior to one ESWT. During the second visit the second ESWT was performed followed by two 6MWTs. The ISWT and 6MWT were performed according to standardised protocols [25, 26]. Since the ESWT has a ceiling effect (maximum 20 min test duration), the protocol [27] was modified so that if a participant completed >10 min in the first ESWT, the test was terminated and repeated at the higher level so that the participant's baseline ESWT time was between 5 and 10 min. This was done to allow opportunity for improvement at the reassessment and minimise the ceiling effect. The 6MWT track varied according to site and was either rectangular (26–32 m) or straight (20–45 m). At each site, participants performed all 6MWTs on the same track. Repeat tests performed on the same day were separated by a 30-min rest period. The test that yielded the greatest distance was recorded as the test outcome. The distances achieved on the ISWT and 6MWT were compared with normative data [28, 29]. During all walk tests, S_{pO_2} (Masimo Rad 5, Masimo Corporation or Novametric, Respironics) and heart rate (polar heart rate monitor; Polar Electro, Kempele, Finland) were continuously monitored. If S_{pO_2} fell

below 80% during testing, the ISWT was terminated and a rest was imposed in the 6MWT until S_{pO_2} increased to ⩾90%. Dyspnoea and rate of perceived exertion (RPE) were assessed before and after each exercise test using the modified 0–10 point category-ratio scale [17]. During the ESWT, dyspnoea and RPE were assessed at 1-min intervals in order to compare ratings at isotime. Isotime was defined as the end time of the pre- or post-intervention ESWT, whichever was shorter.

Sample size

The sample size was based on detection of a meaningful difference in the mean total CRQ score between the walking group and the control group. The recommended minimum important difference for the total CRQ score is 10 points [30]. Allowing for a 20% loss to follow-up and assuming a SD of 17 points for total CRQ score [31], 132 participants were sufficient to provide 80% power with an α of 0.05 (two-sided) (after adjusting for group size imbalance). This sample size was also sufficient to detect a -4 point difference in SGRQ total score, which is the minimum important difference for SGRQ [32].

Data analysis

Data are presented as mean±SD, unless otherwise stated. Data were analysed using SPSS (version 20; SPSS Inc., Chicago, IL, USA). A p-value ⩽0.05 was considered significant. ANCOVA was used with baseline values as the covariate to assess differences between groups for all data. Intention-to-treat analysis was conducted with no imputation of missing values. Independent sample t-tests were used to assess the differences between groups in the isotime data.

Results

Participant characteristics

The flowchart of study participants is presented in figure 1. 130 out of 143 participants completed the study (mean±SD age 69±8 years, FEV_1 43±15% predicted). Baseline characteristics of participants were similar between groups (table 1). Participants had moderate-to-severe COPD [13], reduced HRQoL (SGRQ total score 47±17) and reduced exercise capacity (6MWD 74±13% predicted). 13 (9%) participants in the walking group did not complete the post-intervention outcome measures for the following reasons: withdrew due to medical conditions other than COPD (n=4, 3%); admitted to hospital (n=3, 2%; COPD exacerbation n=2, bowel obstruction n=1); unable to be contacted (n=3, 2%); discontinued the intervention and declined reassessment (n=2, 1%); and declined to attend for reassessment (n=1, 1%). Of these 13 participants, five did not commence any training sessions. There were no differences in baseline

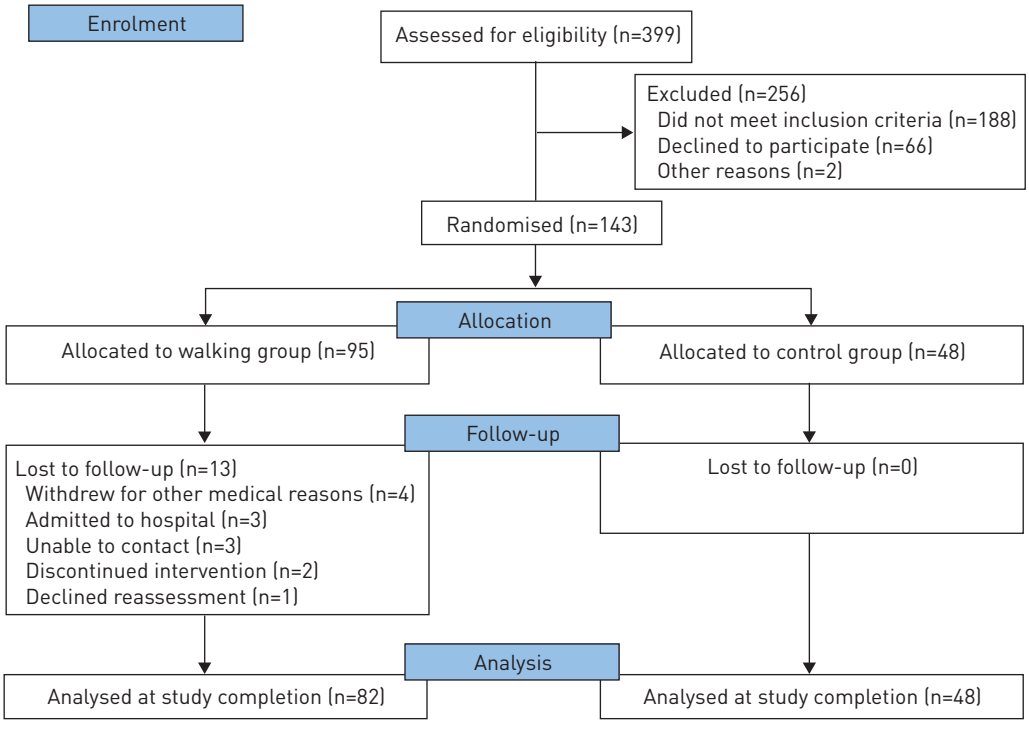

FIGURE 1 Flowchart of the study participants.

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TABLE 1 Participant characteristics

Variable	Walking group	Control group
Participants	95	48
Age years	69±8	68±9
Male/female	56/39	28/20
Height m	1.67±0.10	1.68±0.11
Weight kg	71±15	78±19
BMI kg·m^{-2}	25±5	27±6
Current smokers	15	10
Pulmonary function		
FEV1 L	1.13±0.42	1.19±0.47
FEV1 % predicted	43±15	43±15
FVC L	2.71±0.84	2.76±0.83
FVC % predicted	76±17	75±18
FEV1/FVC	0.43±0.14	0.43±0.12
TLC % predicted	114±32	109±18
FRC % predicted	153±60	139±37
RV % predicted	162±82)	147±51
RV/TLC ratio	0.54±0.09	0.52±0.11
*D*LCO % predicted	44±17	43±15
GOLD grade		
II	40 (42)	22 (46)
III	42 (44)	21 (44)
IV	13 (14)	5 (10)

Data are presented as n, mean±SD or n (%). BMI: body mass index; FEV1: forced expiratory volume in 1 s; FVC: forced vital capacity; TLC: total lung capacity; FRC: functional residual capacity; RV: residual volume; *D*LCO: diffusing capacity of the lung for carbon monoxide; GOLD: Global Initiative for Chronic Obstructive Lung Disease.

lung function (FEV1 % predicted, p=0.53), HRQoL (SGRQ total score, p=0.97) or exercise capacity (6MWD % predicted, p=0.18) between the participants who completed or did not complete the study. The modification to the ESWT protocol resulted in the ESWT level (speed) being increased for 36 (25%) participants at baseline assessment.

In the walking group, 75% of sessions (*i.e.* 18±6 out of a possible 24 sessions) were completed by the 90 participants who commenced walking training. 53 (56%) participants rested during training due to dyspnoea or fatigue. 11 (9%) of the 90 participants used weight belts during training. The walking distances achieved by the walking group during training showed a progressive increase (fig. 2), with 76 (84%) participants progressing their walking duration. Of those who progressed, 89% were in GOLD II, 85% were in GOLD III and 67% were in GOLD IV. Dyspnoea ratings remained constant between "moderate" to "somewhat severe" as the training duration increased (fig. 2). No adverse events were reported with the walking training.

HRQoL

Within group differences in HRQoL showed significant improvement in total scores and all domains of both the SGRQ and the CRQ in the walking group but not the control group (table 2). Compared to the control group, the walking group demonstrated greater improvements in the SGRQ total score and the SGRQ domains of activity limitations and impact of disease, as well as CRQ total score and the CRQ domains of emotional function and disease mastery (table 2).

Exercise capacity

Within group analyses showed there was a significant increase in ISWT distance and ESWT time in the walking group (table 2), but not the control group. Compared to the control group, the walking group demonstrated greater improvements in ESWT time and 6MWD, although the latter was partially due to a nonsignificant decrease in walk distance in the control group (table 2). There were no differences between groups in ISWT distance (table 2). At study completion, 15 (18%) participants in the walking group and two (4%) participants in the control group completed 20 min on the ESWT. When measurements were compared at isotime during the ESWT (table 3) a small but significant decrease in dyspnoea was noted in

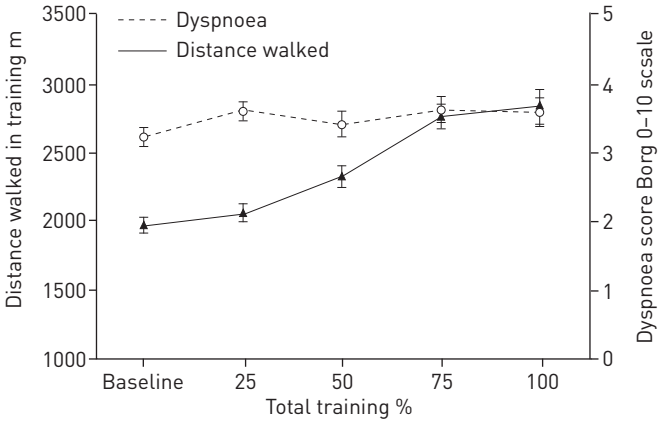

FIGURE 2 Peak walking distances and dyspnoea ratings during the walking training programme.

the walking group; however, there were no differences in dyspnoea or RPE between the walking group and control group at isotime (table 3).

Discussion

Many pulmonary rehabilitation programmes are designed around cycling and treadmill walking as the primary training modalities [1]. There has been a growing interest in the effectiveness of ground-based walking programmes to improve HRQoL and exercise capacity, given that ground-based walking training is simple to perform, readily available and easy to administer as it requires no exercise equipment. This is the first large randomised controlled trial of the effects of supervised ground-based walking training on HRQoL and exercise capacity compared with a control group receiving usual care and no exercise intervention in people with moderate-to-severe COPD. The outcome measures used in this study were comprehensive and included two disease specific questionnaires to evaluate HRQoL and three different types of walking exercise tests to evaluate exercise capacity. The main findings of this study were that ground-based walking training improved HRQoL and endurance walking capacity when compared to usual care.

We consider it a notable finding that walking training significantly improved HRQoL, especially given that no other mode of training or any disease management education was provided. The few studies that have examined the effect of ground-based walk training on HRQoL have also shown improvements [12, 33, 34]. These programmes have varied in the delivery of walking training being either supervised [12], unsupervised [33] or involving Nordic walking [34]. All studies had relatively small sample sizes (20 to 30 participants per group) thereby limiting the ability to both generalise the findings and determine a precise estimate of the magnitude of the effect that walking training had on HRQoL. Our study, in a much larger cohort, confirms these early findings that ground-based walking training can improve HRQoL. The key components of walking training, which we believe were important to achieve improved HRQoL, were the individualised walking intensity based on the initial 6MWT and supervision by physiotherapists experienced in pulmonary rehabilitation enabling continued monitoring to ensure appropriate progression of intensity and duration of walking training.

Two HRQoL questionnaires were used as primary outcome measures in this study. The total score of the SGRQ showed a significant and clinically relevant improvement (a reduction in score by $\geqslant$4 points) [23] in the walking group compared to the control group with significant improvements in the subscores of activity limitation and impacts between groups. For the CRQ total score, the between group difference did show a significant improvement, but this did not reach the minimum important difference for this outcome [30]. The types of questions within each HRQoL questionnaire may explain the difference in responsiveness of the two HRQoL measures. Many of the activity questions within the SGRQ were focused on activities involving walking whereas for the CRQ, participants chose activities that caused them to be short of breath and these activities may not have involved walking and, therefore, may not have been altered by the effects of the intervention.

The secondary aim of the study was to determine the effects of supervised, ground-based walking training on endurance and functional and peak exercise capacity. Ground-based walking training improved endurance exercise capacity, measured by the ESWT, in the walking group compared to the control group. The improvement in ESWT time was 71% greater in the walking group compared to the control group. This improvement exceeded the distribution-based minimum important difference for pulmonary rehabilitation of 186 s [35]. It is likely that the observed improvement in endurance exercise capacity

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TABLE 2 Walk test and questionnaire data in the walking group and control group participants at baseline and study completion

Outcome	Participants n		Baseline		Study completion		Within group		Between group	ANCOVA p-value
	Walking	Control	Walking	Control	Walking	Control	Walking	Control		
ISWT m	74	47	319±115	332±118	344±132	335±127	25 (10–40)*	3 (-13–18)	22 (-0.2–44)	0.052
ESWT s	78	47	330±208	294±168	574±389	333±227	245 (174–315)*	38 (-29–106)	208 (104–313)#	<0.001
6MWT m	77	45	465±85	473±91	474±92	459±90	9 (-1–19)	-14 (-29–0.3)	22 (6–39)#	0.01
SGRQ	80	45								
Total score			47±17	47±16	41±14	47±16	-6 (-9– -3)*	0.1 (-4–4)	-6 (-10– -2)#	0.003
Symptoms			56±22	62±21	50±23	59±21	-6 (-10– -1)*	-3 (-9–3)	-5 (-12–2)	0.19
Activity limitations			63±19	64±20	59±18	66±20	-5 (-7– -2)*	2 (-2–7)	-7 (-11– -2)#	0.003
Impacts			33±18	33±17	27±14	33±16	-6 (-9– -3)*	-0.3 (-5–4)	-6 (-10– -1)#	0.01
CRQ	81	48								
Total score			89±19	89±17	97±18	90±18	8 (5–11)*	1 (-3–5)	7 (2–11)#	0.01
Dyspnoea			16±5	17± 5	19±5	18±6	2 (1–3)*	1 (-0.4–2)	1 (-0.4–3)	0.15
Fatigue			17±6	17±4	19±5	17±4	1 (0.4–2)*	1 (-0.3–2)	1 (-0.4–2)	0.18
Emotional function			35±8	34±9	37±7	35±9	3 (1–4)*	0.2 (-2–2)	3 (1–5)#	0.01
Mastery			21±5	21±5	22±5	21±5	1 (1–2)*	0.2 (-1–1)	1 (0.1–3)#	0.04

Data are presented as mean±SD or mean difference (95% CI), unless otherwise stated. ISWT: incremental shuttle walk test; ESWT: endurance shuttle walk test; 6MWT: 6-min walk test; SGRQ: St George's Respiratory Questionnaire; CRQ: Chronic Respiratory Disease Questionnaire. *: significant difference within groups ($p<0.05$); #: significant difference between groups from ANCOVA adjusting follow-up measures for baseline measures ($p<0.05$).

TABLE 3 Group data for dyspnoea and rate of perceived exertion (RPE) at isotime during the endurance shuttle walk test (ESWT)

	Baseline		Study completion		Within group		Between group	ANCOVA p-value
	Walking	Control	Walking	Control	Walking	Control		
Dyspnoea score	4.5±2.0	4.2±1.7	3.9±1.8	4.1±1.7	-0.6 (-0.1– -1.0)*	-0.1 (-0.6–0.4)	0.5 (-0.2–1.2)	0.13
RPE score	4.5±2.0	4.6±2.0	4.2±1.7	4.4±1.7	-0.4 (-0.8–0.0)	-0.2 (-0.8–0.5)	0.2 (-0.48–0.95)	0.52

Data are presented as mean±SD or mean difference (95% CI), unless otherwise stated. Isotime was defined as the end time of the pre- or post-intervention ESWT, whichever was the shorter. *: significant difference within groups ($p<0.05$).

was an underestimation of the true increase since 15 participants in the walking group completed 20 min on the ESWT at the final assessment, which reduced the responsiveness of this measure to detect change. In terms of functional exercise capacity, measured by the 6MWT, there was a small, statistically significant between group difference in 6MWD of 22 m but this was largely a consequence of a small nonsignificant reduction in 6MWD in the control group rather than an improvement in the walking group. This small improvement did not reach the reported minimum important difference following pulmonary rehabilitation of 25 m [36]. In terms of peak exercise capacity, while the walking group showed a small statistically significant improvement in ISWT distance of 25 m, this improvement did not result in a statistically significant or clinically important between group difference.

In order to improve 6MWD and ISWT distance, participants must be able to walk faster. While walking training was effective at improving endurance exercise capacity, it did not improve the average speed walked over 6 min in the 6MWT or the peak walking speed in the ISWT, suggesting that walking training enabled participants to walk further but not faster. Given that the programme of walking training focussed on increasing walking duration rather than increasing walking speed it is possible that participants were conditioned to walk at a particular speed during the post-training tests. Importantly, improvement in walking endurance rather than speed may make a greater difference to a person's ability to perform activities of daily living. In the present study, the improvement in the activity limitation subscale of the SGRQ would support this proposition.

There were no adverse events reported during walking training despite the relatively long walking durations of up to 45 min. During the training sessions, dyspnoea levels remained stable while duration of training sessions and distances achieved increased (fig. 2). Such a finding indicated that the participants were able to train for progressively longer durations without increased levels of dyspnoea, reflecting the improvement in exercise tolerance achieved at study completion. Given the ease of transferability of walk training, this mode of training could be transposed to other settings (*e.g.* community). However, the key principles applied in this study would need to be adhered to, namely, individually determined training prescription from baseline exercise testing and adequate supervision of training to enable appropriate training progression. Walking training may also be easily implemented in the home environment, enabling participants to continue this mode of exercise in the longer term with potential maintenance of benefits.

The study had a low drop-out rate of 9%, which is in contrast with higher attrition from clinical pulmonary rehabilitation programmes [2]. One reason for this difference may be that ''drop out'' from a clinical pulmonary rehabilitation programme is often reported when patients do not attend training, whereas, in a clinical trial, participants remain in the trial as long as some of the final assessments are performed (*i.e.* intention-to-treat). Interestingly, there were no drop-outs in the control group, most probably because this group had no exercise intervention and the only requirement was to perform final assessment testing. Following participation in the study the control group participants were offered standard pulmonary rehabilitation which may have been an incentive to attend for reassessment.

A limitation of the study was that detailed physiological testing was not performed. This limited our ability to explain the mechanisms of improvement in endurance exercise capacity in the walking group compared to the control group. One indication of a training effect was the small but significant reduction in dyspnoea at isotime during the ESWT suggesting that ventilatory demand may have been reduced at an equivalent work rate after training in the walking group. However, such a reduction in dyspnoea could also have been due to reduced levels of anxiety or improved neuromuscular recruitment. More detailed studies would be required to elucidate the physiological effects of walking training. A further study limitation was that people with mild COPD (GOLD I) were not recruited, therefore we cannot readily extend the study findings to this group.

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Conclusion

In conclusion, ground-based walking training improved HRQoL and endurance exercise capacity compared to usual medical care in people with COPD. The robust design of this study provides strong support for ground-based walking training having a therapeutic role as an endurance training modality for people with moderate-to-severe COPD, and this may be particularly applicable where specialised exercise equipment is not readily available.

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