Modified incremental step test: testing exercise capacity & exercise prescription

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Background

Pulmonary rehabilitation is a highly effective treatment for people with chronic respiratory disease

- ✓ COPD McCarthy *CDSR* 2015, Puhan *CDSR* 2016
- ✓ Bronchiectasis Lee *Arch Phys Med Rehabil* 2017
- ✓ Interstitial lung disease Dowman *CDSR* 2014
- ✓ Pulmonary hypertension Morris *CDSR* 2017
- ✓ Asthma Trevor *J Asthma* 2015

Program referral, uptake & completion is a worldwide challenge

Desveaux *COPD* 2015

Alternative service models

e.g. Home-based program homebaserehab.net

- ✓ Clinical equivalence Holland *Thorax* 2017
- ✓ Cost-effectiveness Burge *Respirology* 2020
- ✓ Clinical implementation Bondarenko *ERJ Open Res* 2020

Participants need pre-post program assessments

- Safety prior to commencing exercise program
- Accurate prescription of exercise intensity
- Demonstrate effectiveness of the intervention

Participants still need to attend a centre for standard field walking tests

Defining Modern Pulmonary Rehabilitation

An Official American Thoracic Society Workshop Report

Anne E. Holland, Narelle S. Cox, Linzy Houchen-Wolloff, Carolyn L. Rochester, Chris Garvey, Richard ZuWallack, Linda Nici, Trina Limberg, Suzanne C. Lareau, Barbara P. Yawn, Mary Galwicki, Thierry Troosters, Michael Steiner, Richard Casaburi, Enrico Clini, Roger S. Goldstein, and Sally J. Singh; on behalf of the American Thoracic Society Assembly on Pulmonary Rehabilitation

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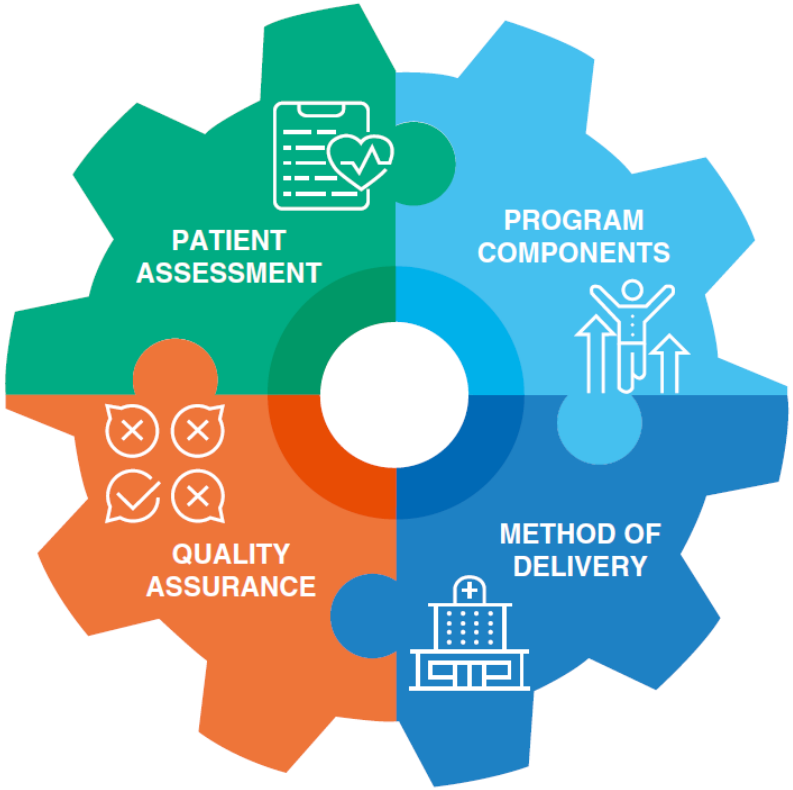

ESSENTIAL COMPONENTS OF PULMONARY REHABILITATION

1. An initial center-based assessment by a health care professional
2. An exercise test at the time of assessment
3. A field exercise test
4. Quality of life measure
5. Dyspnea assessment
6. Nutritional status evaluation
7. Occupational status evaluation

8. Endurance training
9. Resistance training

10. An exercise program that is individually prescribed
11. An exercise program that is individually progressed
12. Team includes a health care professional with experience in exercise prescription and progression

13. Health care professionals are trained to deliver the components of the model that is deployed

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Home-based or remote exercise testing in chronic respiratory disease, during the COVID-19 pandemic and beyond: A rapid review

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Abstract

Objectives: To identify exercise tests that are suitable for home-based or remote administration in people with chronic lung disease. **Methods:** Rapid review of studies that reported home-based or remote administration of an exercise test in people with chronic lung disease, and studies reporting their clinimetric (measurement) properties. **Results:** 84 studies were included. Tests used at home were the 6-minute walk test (6MWT, two studies), sit-to-stand tests (STS, five studies), Timed Up and Go (TUG, 4 studies) and step tests (two studies). Exercise tests administered remotely were the 6MWT (two studies) and step test (one study). Compared to centre-based testing the 6MWT distance was similar when performed outdoors but shorter when performed at home (two studies). The STS, TUG and step tests were feasible, reliable (intra-class correlation coefficients >0.80), valid (concurrent and known groups validity) and moderately responsive to pulmonary rehabilitation (medium effect sizes). These tests elicited less desaturation than the 6MWT, and validated methods to prescribe exercise were not reported. **Discussion:** The STS, step and TUG tests can be performed at home, but do not accurately document desaturation with walking or allow exercise prescription. Patients at risk of desaturation should be prioritised for centre-based exercise testing when this is available.

Modified incremental step test (MIST)

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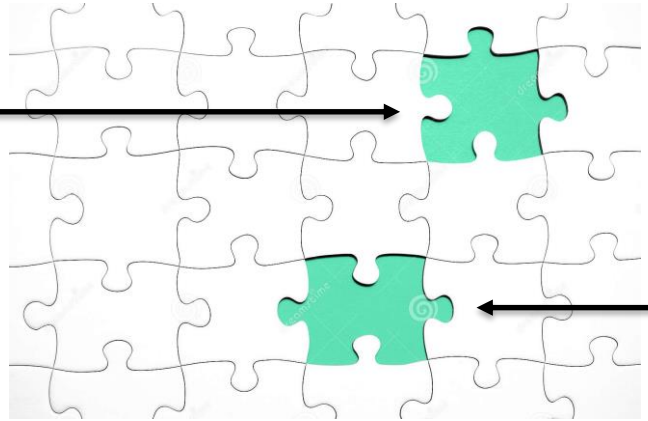
- Incremental externally-paced test
- Main outcome: number of steps
- Modified version of Chester step test de Carmargo *Resp Care* 2011, de Andrade *Respir Care* 2012
  - COPD: reduced commencement rate, modified increment rate
- Reproducible
  - Bronchiectasis Camargo *Braz J Phys Ther* 2013
  - COPD Dal Corso *Respir Med* 2013
- COPD: similar responses at peak exercise (CPET, Chester step test)
- Acute respiratory admission: relationship with 6MWD; dyspnoea; FVC; & no adverse events Jose *J Cardiopulm Rehabil Prev* 2016
- PHT: preliminary work Vieira *Respir Physiol Neurobiol* 2020

MIST for pulmonary rehabilitation

Home-based exercise testing



Exercise prescription

Burge AT, Rodrigues JC, Abramson MJ, Cox NS, Bondarenko J, Webb E, Marceau T, Handley E, Macdonald H, Askin A, Calasans GA, do Amaral DP, Dreger J, Dal Corso S, Holland AE. Application of the modified incremental step test for pulmonary rehabilitation. *Phys Ther* 2021;101:1–9.

Aims: home-based exercise testing

- To determine the feasibility of conducting home- and centre-based MISTs in people with chronic respiratory disease
- To establish the reliability of MIST undertaken in the home environment
- To demonstrate responsiveness of the MIST to change in exercise capacity following pulmonary rehabilitation
- To identify what represents a meaningful change in the MIST by defining the minimal important difference (MID)

Methods: participants

Inclusion criteria

- Referred to pulmonary rehabilitation
- Stable primary chronic lung disease (COPD, asthma, bronchiectasis)

Exclusion criteria

- Primary diagnosis of ILD, IPF, PHT or lung cancer
- Pulmonary rehabilitation within 18 months (unless admission for exacerbation)
- Unstable or brittle asthma (acute presentation within 3 months)

Methods: MIST procedure

Standardised protocol Dal Corso *Respir Med* 2013

Digital audio recording dictated stepping rate

As per other field walking tests*

- Two tests
- Continuous monitoring SpO_2 & heart rate
- Borg rating for dyspnoea and perceived exertion

Replicate conditions e.g. upper limb support

*Holland AE, et al. An official European Respiratory Society/ American Thoracic Society technical standard: field walking tests in chronic respiratory disease. *Eur Respir J* 2014;44:1428–46.

Methods: timing

Usual centre-based pulmonary rehabilitation Ax including 6MWT

BASELINE ASSESSMENT → PULMONARY REHABILITATION → PROGRAM COMPLETION

Methods: timing

random order

BASELINE ASSESSMENT → PULMONARY REHABILITATION → PROGRAM COMPLETION

Methods: feasibility

FEASIBILITY

Frequency of conditions that preclude participation

BASELINE ASSESSMENT → PULMONARY REHABILITATION → PROGRAM COMPLETION

Methods: reliability

RELIABILITY

ICC*

Standard error of measurement (SEM)

Agreement between results in both settings

*Sample size calculation:
n=39 to detect an ICC of 0.8
assuming CI lower limit of 0.65

BASELINE ASSESSMENT → PULMONARY REHABILITATION → PROGRAM COMPLETION

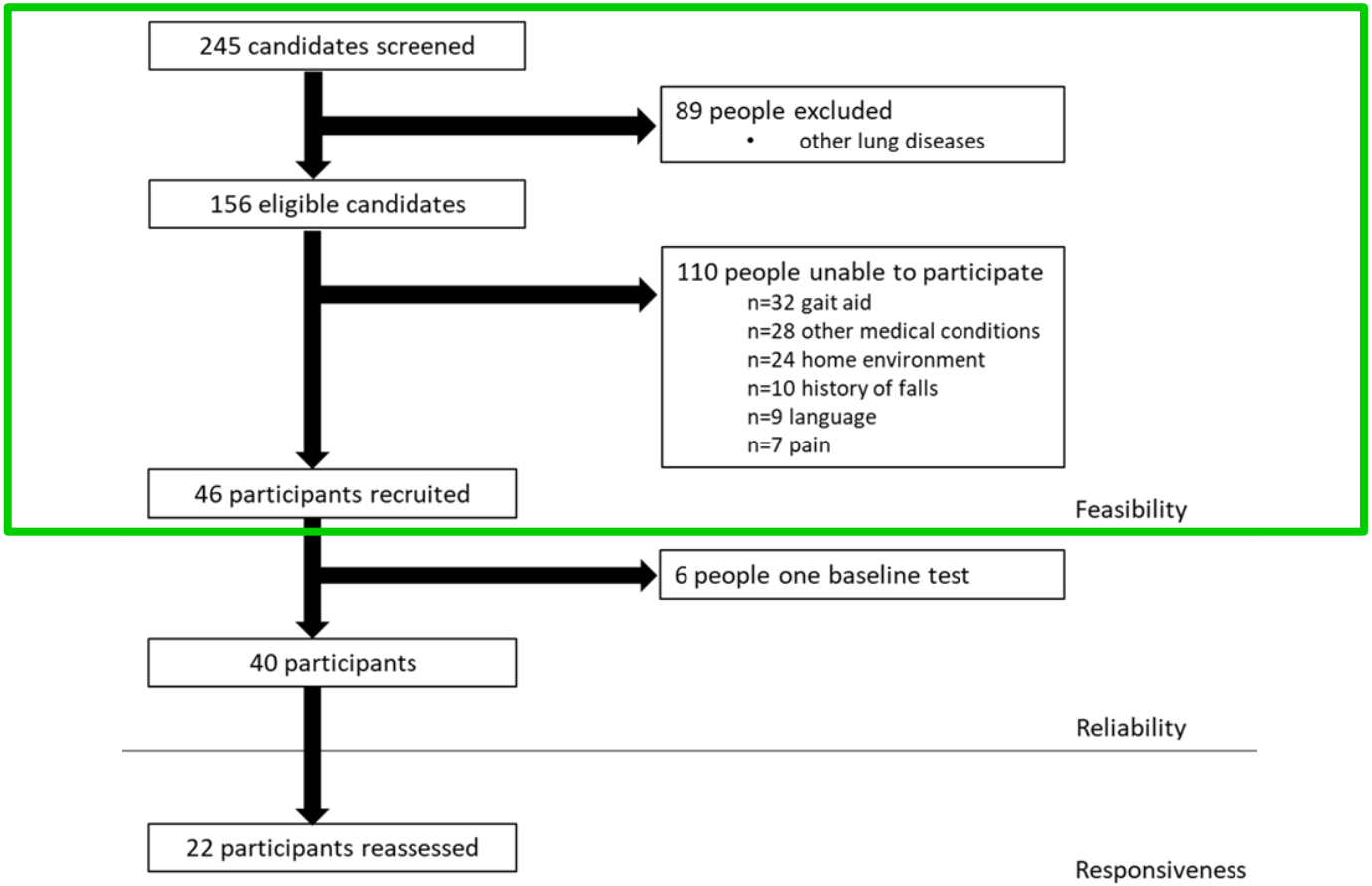
Methods: responsiveness

RESPONSIVENESS

Effect size
MID
Minimal detectable change (MDC_{95})

BASELINE ASSESSMENT → PULMONARY REHABILITATION → PROGRAM COMPLETION

Results: feasibility



Results: participant characteristics

		Reliability n= 40	Responsiveness n = 22
Age, years		72 (9)	72 (11)
FEV_1, % predicted		61 (23)	62 (19)
Female, n (%)		23 (58%)	12 (55%)
Diagnosis, n	COPD	31	16
	Asthma	8	4
	Bronchiectasis	2	2

Data are mean (SD) unless indicated.

Results: baseline

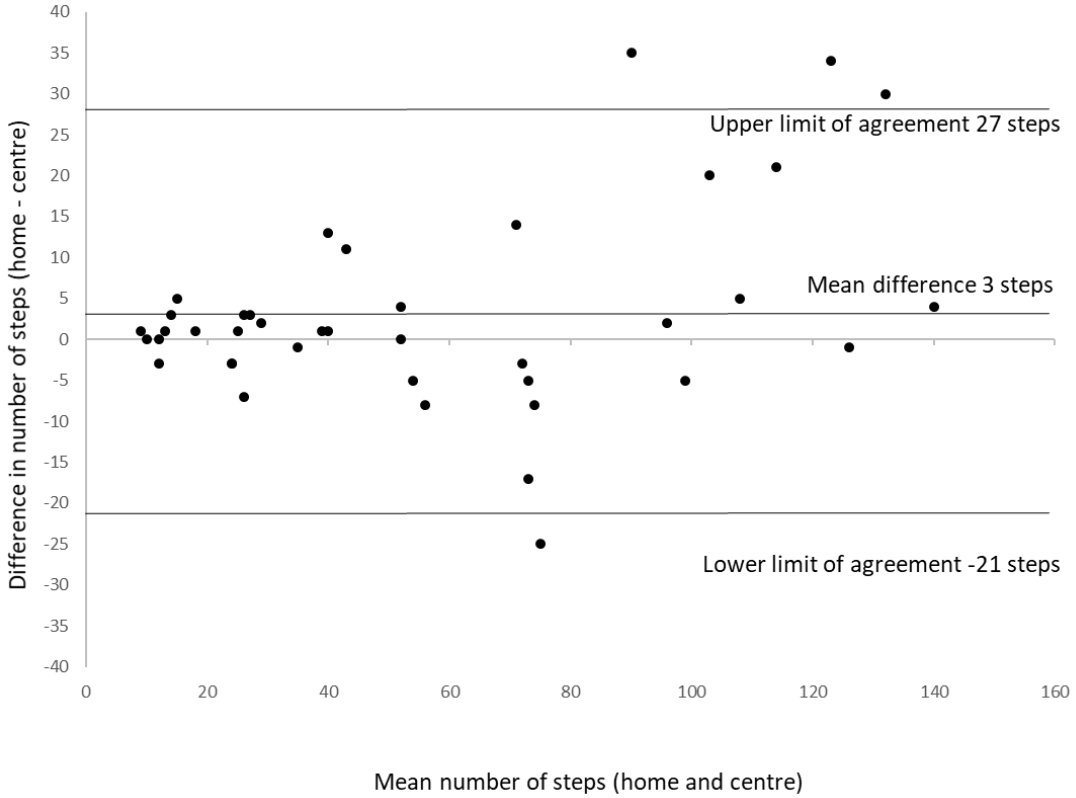
n=40	Location of MIST		6MWT	Comparisons of tests, MD (95% CI)	
	Home-based	Centre-based		Home – centre-based MIST	Home-based MIST vs. 6MWT
Outcome	58 (42) steps	55 (37) steps	434 (117) metres	3 (-1 to 7) steps	-
Nadir SpO_2, %	89 (5)	89 (5)	88 (7)	0.3 (-0.6 to 1.2)	1 (-1 to 3)
Peak pulse rate, bpm	105 (13)	106 (15)	106 (15)	-1 (-5 to 3)	1 (-6 to 4)
Maximum dyspnoea rating, median [IQR]	3 [3 to 4]	3 [3 to 4]	3 [3 to 4]	p = 0.449	p = 0.790
Maximum RPE, median [IQR]	13 [11 to 13]	12 [11 to 13]	13 [11 to 13]	p = 0.715	p = 0.320
Correlation, Pearson					0.778, p<0.005

Data are mean (SD) unless indicated.
bpm = beats per minute; MD = mean difference; RPE = rating of perceived exertion; s_pO_2 = oxyhaemoglobin saturation.

Results: baseline MIST (home vs. centre)

ICC 0.938 (95%CI 0.864 to 0.972)

SEM 3.2 steps



Results: responsiveness

n=22	MIST, steps	6MWD, metres
Baseline	62 (41)	442 (113)
Program completion	75 (51)	472 (109)
Change following pulmonary rehabilitation, MD (95%CI)	13 (2 to 25)	30 (13 to 46)
Effect size	0.34	0.27
MID	13	
MDC_{95}	7	

Background: exercise prescription

- Pulmonary rehabilitation guidelines
  - Target ≥60% of peak exercise should be used in training programs as the threshold intensity necessary to incite a physiological training response
    Garvey *J Cardiopulm Rehabil Prev* 2016
- Use of the MIST for exercise prescription
  - Evidence that the intensity achieved during constant rate step exercise training exceeds this threshold and achieves a steady-state response*
    Whipp *J Appl Physiol* 1972

* minute-to-minute variations in VO_2 <60 mL/min Zainuldin *J Cardiopulm Rehabil Prev* 2016

Aim: exercise prescription

- To investigate whether prescription of intensity for exercise training (based on MIST results) provided a physiological response within the recommended training range

Participants: exercise prescription

Recruited from pulmonary rehabilitation programs at:

- Alfred Health, Melbourne
- Wimmera Base Hospital, Horsham
- Universidade Nove de Julho, Sao Paulo, Brazil

Sample size calculation: n = 19 to detect a relationship between VO_2 & RPE (r = 0.6, 80% power, α=0.05)

Additional inclusion criteria:

- SpO_2 >90% in room air
- No supplemental oxygen on previous exercise tests
- No medications that could affect exercise responses

Methods: exercise prescription

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Monitoring: MetaMax 3B (Cortex; Germany)

- Each minute: pulse rate, SpO_2, dyspnoea rating & RPE

MIST

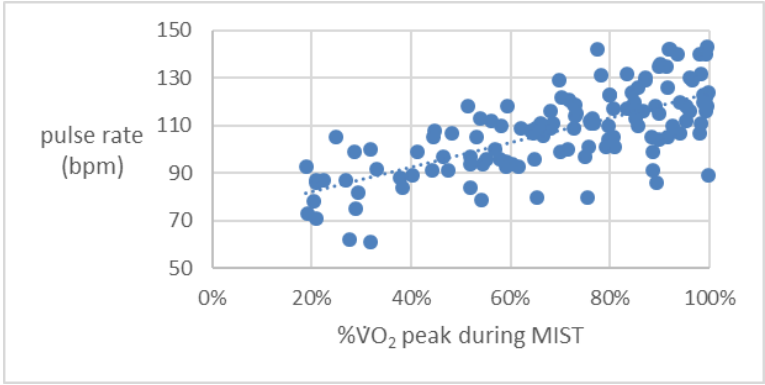
- Peak VO_2 = highest 20-sec mean O_2 consumption
- Relationship between VO_2 & pulse rate, dyspnea rating & RPE used to determine the level at which 60% VO_2peak was achieved

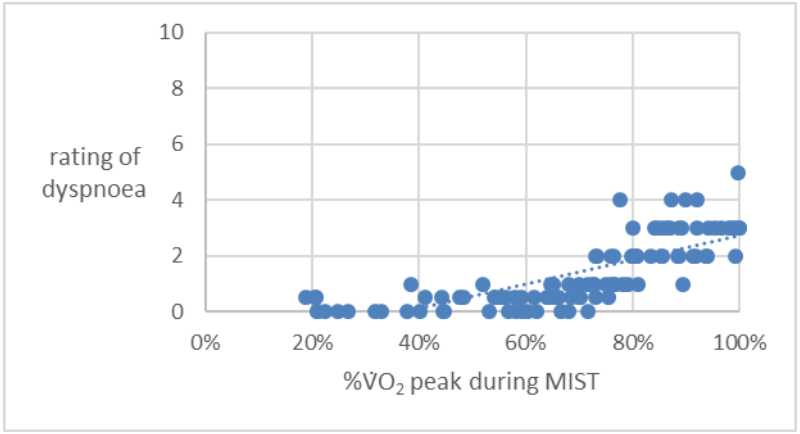
Constant rate step training session

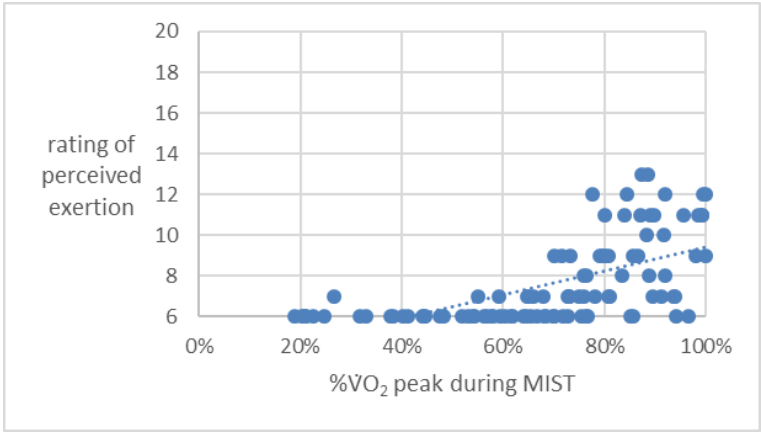
- Rate corresponding to MIST 60% peak VO_2
  - Externally paced, duration ~ 10 minutes
- Proportion of participants who achieved steady-state exercise intensity of ≥60% VO_2peak

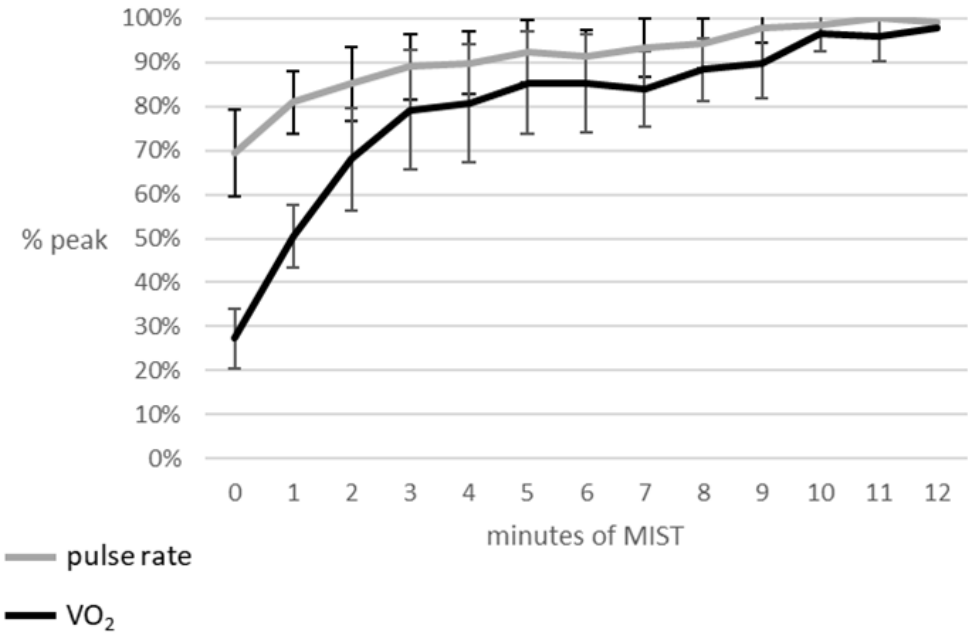
Results: exercise prescription

		n = 18
Age, years		67 (10)
FEV_1, % predicted		63 (23)
Female, n (%)		11 (61%)
Diagnosis, n	COPD	12
	Asthma	4
	Bronchiectasis	2



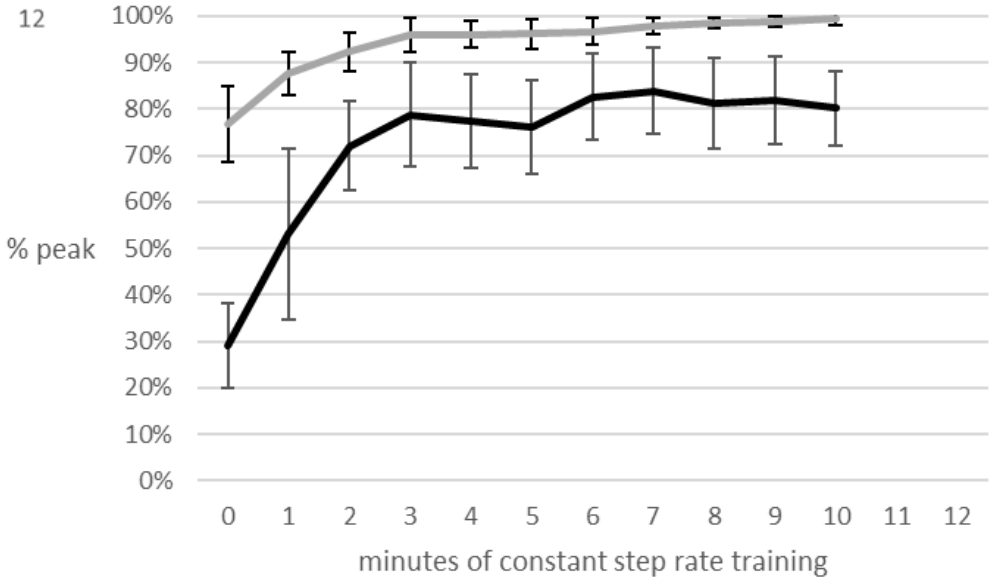






- By minute 4, all participants achieved ≥60% of VO_2peak
- MIST level at which participants achieved 60% of VO_2peak was mean 37% (95% CI 29 to 44)

- By minute 4, 17 (94%) participants reached steady-state in VO_2



Discussion

MIST is feasible and reliable in the home environment

- Minimal space requirements
- Not suitable for some participants for a range of reasons

Responsiveness

- Change following pulmonary rehabilitation
- A change of ≥7 steps reflects change in an individual, MID 13 steps

Prescription of exercise intensity

- Limited capacity to use symptoms or pulse rate
- 95% of participants achieved at least 60% of VO_2peak at 44% of their final level, and this workload was sustainable over 10 minutes

Conclusion

In people with chronic respiratory disease referred to pulmonary rehabilitation, the MIST is a feasible, reliable and responsive home-based test that can be used to prescribe exercise training capacity

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