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Better lung health for all

Application of intermittent exercise

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Northumbria University Newcastle

Objectives

- Demonstrate the mechanisms by which **acute application** of intermittent compared to continuous exercise lessens exertional symptoms in chronic respiratory diseases

- Review the efficacy of intermittent compared to continuous **exercise training** in patients with chronic respiratory diseases

- Provide practical considerations to implement different intermittent exercise modalities in the pulmonary rehabilitation setting

Pulmonary Rehabilitation: evidence of true physiological training effects

- ↑ Peak work rate
- ↑ Peak oxygen uptake
- ↑ Oxygen uptake @ Lactate threshold
- ↓ Ventilatory requirement and dyspnoea
- ↑ Muscle fiber size
- ↑ Muscle fiber capillarisation
- ↑ Oxidative enzyme activity

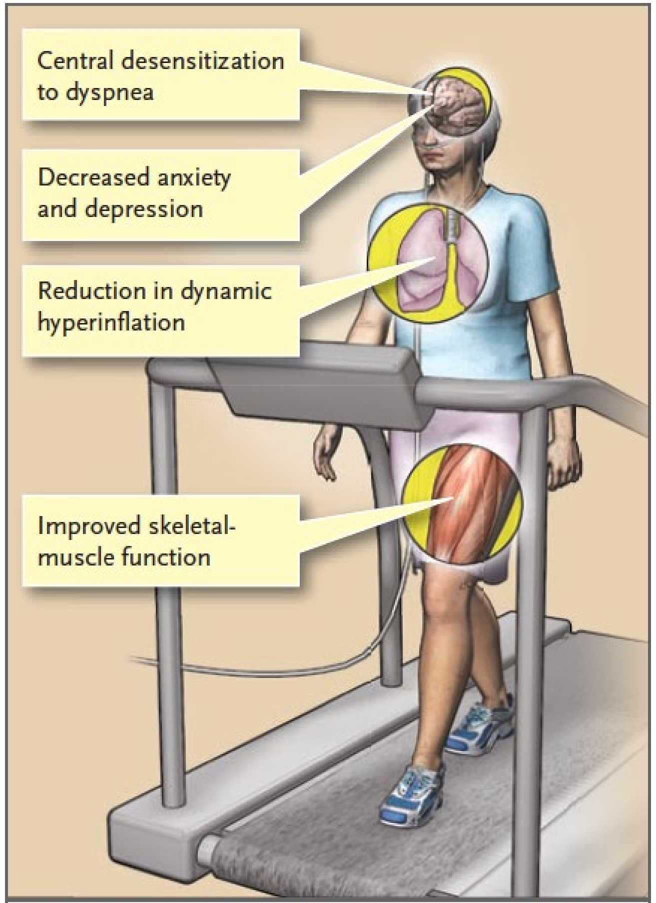


Figure 1. Targets of Exercise Training as Part of a Pulmonary Rehabilitation Program for Patients with COPD.

Maltais et al. AJRCCM 2014: ATS/ERS Updated Statement on limb muscle dysfunction in COPD

Spruit et al. AJRCCM 2013: ATS/ERS Statement on Pulmonary Rehabilitation

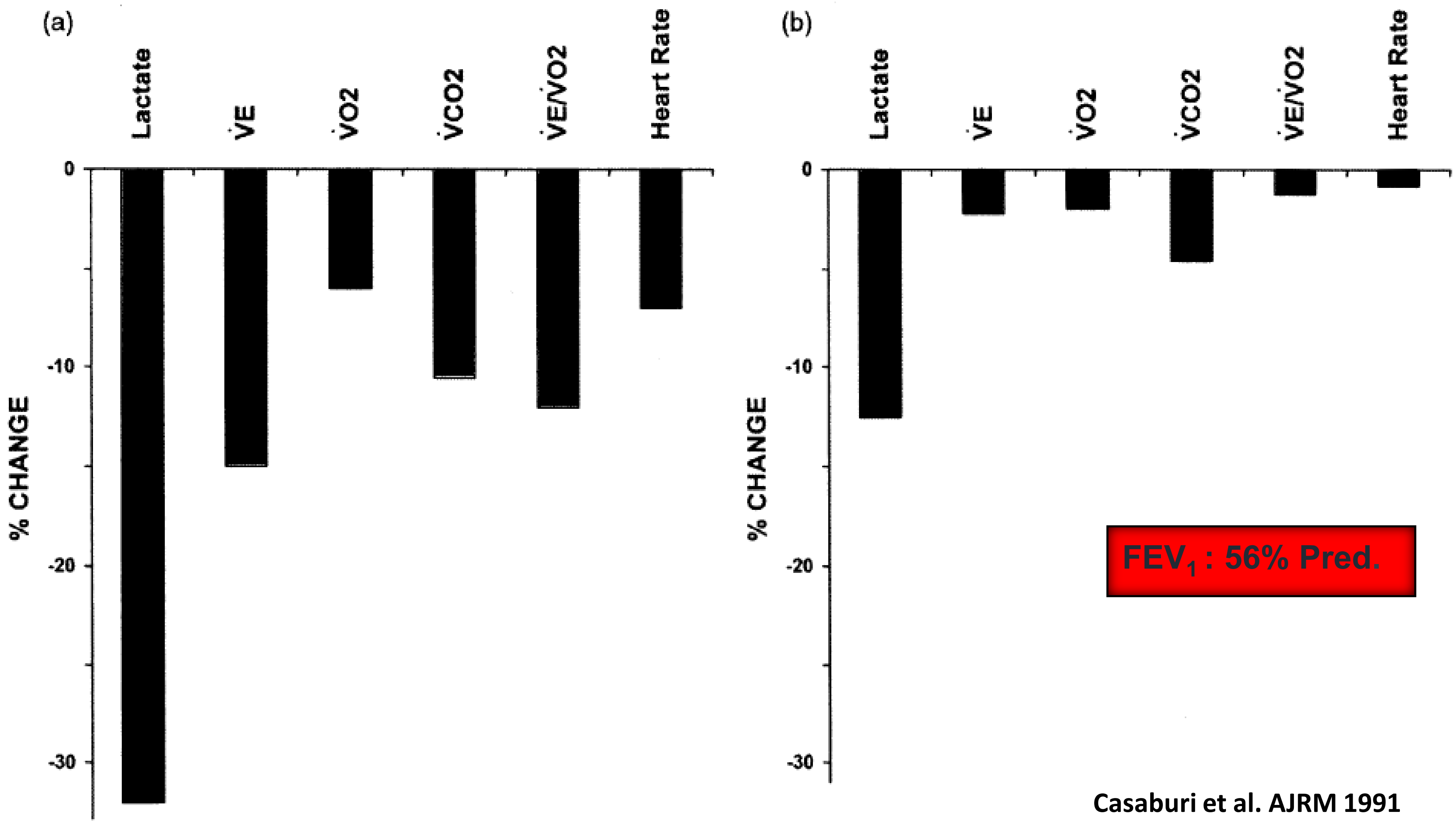
Pulmonary Rehabilitation for Management of Chronic Obstructive Pulmonary Disease

Richard Casaburi, Ph.D., M.D., and Richard ZuWallack, M.D.

N ENGL J MED 360;13 NEJM.ORG MARCH 26, 2009

High-intensity constant-load training is superior to moderate intensity training

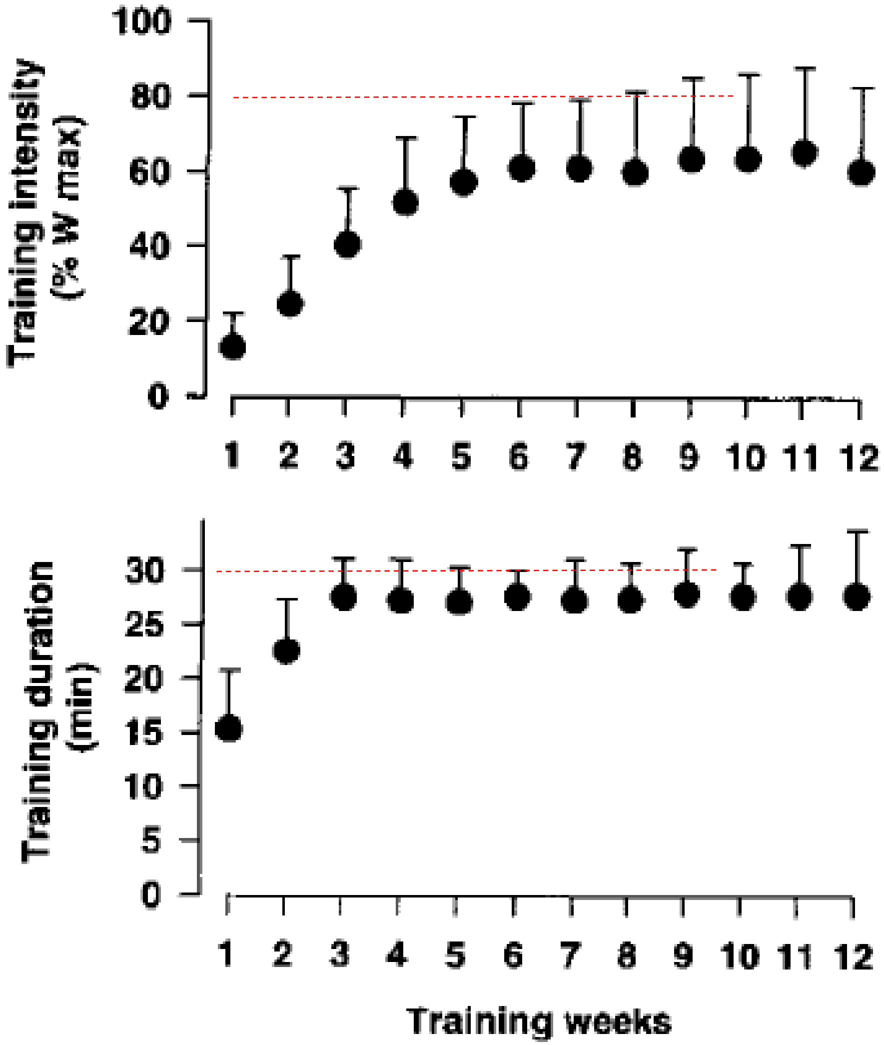
80% Peak Work Rate | **50% Peak Work Rate**



Casaburi et al. AJRM 1991

Severe COPD cannot sustain high intensity constant-load exercise

FEV_1 = 36 %

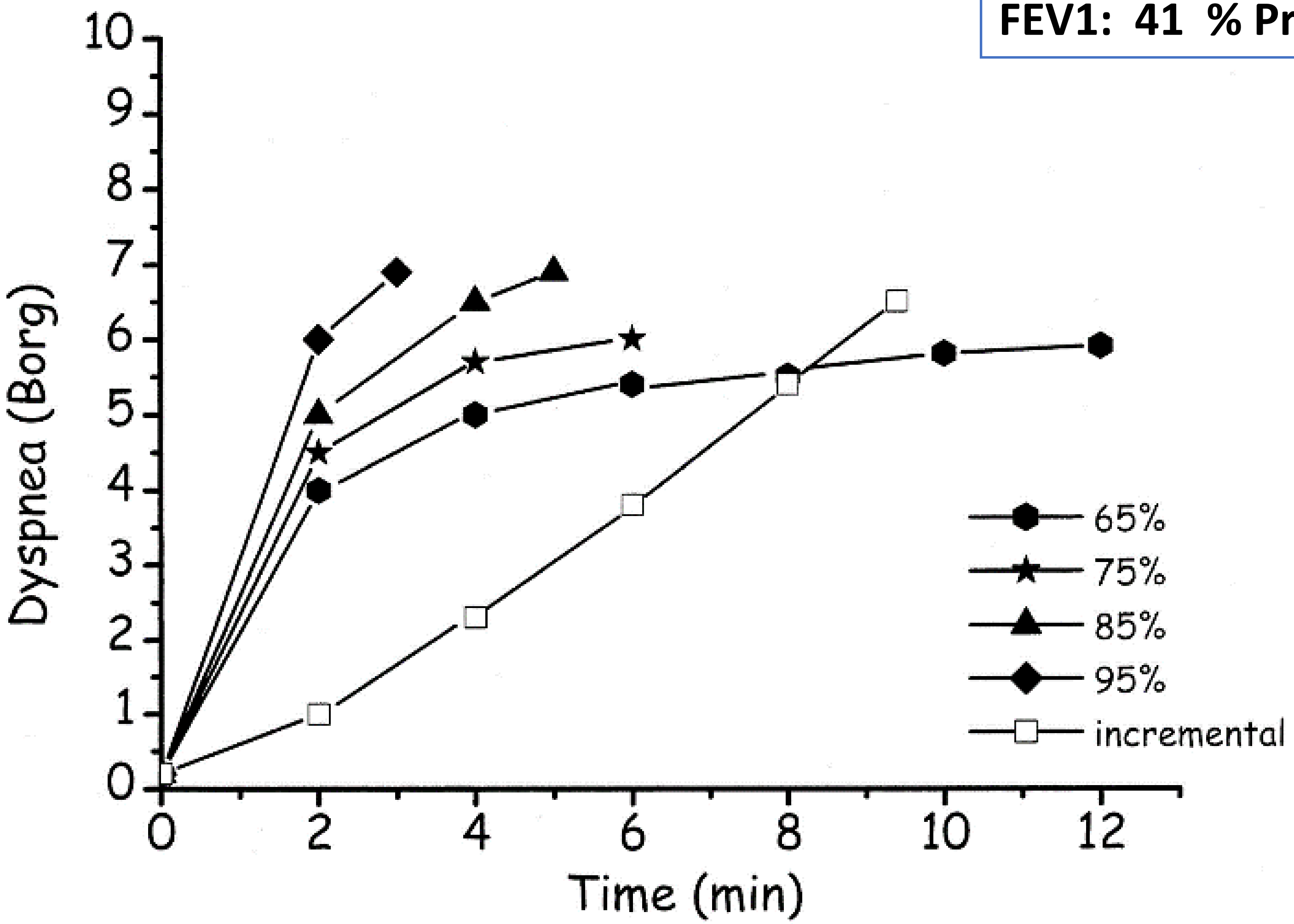


Intensity of training and physiologic adaptation in patients with chronic obstructive pulmonary disease. Maltais et al, AJRCCM. 1997

Dyspnea, Ventilatory Pattern, and Changes in Dynamic Hyperinflation Related to the Intensity of Constant Work Rate Exercise in COPD*

Puente-Maestu et al. Chest. 2005

FEV1: 41 % Predicted

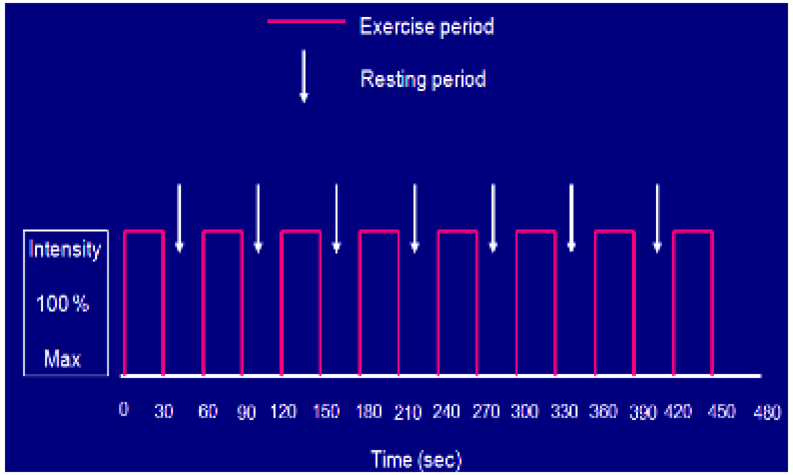


High Intensity Intermittent Exercise

- When a healthy person sustained high-intensity constant-load cycling work (170 Watts) endurance time was limited to 9 min

- When the same load (170 Watts) was performed intermittently (alternating work and rests of 0.5 min, or 1 min) the individual sustained the load for 1 hour

- It was found that the heavy work was transformed into a submaximal load on respiration and circulation with the shorter work periods of 0.5 and 1 minute.



Astrand, I., Astrand, P-O., Christensen, E. H., & Hedman, R. (1960). Intermittent muscular work. ***Acta Physiologica Scandinavica, 48,*** **448-453.**

Physiological Rationale for intermittent exercise

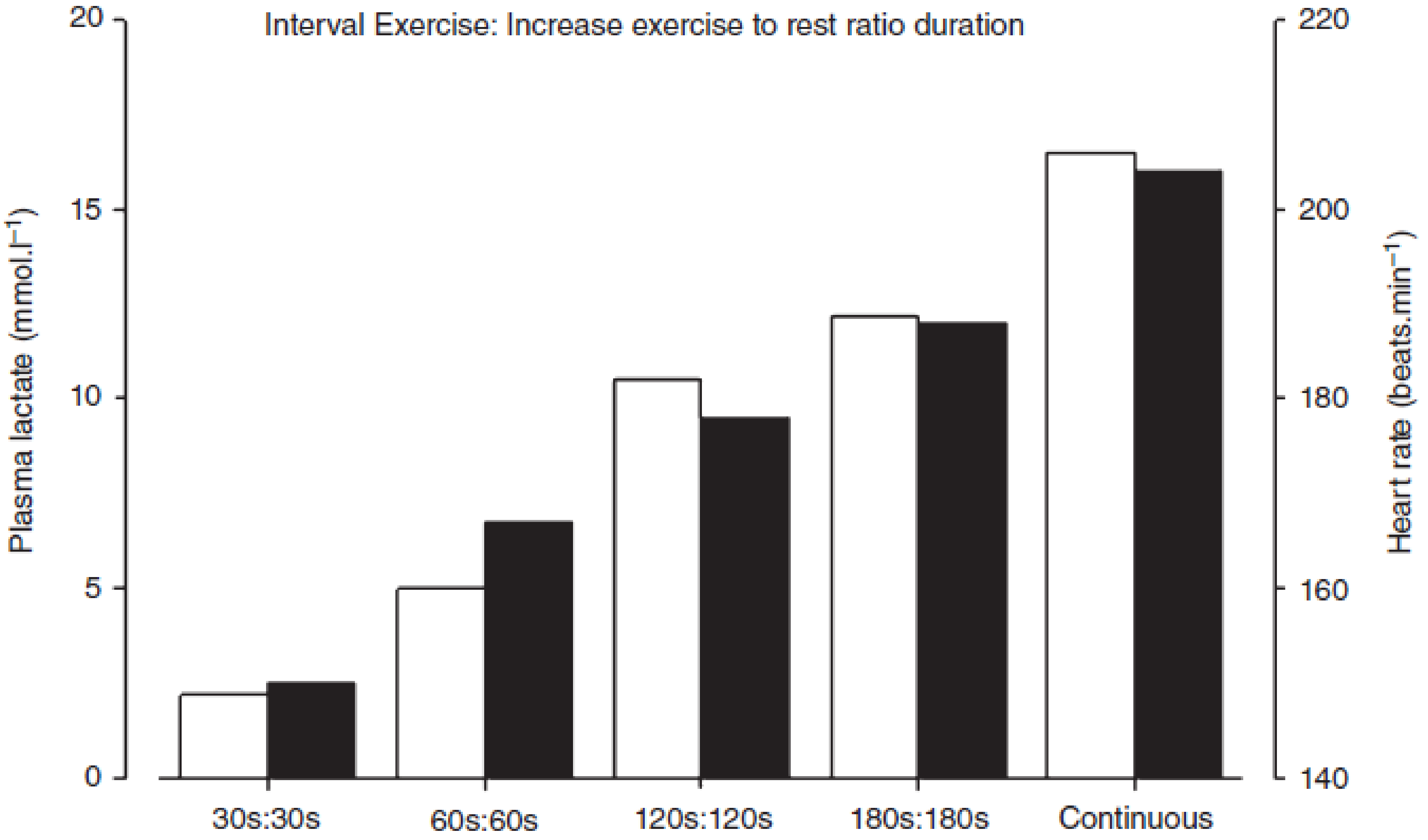
- During the recovery phases there is partial restoration of muscle phosphocreatine levels to rapidly regenerate ATP

- During the recovery phases there is partial reloading of myoglobin stores promoting oxidative degradation of glycogen and lower reliance on anaerobic glycolysis

- Alteration of exercise with rest maintains cardiac output and minute ventilation at relatively constant levels

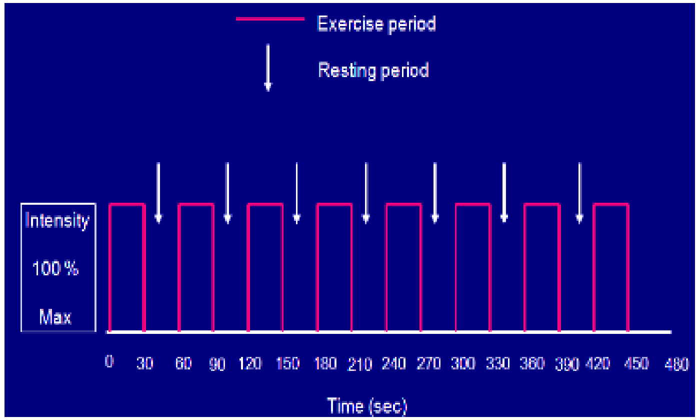
Astrand, I., Astrand, P-O., Christensen, E. H., & Hedman, R. (1960). Intermittent muscular work. *Acta Physiologica Scandinavica, 48,* 448-453.

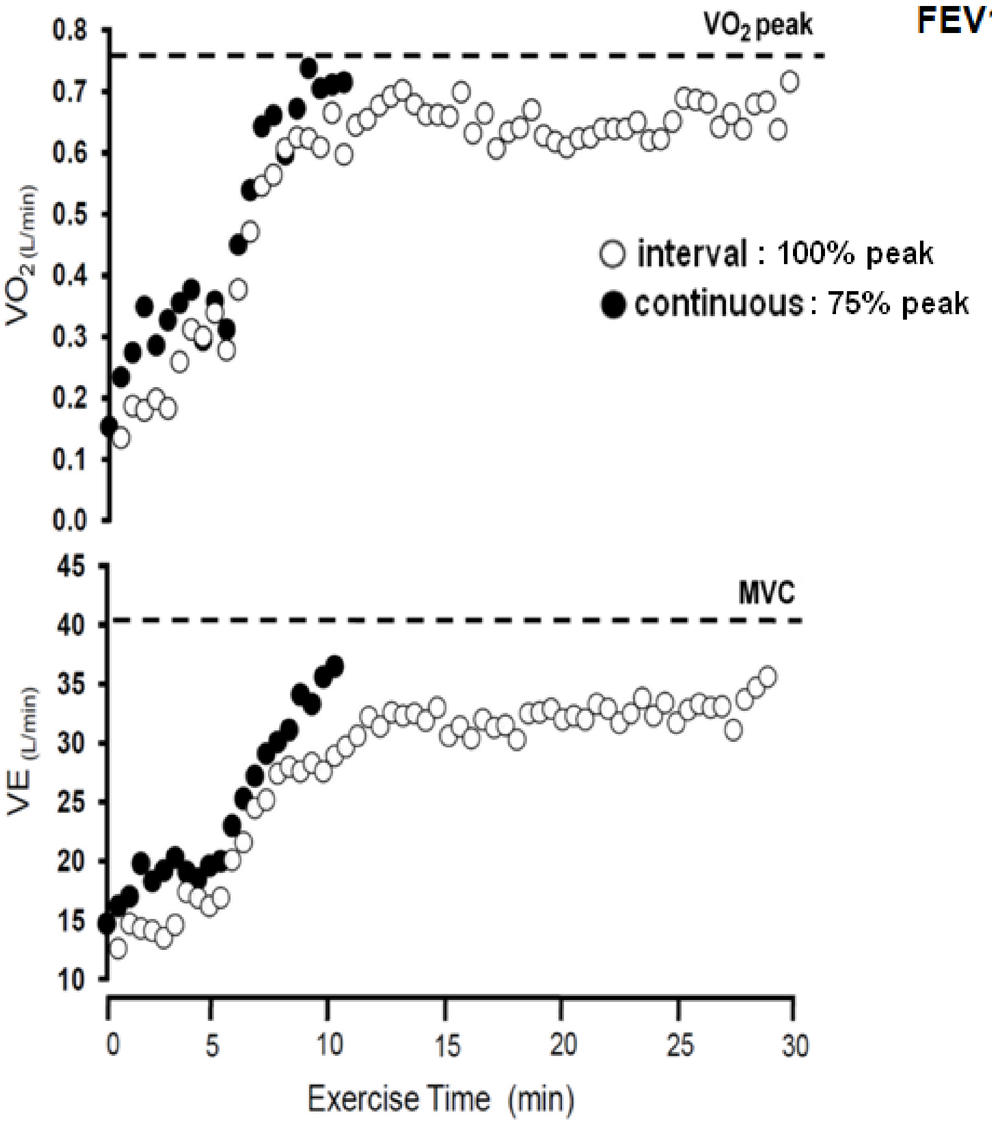
Physiological Rationale for interval training



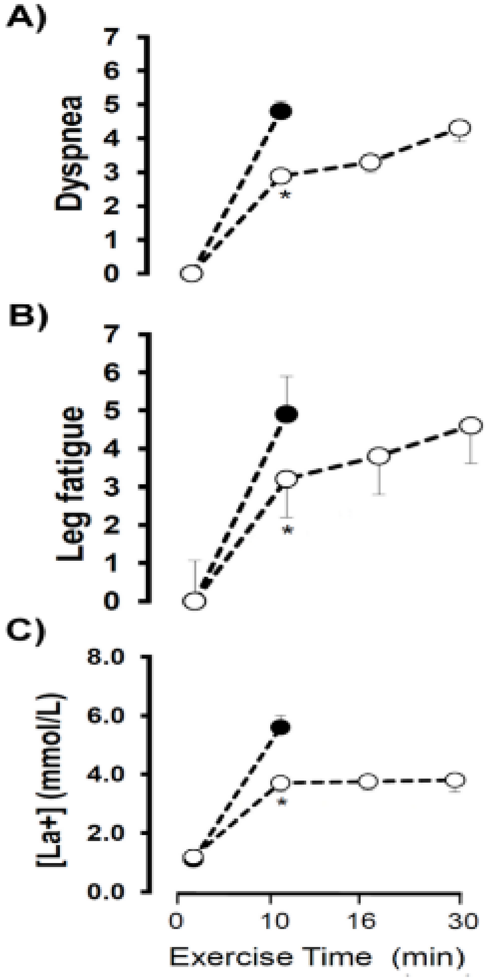
Astrand, I., Astrand, P-O., Christensen, E. H., & Hedman, R. (1960). Intermittent muscular work. *Acta Physiologica Scandinavica, 48,* 448-453.

Application of interval exercise in severe COPD





FEV1: ~36%



Vogiatzis I. et al. ERJ 2004

High intensity interval exercise in COPD

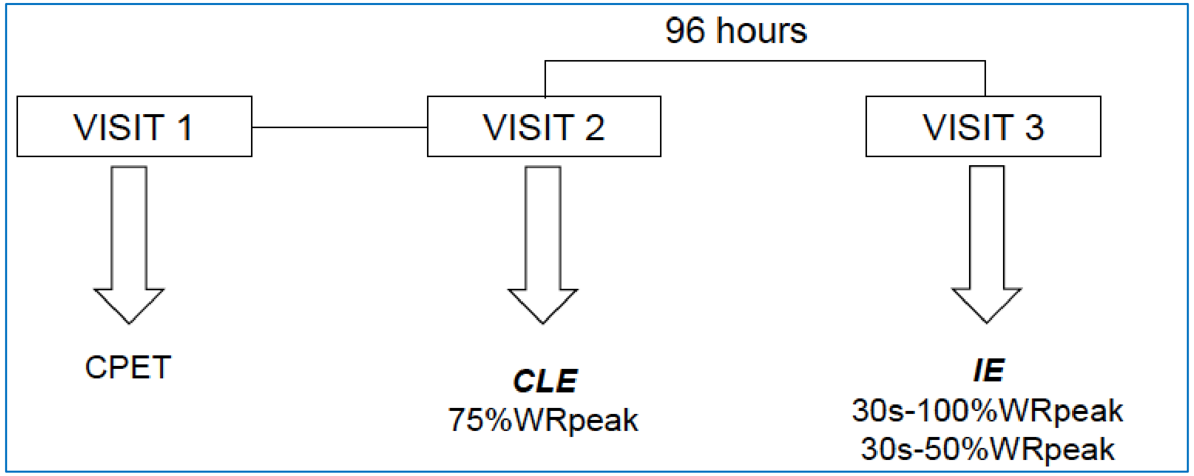
J Physiol 598.17 (2020) pp 3613–3629

Greater exercise tolerance in COPD during acute interval, compared to equivalent constant-load, cycle exercise: physiological mechanisms

Zafeiris Louvaris[1,2], Nikolaos Chynkiamis[3], Stavroula Spetsioti[1], Andreas Asimakos[1], Spyros Zakynthinos[1], Peter D. Wagner[4] and Ioannis Vogiatzis[1,3]

Pulmonary function data	
FEV_1, % predicted	58.4 ± 17.2
FVC, % predicted	81.6 ± 15.7
FEV_1/FVC	52.4 ± 11.1
RV, % predicted	158 ± 33
FRC, % predicted	144 ± 24
TLC, % predicted	112 ± 19
IC, % predicted	74 ± 16
RV/TLC, %	47 ± 6
IC/TLC, %	32 ± 9
TL_{CO}, % predicted	64.6 ± 13.1
MVV, $l\ min^{-1}$	71.5 ± 22.3
SaO_2, %	95.3 ± 1.3
Hb, $g\ dl^{-1}$	14.84 ± 0.66
mMRC	2.00 ± 0.71

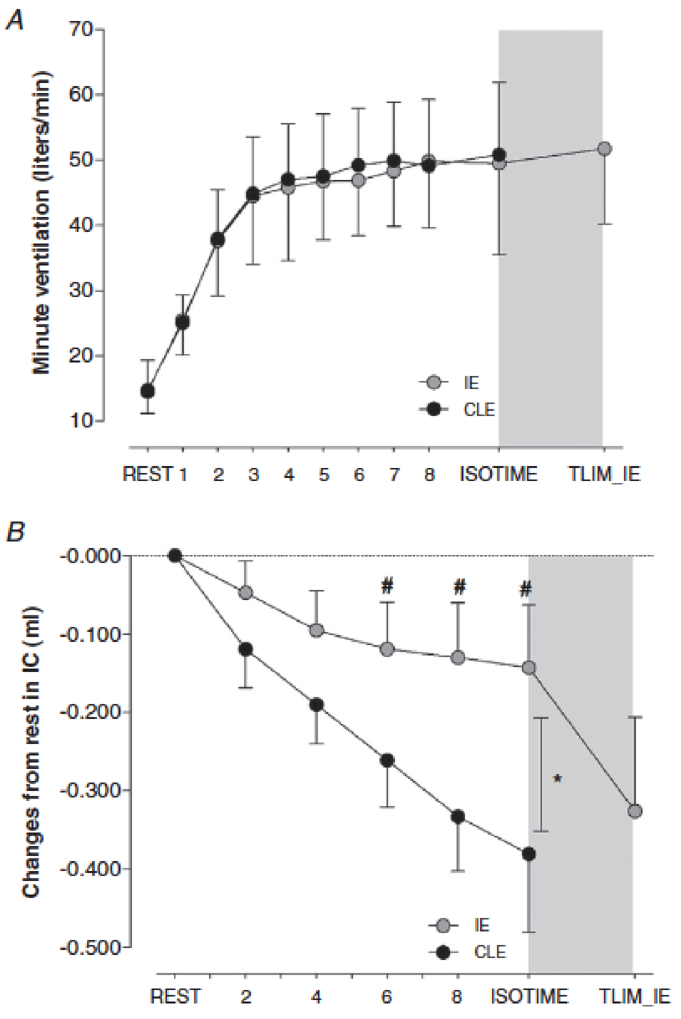
Patient: COPD
Intervention: Interval exercise (IE)
Comparator: constant load exercise (CLE)
Outcome: exercise tolerance

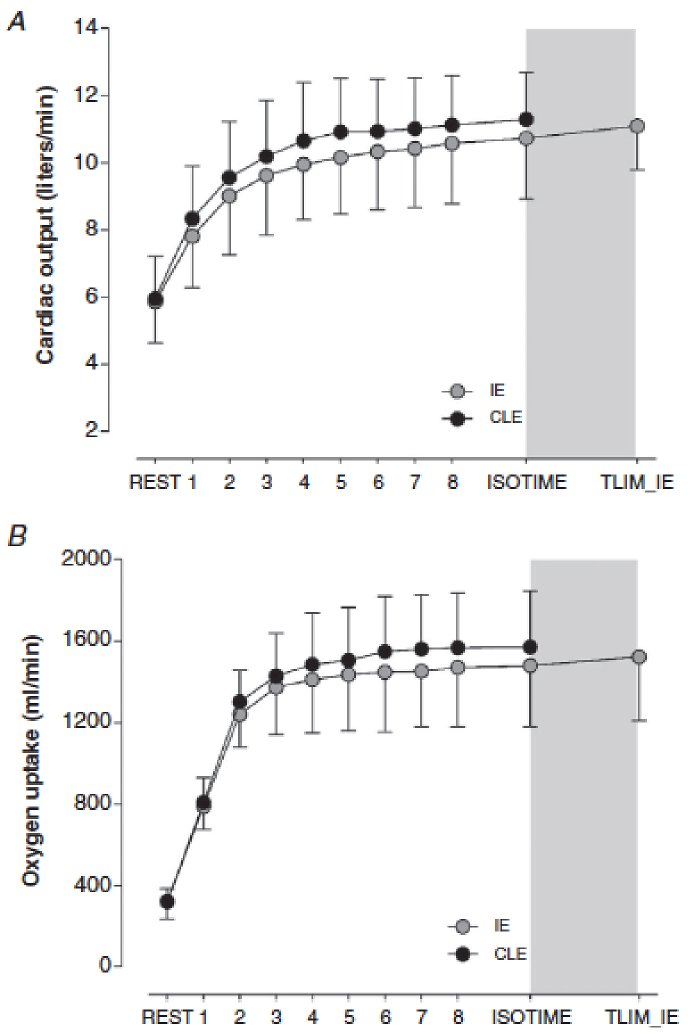


Physiological measures during constant load and interval exercise

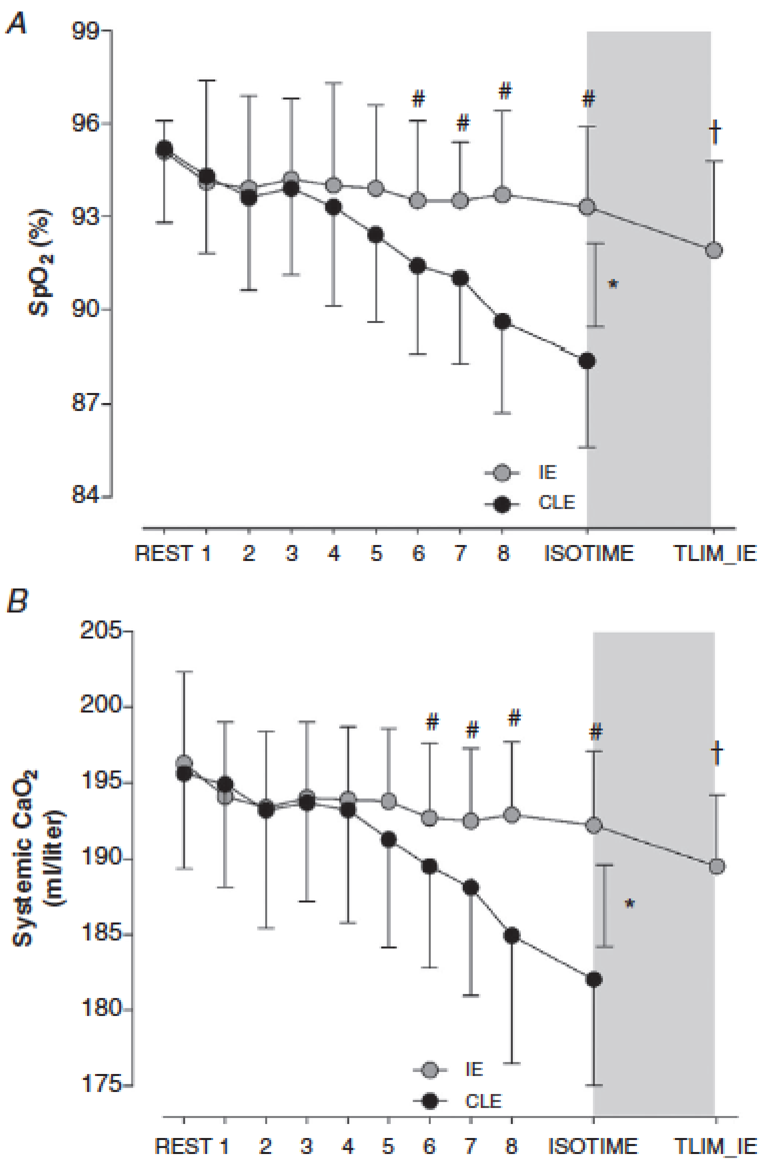
	Tlim_CLE	Isotime	Tlim_IE
Cycling responses			
Work rate, W	69.8 ± 18.6	–	69.5 ± 16.6
Cadence, rpm	60 ± 6.9	–	59 ± 6.9
Tlim, min	11.4 ± 2.1	–	19.5 ± 4.8*
Total work, kJ	48.9 ± 23.8	–	81.3 ± 27.7*
Metabolic and ventilatory responses			
E.E., kcals	83 ± 28	81 ± 21	147 ± 44*
VO_2, ml min^{-1} kg^{-1}	18.1 ± 4.0	17.2 ± 3.6	17.7 ± 3.6
VCO_2, l min^{-1}	1492 ± 331	1378 ± 355	1449 ± 342
RER	0.95 ± 0.03	0.93 ± 0.03	0.95 ± 0.07
Lactate, mmol l^{-1}	6.43 ± 2.24	3.96 ± 1.76*	4.87 ± 2.39*
V_E, l min^{-1}	50.3 ± 10.8	49.5 ± 15.0	51.8 ± 11.5
V_E/MVV, %	70.4 ± 16.9	69.7 ± 15.2	72.8 ± 16.6
V_E/VCO_2, %	34.2 ± 6.6	34.5 ± 6.0	35.4 ± 6.6
V_{Tpeak}, l min^{-1}	1.66 ± 0.29	1.74 ± 0.38*	1.67 ± 0.34
Ti, s	0.78 ± 0.14	0.93 ± 0.17*	0.80 ± 0.26
Ti/Ttot	37.3 ± 5.4	44.4 ± 5.5*	38.0 ± 4.5
Bf, breaths/min	30.6 ± 5.4	28.4 ± 4.9	31.0 ± 5.0
ΔIC, l	−0.381 ± 0.10	−0.143 ± 0.08*	−0.326 ± 0.12
V_T/IC, %	84.3 ± 19.9	78.3 ± 12.9	82.8 ± 18.9

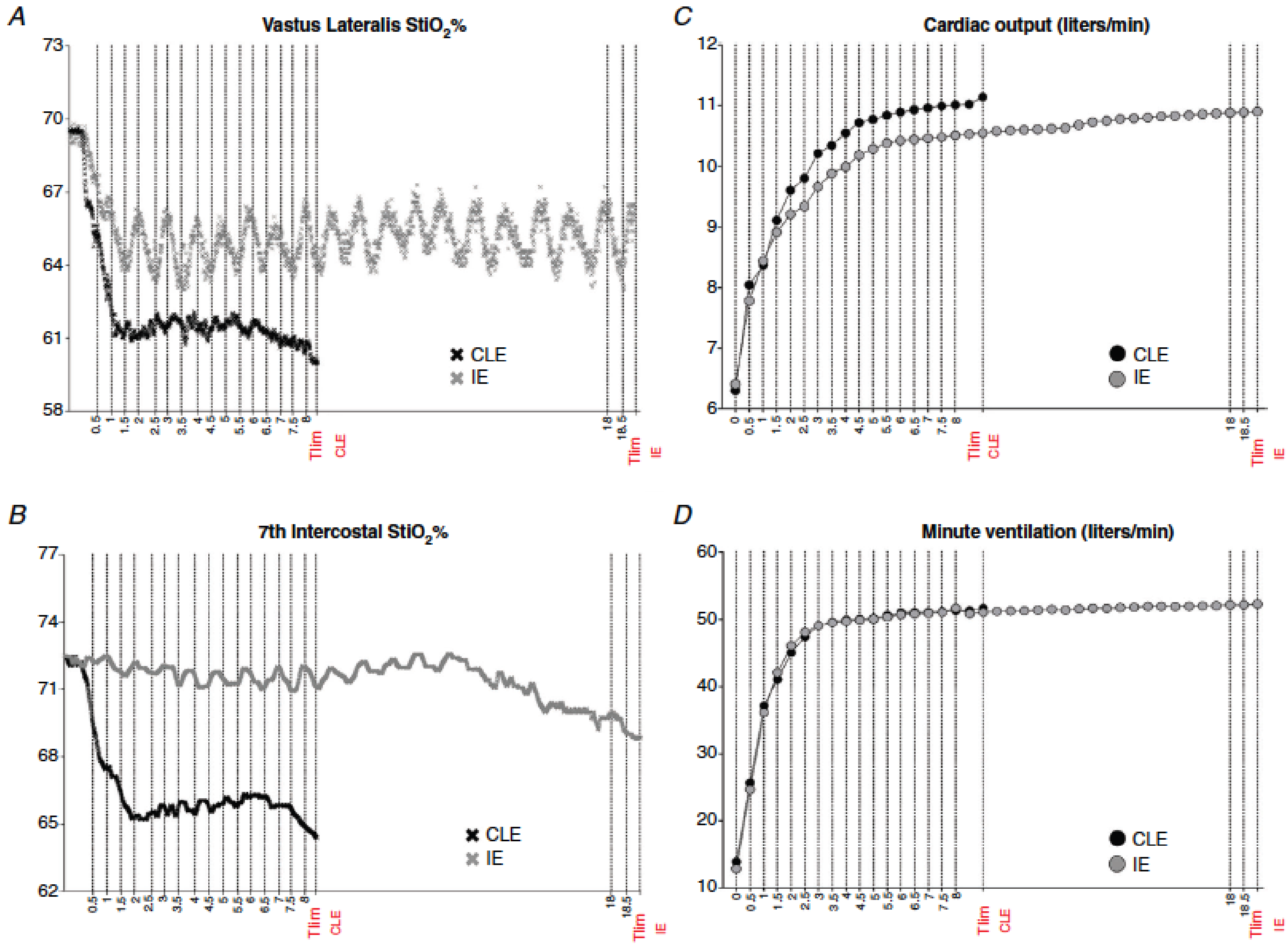
Respiratory, central haemodynamic, metabolic and symptom responses





Arterial and local muscle oxygen saturation





Application of intermittent exercise in COPD

- Acute alteration of maximal and moderate intensity exercise, compared to constant load exercise sustained at the same average power output:

1. Places comparable loads on respiration and circulation to constant load exercise with lower exertional symptoms

2. Leads to a two-fold increase in total work output and endurance time

- Interval exercise is deemed safer than constant load exercise as arterial oxygen desaturation is only mild compared with constant load exercise

Intermittent compared to continuous walking in COPD

Original Paper

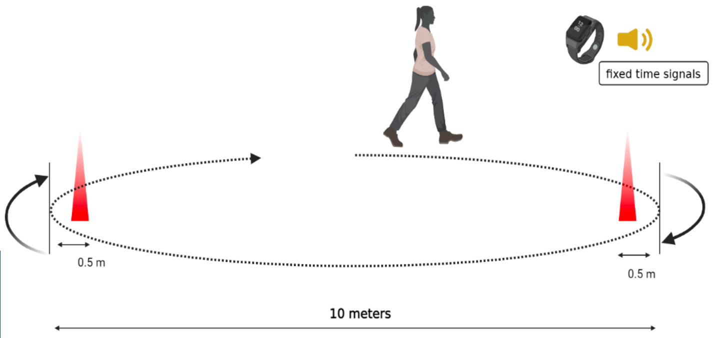
Chronic Respiratory Disease

Chronic Respiratory Disease
Volume 19: 1–11

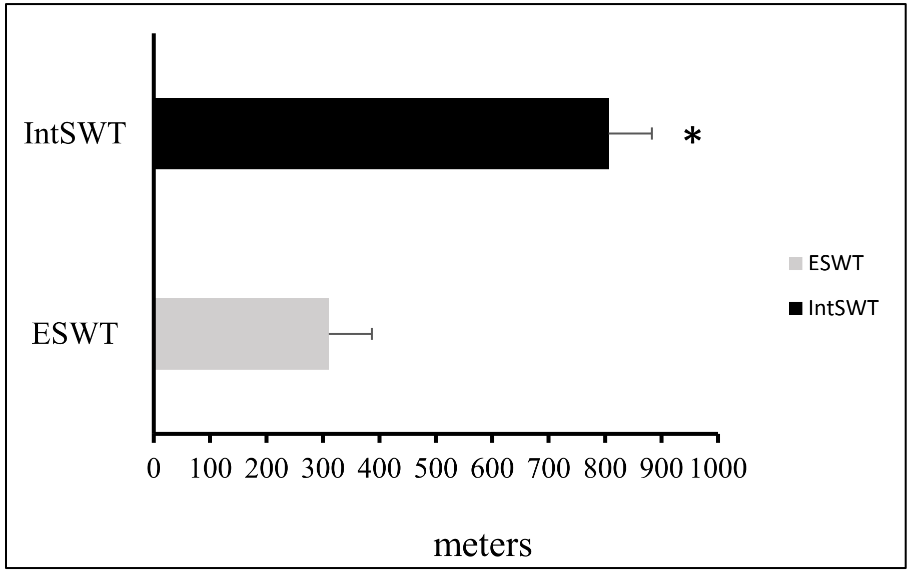
DOI: 10.1177/14799731221142023
journals.sagepub.com/home/crd
SAGE

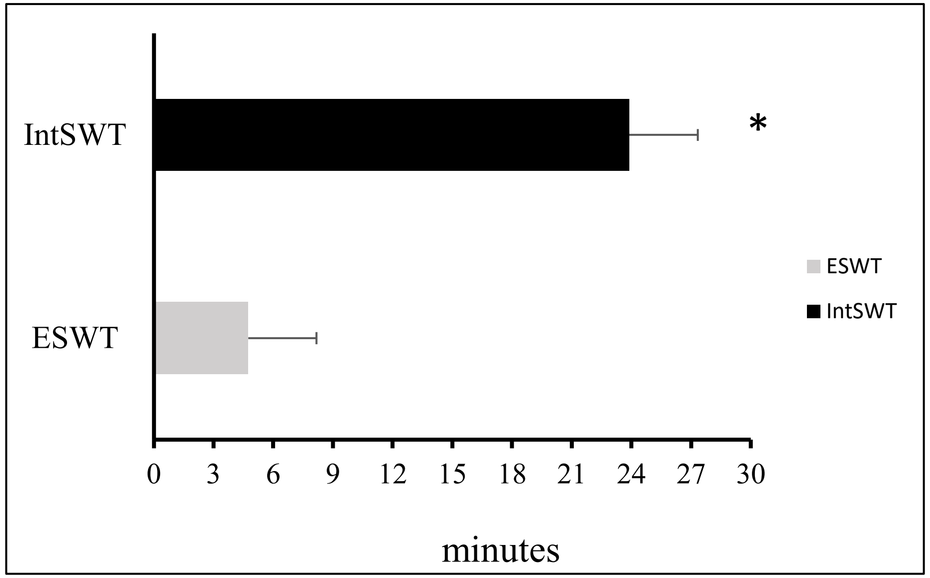
Greater exercise tolerance in COPD during acute intermittent compared to continuous shuttle walking protocols: A proof-of-concept study

Charikleia Alexiou[1], Francesca Chambers[2], Dimitrios Megaritis[1], Lynsey Wakenshaw[2], Carlos Echevarria[3] and Ioannis Vogiatzis[1]

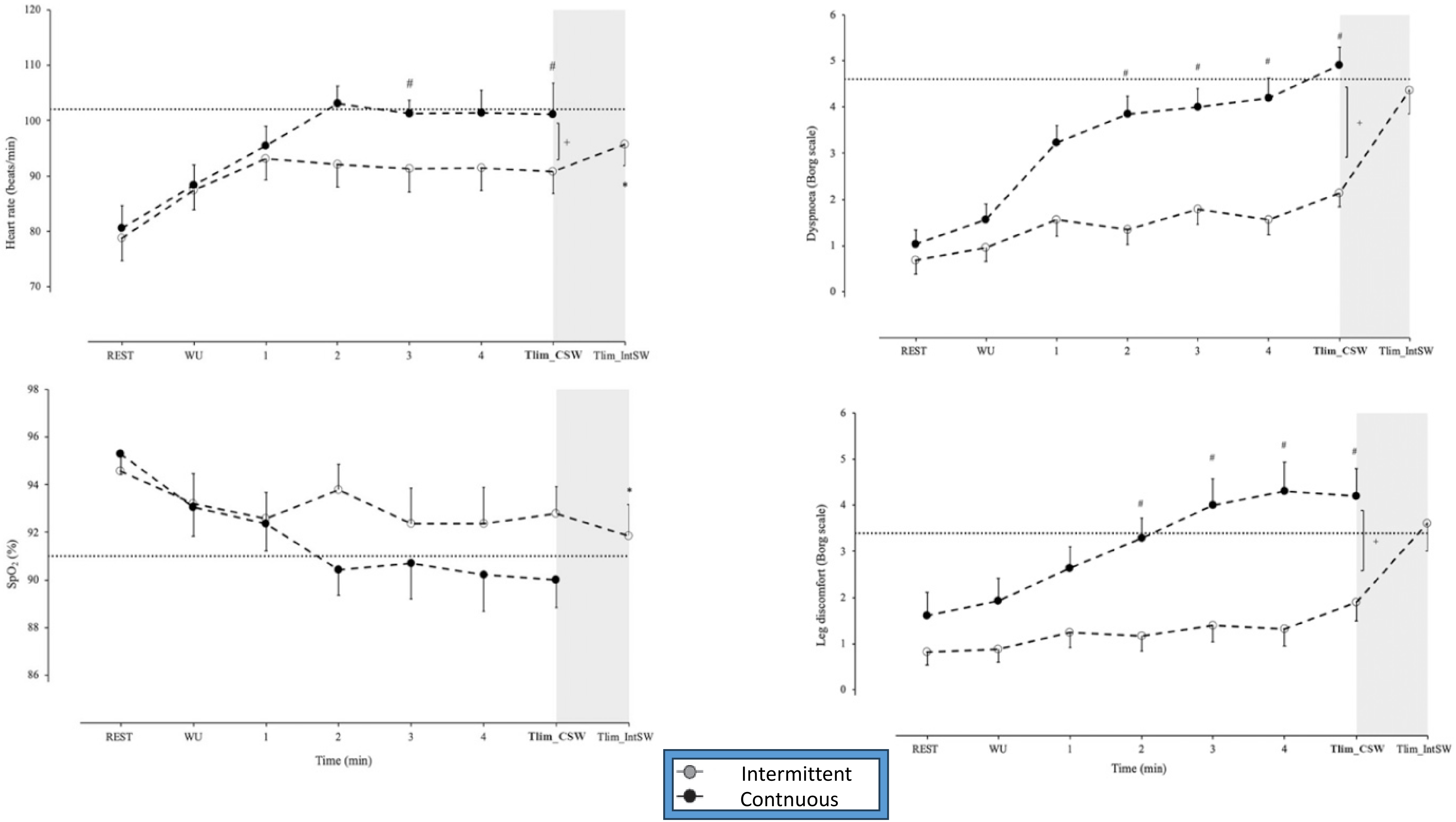


Continuous: ESWT (85% ISWT)
Intermitent: 1-min at 85% ISWT
1-min rest





Physiological & symptom responses during continuous and intermittent walking



High intensity interval exercise in Cystic Fibrosis

Contrasting interval to continuous exercise of equivalent work rate

- Continuous exercise at 70% peak work rate (PWR)
- Interval exercise at 100% PWR for 30 sec alternated with 30 sec at 40 % PWR

Respiratory Physiology & Neurobiology 288 (2021) 103643

Contents lists available at ScienceDirect

Respiratory Physiology & Neurobiology

journal homepage: www.elsevier.com/locate/resphysiol

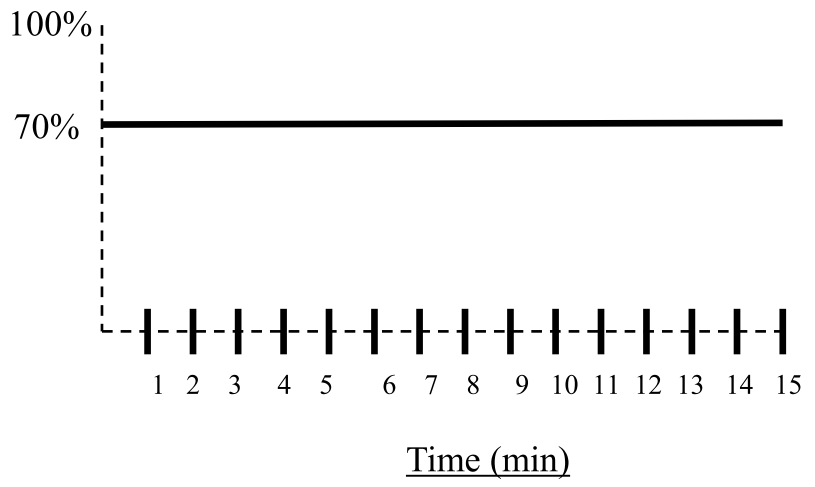
https://doi.org/10.1016/j.resp.2021.103643

Interval versus constant-load exercise training in adults with Cystic Fibrosis

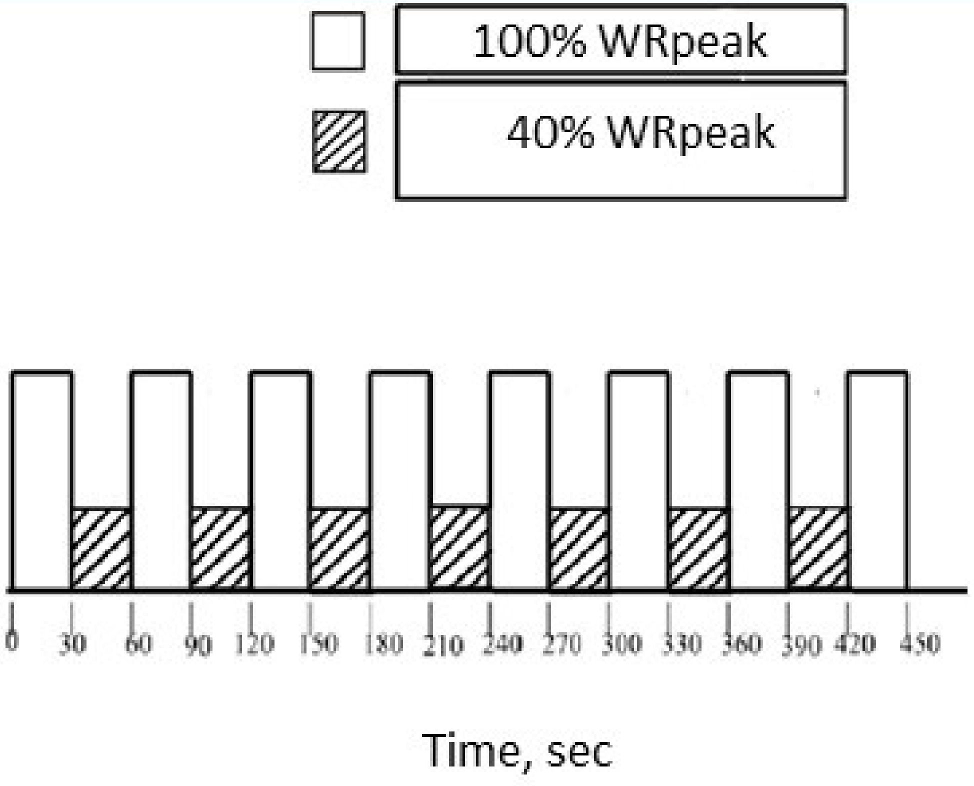
G. Kaltsakas [a,b,c,1], N. Chynkiamis [c,d,e,1], N. Anastasopoulos [c], P. Zeliou [f], V. Karapatoucha [f], K. Kotsifas [f], F. Diamantea [f], I. Inglezos [f], N.G. Koulouris [c,2], I. Vogiatzis [c,e,*,2]

Representative case

- 32-year old female with cystic fibrosis
- FEV_1: 45% predicted
- FVC: 64% predicted
- Endurance time at 70% PWR: 15 min
- Exertional dyspnea (1-10 Borg scale): 8

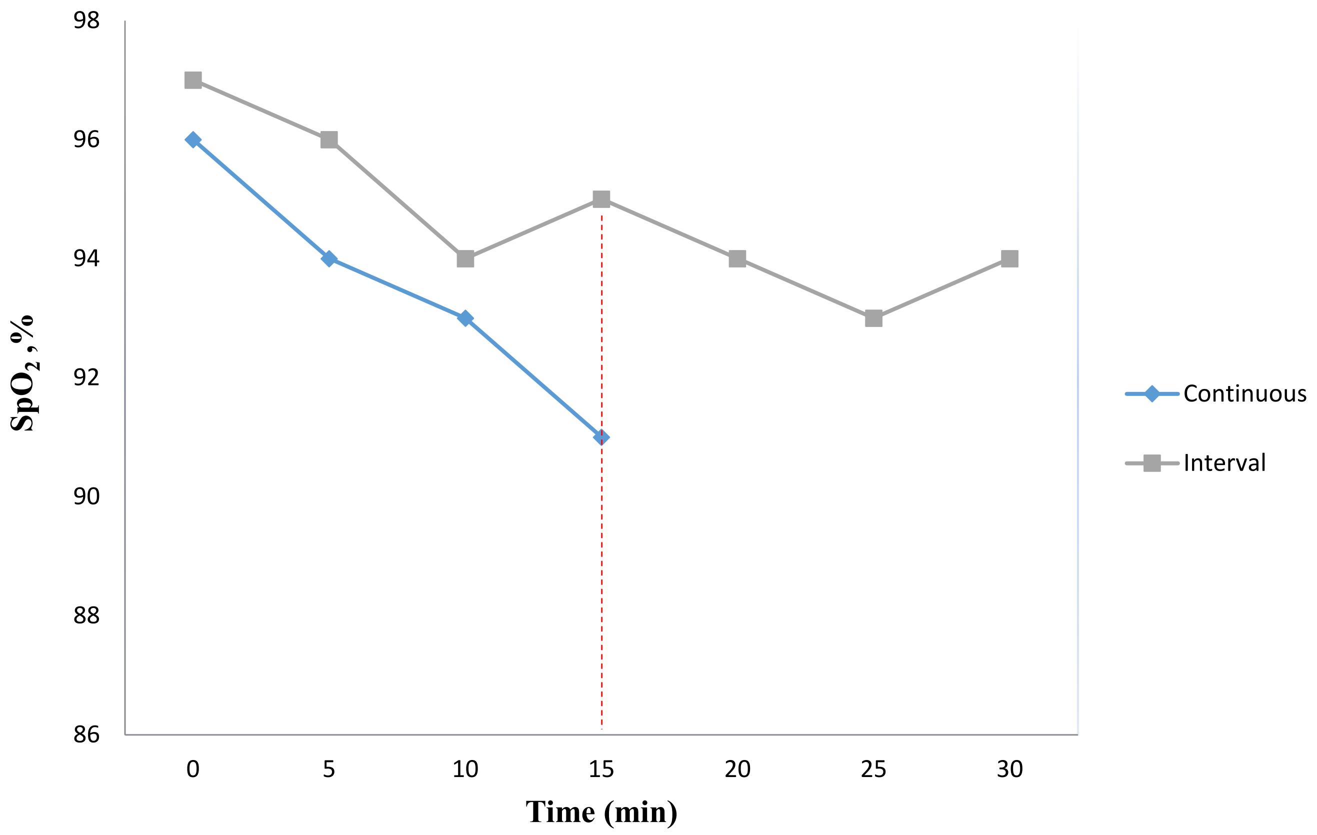


High Intensity Interval Exercise

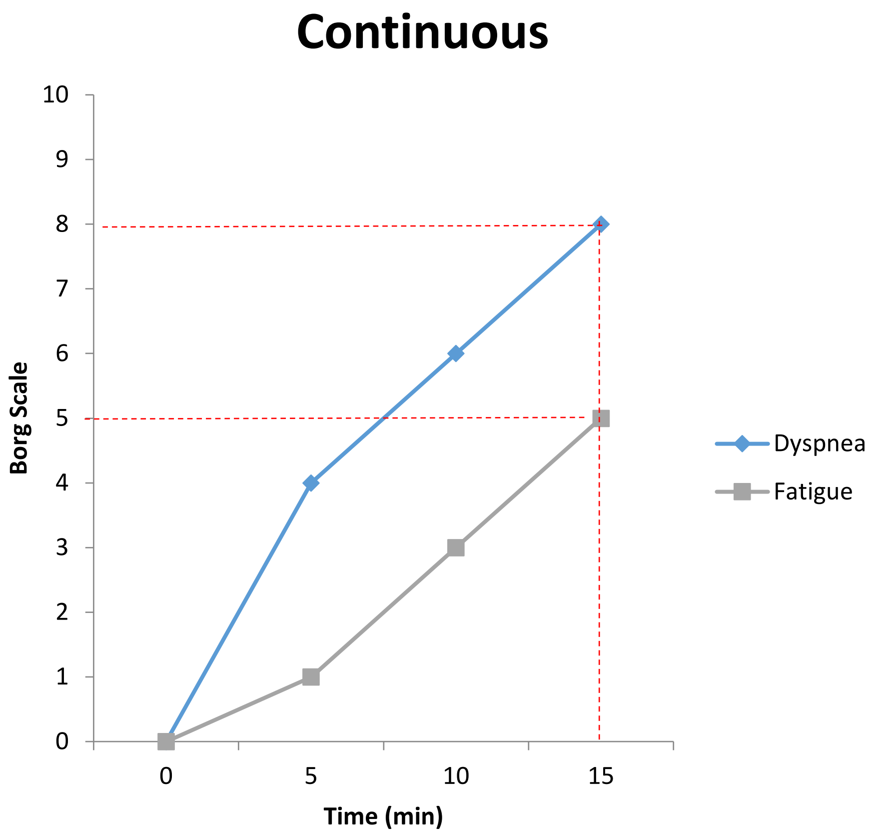


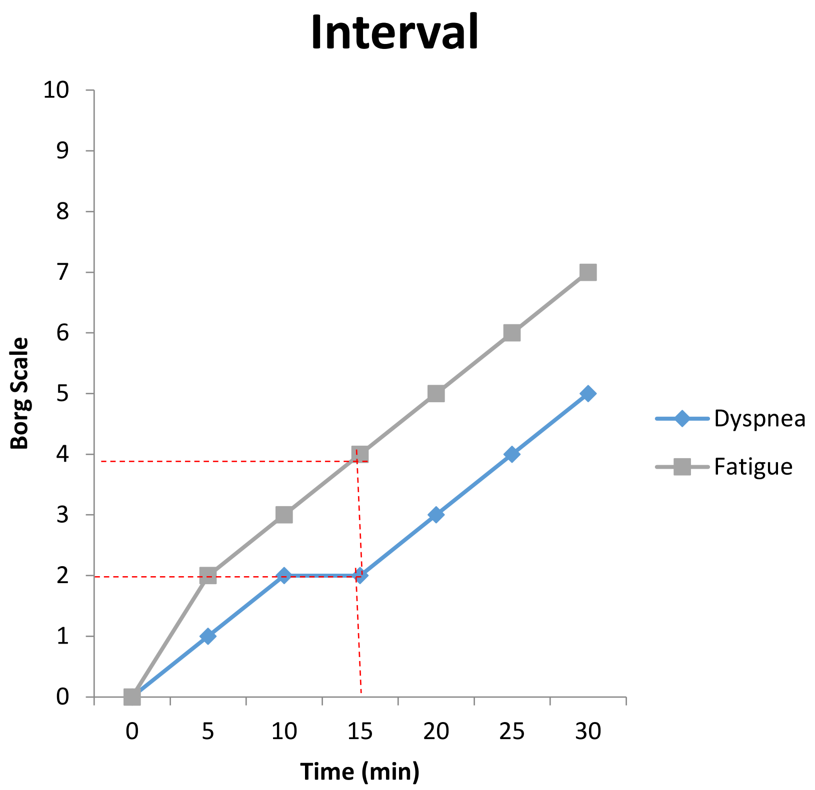
Duration: 30 min

Arterial oxygen saturation in Cystic Fibrosis

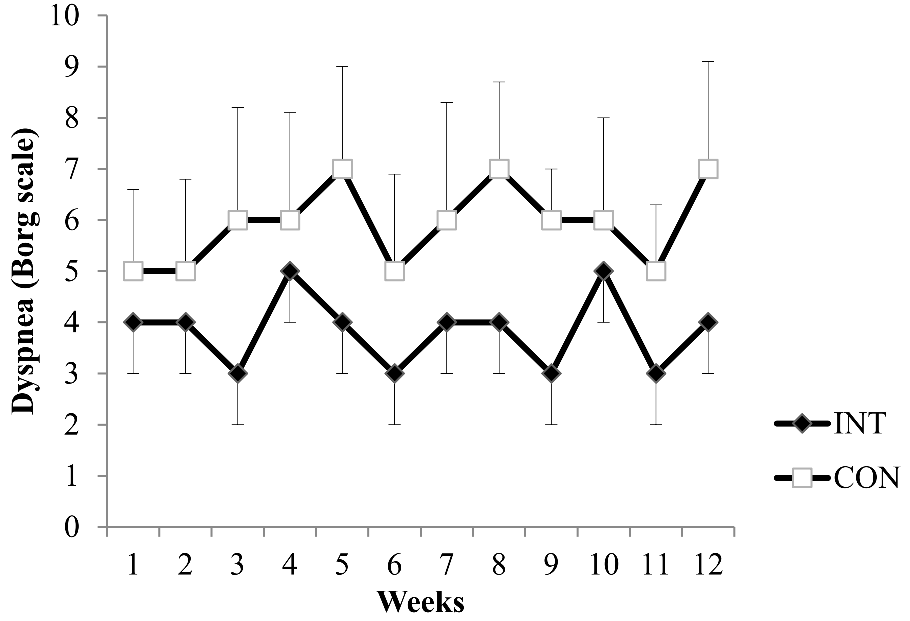


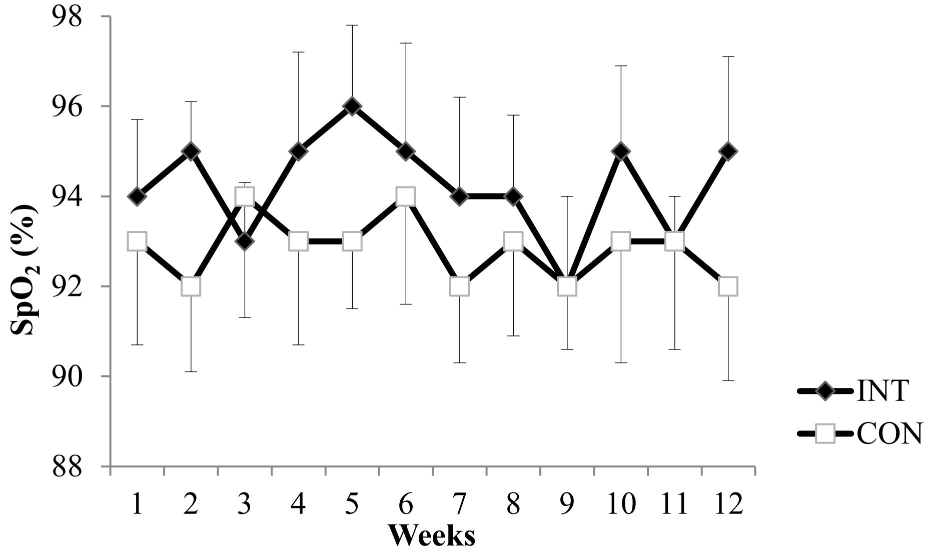
Symptoms during Continuous and Interval Exercise in Cystic Fibrosis

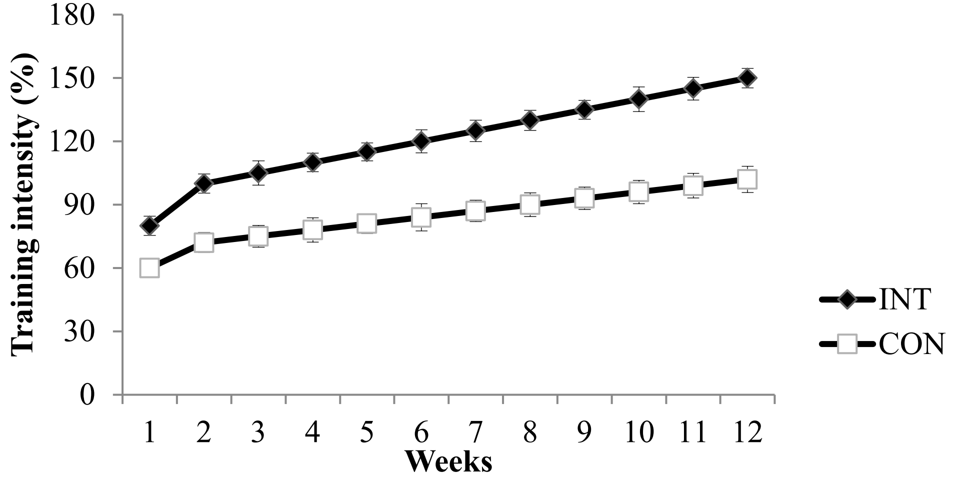




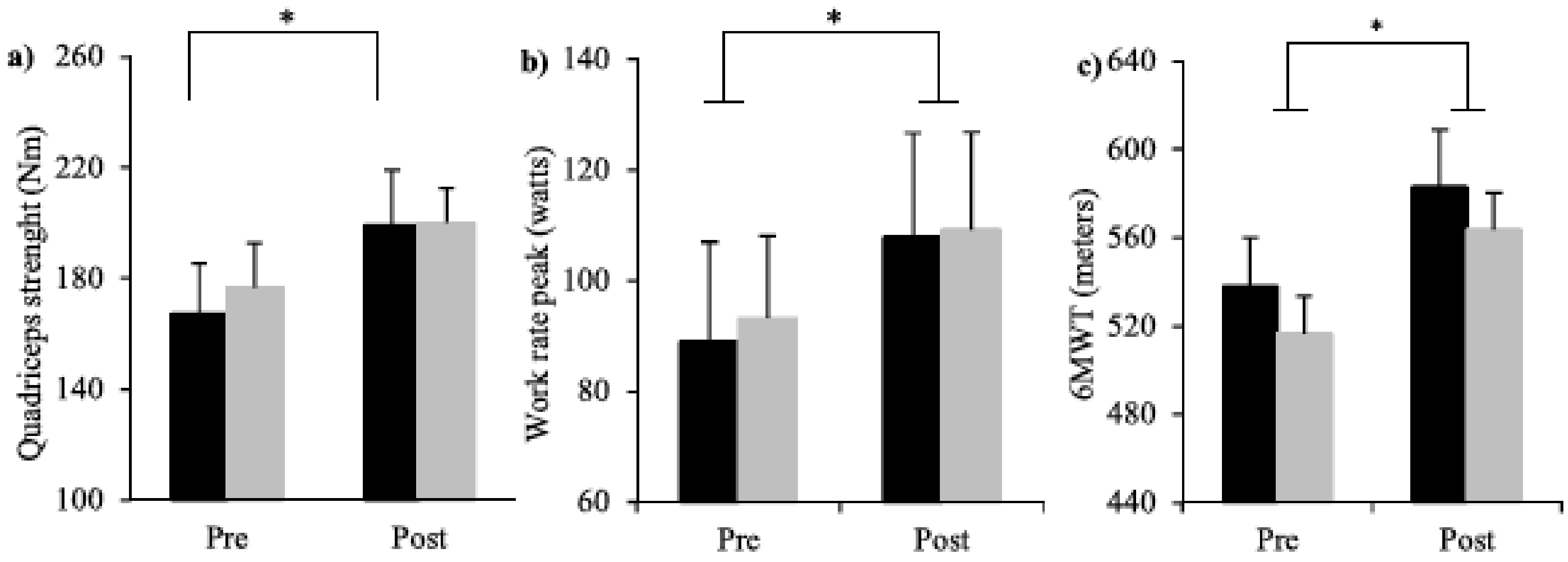
Application of interval exercise training during Pulmonary Rehabilitation in Cystic Fibrosis







Effects of interval & continuous exercise in CF



Interval exercise

Continuous exercise

Table 2
Effects of IE and CLE training on physiological outcomes.

	High Intensity IE		Moderate Intensity CLE	
	Pre	Post	Pre	Post
WRpeak (watt)	89 ± 56	108 ± 60*	93 ± 49	109 ± 59*
VO_2 peak (ml/kg/min)	24.1 ± 10.7	26.9 ± 11.0*	23.2 ± 8.4	25.7 ± 9.5*
6MWT (meters)	538 ± 70	583 ± 83*	516 ± 57	564 ± 55*
BMI (kg m^{-2})	21.0 ± 2.1	21.3 ± 1.6	20.2 ± 2.0	20.7 ± 1.9
FFMI (kg m^{-2})	16.7 ± 1.7	16.8 ± 1.5	16.5 ± 2.0	16.8 ± 1.6
Quadriceps Strength (Nm)	167 ± 58	199 ± 63*	177 ± 54	200 ± 41
PEmax (cmH_2O)	121 ± 23	151 ± 30*	100 ± 58	112 ± 58
PImax (cmH_2O)	−71 ± 27	−84 ± 16*	−66 ± 33	−73 ± 31

Application of intermittent exercise in Cystic Fibrosis

- Intermittent compared to continuous exercise training:

1. Is superior in improving locomotor and respiratory muscle strength

2. It is associated with lower breathlessness and oxygen desaturation during training

- It is deemed safer than constant load exercise as arterial oxygen desaturation is only mild compared with constant load exercise

PHYSIOTHERAPY THEORY AND PRACTICE
2021, VOL. 37, NO. 9, 1034–1042
https://doi.org/10.1080/09593985.2019.1678207

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Interval aerobic exercise in individuals with advanced interstitial lung disease: a feasibility study

Lisa Wickerson, PT, PhD[a], Dina Brooks, PT, PhD [b], John Granton, MD [a], W. Darlene Reid, PT, PhD [c], Dmitry Rozenberg, MD[a], Lianne G. Singer, MD[a], and Sunita Mathur, PT, PhD [c]

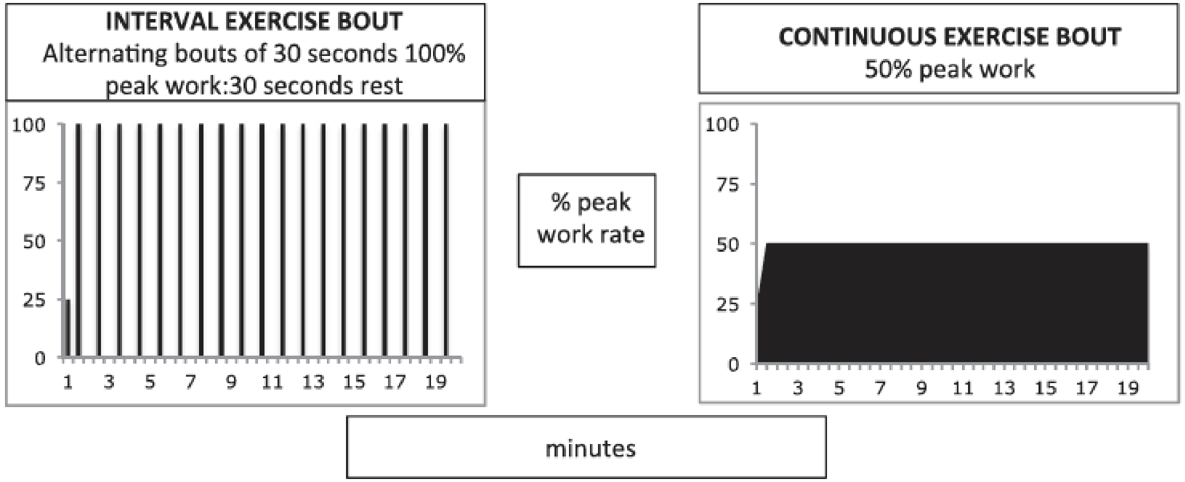


Table 2. Physiological responses to cycling bouts (n = 9), mean (SD).

	Interval	Continuous	p value
Pre-exercise SpO_2 (%)	100 (0.4)	100 (0.7)	0.99
Nadir SpO_2 (%)	92 (4)	89 (5)	0.06
Change in SpO_2 (%)	- 8 (4)	- 11 (5)	0.05
Pre-exercise HR	85 (6)	84 (14)	0.72
Peak HR (bpm)	124 (12)	132 (15)	0.04
Change in HR (bpm)	+ 37 (12)	+ 47 (16)	0.12
Pre-exercise MAP (mmHg)	94 (11)	90 (8)	0.29
End-exercise MAP (mmHg)	110 (16)	112 (17)	0.36
Change in MAP (mmHg)	+ 18 (13)	+ 21 (15)	0.82
Pre-exercise RR (breaths/min)	22 (4)	23 (3)	0.68
End-exercise RR (breaths/min)	37 (5)	37 (8)	0.85
Change in RR (breaths/min)	+ 15 (5)	+ 14 (8)	0.49
Pre-exercise dyspnea	0.7 (0.8)	0.8 (0.6)	0.87
End-exercise dyspnea	4.3 (2)	4.9 (2)	0.21
Change in Borg dyspnea	+ 3.7 (2)	+ 4.1 (2)	0.42
Pre-exercise leg fatigue	0.5 (0.7)	0.7 (0.8)	0.17
End-exercise leg fatigue	3.8 (2)	4.4 (2)	0.05
Change in Borg leg fatigue	+ 3.4 (2)	+ 3.7 (1)	0.19
Pre-exercise lactate (mmol/L)	3.7 (3)	3.3 (3)	0.39
End-exercise lactate (mmol/L)	5.3 (2)	7.3 (5)	0.12
Change in lactate (mmol/L)	+ 1.6 (3)	+ 4.0 (2)	0.07

Application of Interval Exercise in IPF

Respiration

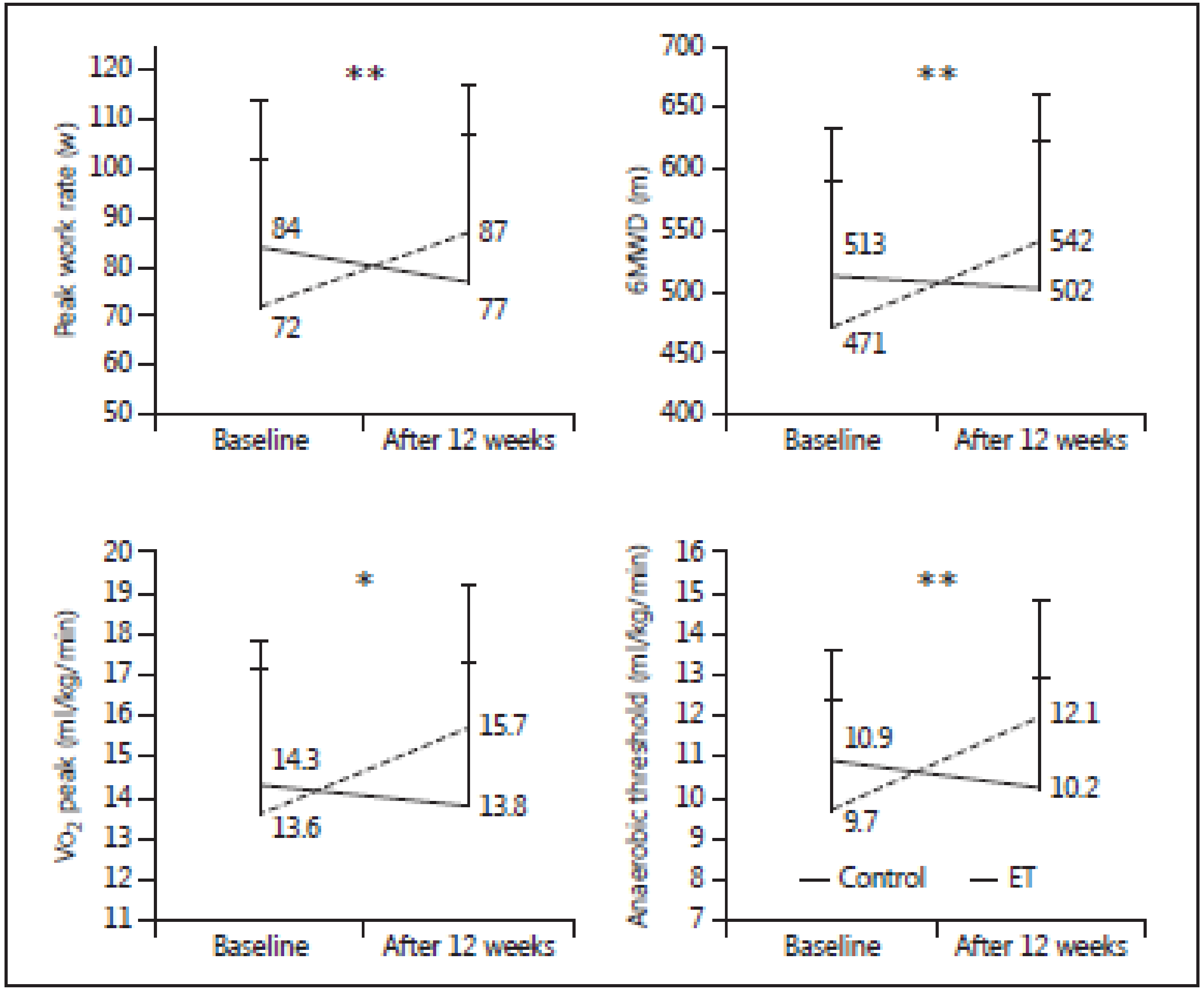
Clinical Investigations

Respiration 2014;88:378–388
DOI: 10.1159/000367899

Received: April 19, 2014
Accepted after revision: July 28,
Published online: October 23, 2

Exercise Training-Based Pulmonary Rehabilitation Program Is Clinically Beneficial for Idiopathic Pulmonary Fibrosis

Baruch Vainshelboim[a, c] Jose Oliveira[c] Liora Yehoshua[a] Israela Weiss[a]
Benjamin Daniel Fox[a, b] Oren Fruchter[a, b] Mordechai Reuven Kramer[a, b]



Application of Interval Exercise in Pulmonary Hypertension

Exercise and Respiratory Training Improve Exercise Capacity and Quality of Life in Patients With Severe Chronic Pulmonary Hypertension

Derliz Mereles, MD*; Nicola Ehlken*; Sandra Kreuscher*; Stefanie Ghofrani, MD; Marius M. Hoeper, MD; Michael Halank, MD; F. Joachim Meyer, MD; Gabriele Karger, MD; Jan Buss, MD; Jana Juenger, MD; Nicole Holzapfel, MA; Christian Opitz, MD; Jörg Winkler, MD; Felix F.J. Herth, MD; Heinrike Wilkens, MD; Hugo A. Katus, MD; Horst Olschewski, MD; Ekkehard Grünig, MD

TABLE 3. Respiratory and Hemodynamic Variables at Baseline and After Intervention

	Control Group (n=15)			Primary Training Group (n=15)		
	Baseline	3 wk	15 wk	Baseline	3 wk	15 wk
$Workload_{max}$, W	64±22	60±24	67±20	70±17	85±26*†	90±25*†
Borg scale	15±2	15±1	16±1*	15±2	15±2	15±2
HR_{rest}, bpm	71±17	74±11	72±11	72±11	73±11	75±11
HR_{max}, bpm	108±19	107±22	110±20	118±16	125±15*†	132±17*†
VE_{max}, L · min	41.6±14.6	40.5±14.1	43.4±15.3	44.2±13.8	47.1±15.1	48.5±15.1
$\dot{V}O_{2\,peak}$, mL · min^{-1} · kg^{-1}	11.9±3.1	11.6±3.4	11.4±3.3	13.2±3.1	14.5±3.5*†	15.4±3.7*†
$\dot{V}O_{2\,\%\,predicted}$, %	46.3±10.7	45.9±14.6	49.8±12.7	51.6±16.3	56.5±18.0*	60.3±19.6*
Workload at AT, W	35±17	31±16	36±17	45±14	56±21*†	65±19*†
$\dot{V}O_2$ at AT, mL/min	640.7±187.4	613.4±206.6	610.4±200.4	736.6±210.3	802.3±229.8†	865.4±264.7*†

(*Circulation*. 2006;114:1482-1489.)

EUROPEAN CLINICAL RESPIRATORY JOURNAL, 2018
VOL. 5, 1468714
https://doi.org/10.1080/20018525.2018.1468714

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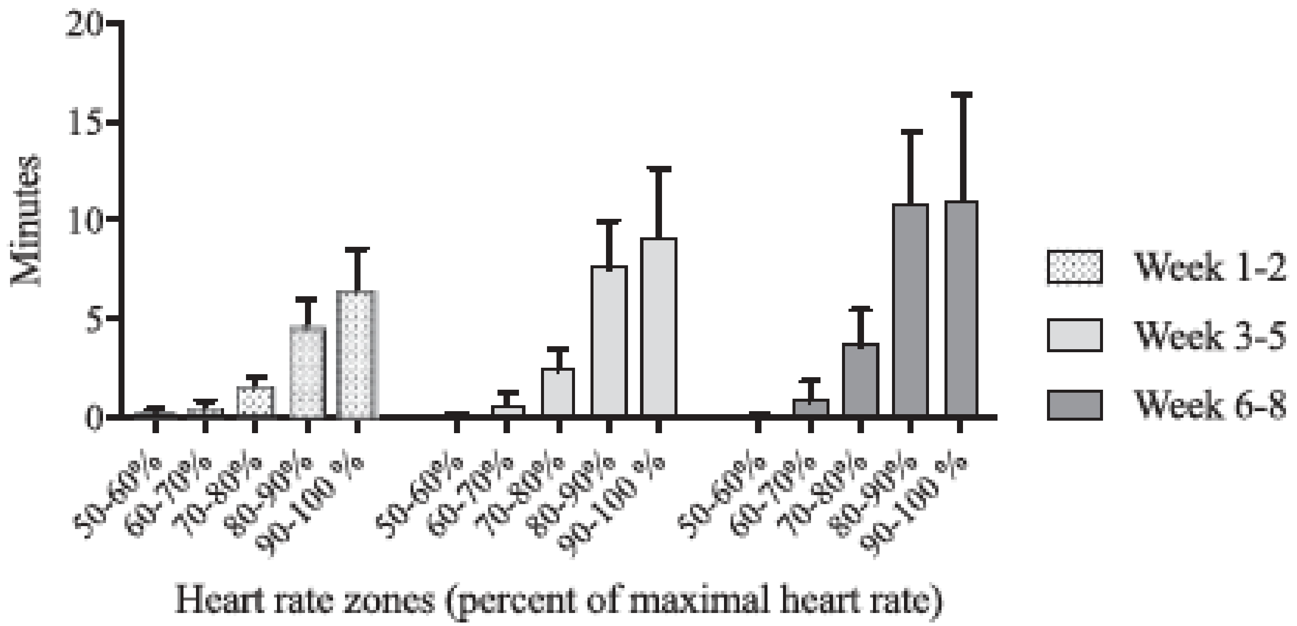
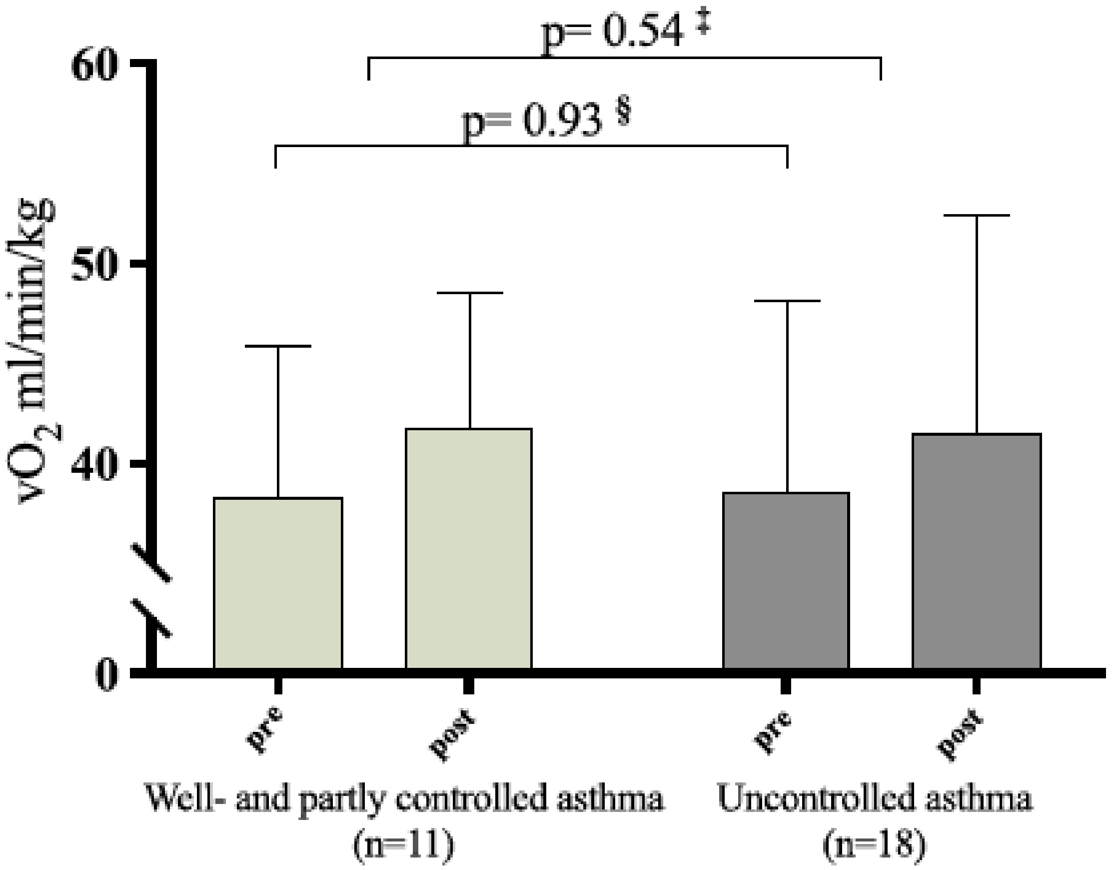
Feasibility of high-intensity training in asthma

L. L. Toennesen [a], E. D. Soerensen [a], M. Hostrup [a,b,c], C. Porsbjerg [a], J. Bangsbo [b] and V. Backer [a,c]





FEATURED CLINICAL TRIAL

Interval versus continuous training in lung transplant candidates: A randomized trial

J Heart Lung Transplant 2012;31:934–41

Rainer Gloeckl, MSc,[a] Martin Halle, MD,[b,c] and Klaus Kenn, MD[a]

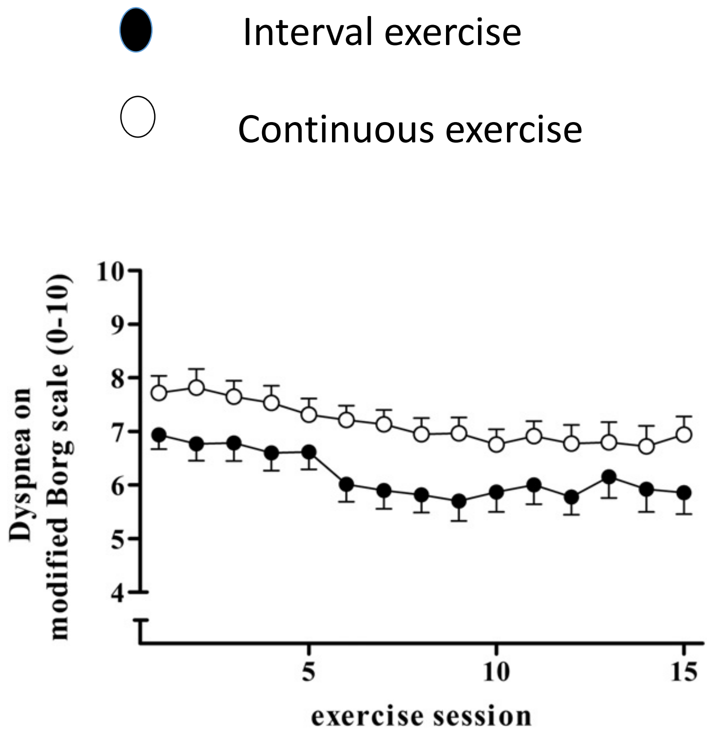


Table 2 Comparison of Treatment Effects of Interval and Continuous Training

	Per protocol analysis				
	Mean changes from baseline				
Outcome[a]	Interval (n = 30)	Continuous (n = 30)	Difference (95% CI)	p-values	Difference in ITT (95% CI)
Primary					
6-MWD, m	35.4 ± 28.9[b]	35.7 ± 42.2[b]	0.3 (−18.2 to 18.8)	0.89	1.1 (−15.6 to 17.8)
6-MWD, % pred[c]	14.1 ± 12.7[b]	15.5 ± 25.1[b]	1.4 (−8.9 to 11.7)	0.78	1.5 (−7.5 to 10.5)
Secondary					
PWR, W	12.0 ± 8.5[b]	9.3 ± 10.1[b]	−2.7 (−7.5 to 2.2)	0.38	−2.0 (−6.5 to 2.5)
FEV_1, liters	0.0 ± 0.1	−0.0 ± 0.1	0.0 (−0.1 to 0.0)	0.055	0.1 (−0.1 to 0.0)
FEV_1, % pred[d]	0.9 ± 2.9	−0.7 ± 3.8	−1.6 (−3.3 to 0.1)	0.064	−1.4 (−2.8 to 0.1)
FEV_1/IVC, %[d]	± 0.1	−0.0 ± 0.1	−0.0 (−0.1 to 0.0)	0.061	−0.0 (−0.0 to 0.0)
DLCO, % pred[d]	0.2 ± 5.3	−2.6 ± 4.4	−2.8 (−6.2 to 0.6)	0.096	−2.4 (−5.2 to 0.4)
Pao_2, mm Hg	1.7 ± 5.7	−1.7 ± 6.1	−3.4 (−6.4 to −0.3)	0.60	−2.9 (1.3 to −5.4)
$Paco_2$, mm Hg	−0.6 ± 4.6	−0.6 ± 7.5	−0.0 (−3.2 to 3.1)	0.85	−0.0 (−2.7 to 2.7)
Short-Form 36 SS					
Physical health	2.3 ± 9.5	4.3 ± 6.9[b]	2.0 (−3.0 to 7.0)	0.43	1.5 (−2.5 to 5.6)
Mental health	9.7 ± 13.0[b]	2.9 ± 10.9	−6.8 (−14.1 to 0.5)	0.066	−5.5 (−11.5 to 0.4)

Review Article

Chronic Respiratory Disease
Volume 18: 1–15

DOI: 10.1177/14799731211041506
journals.sagepub.com/home/crd
SAGE

Effect of interval compared to continuous exercise training on physiological responses in patients with chronic respiratory diseases: A systematic review and meta-analysis

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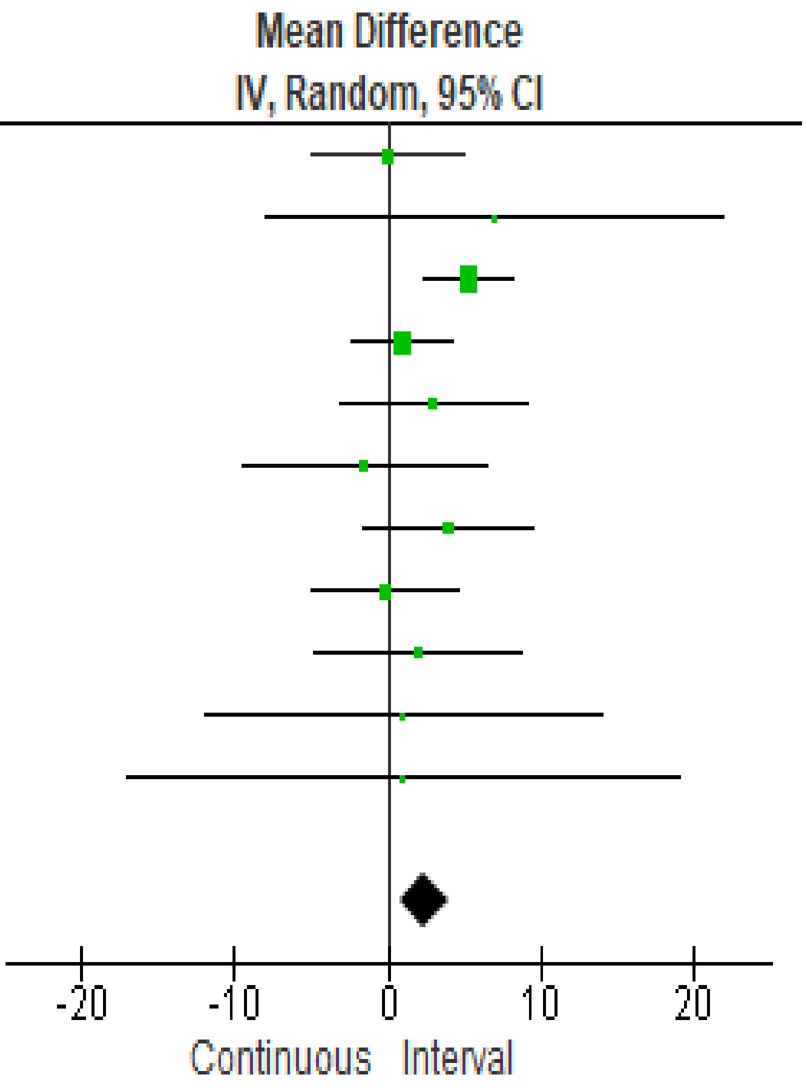
Comparison of the effect of interval versus continuous exercise on Peak Work Rate (Watts)

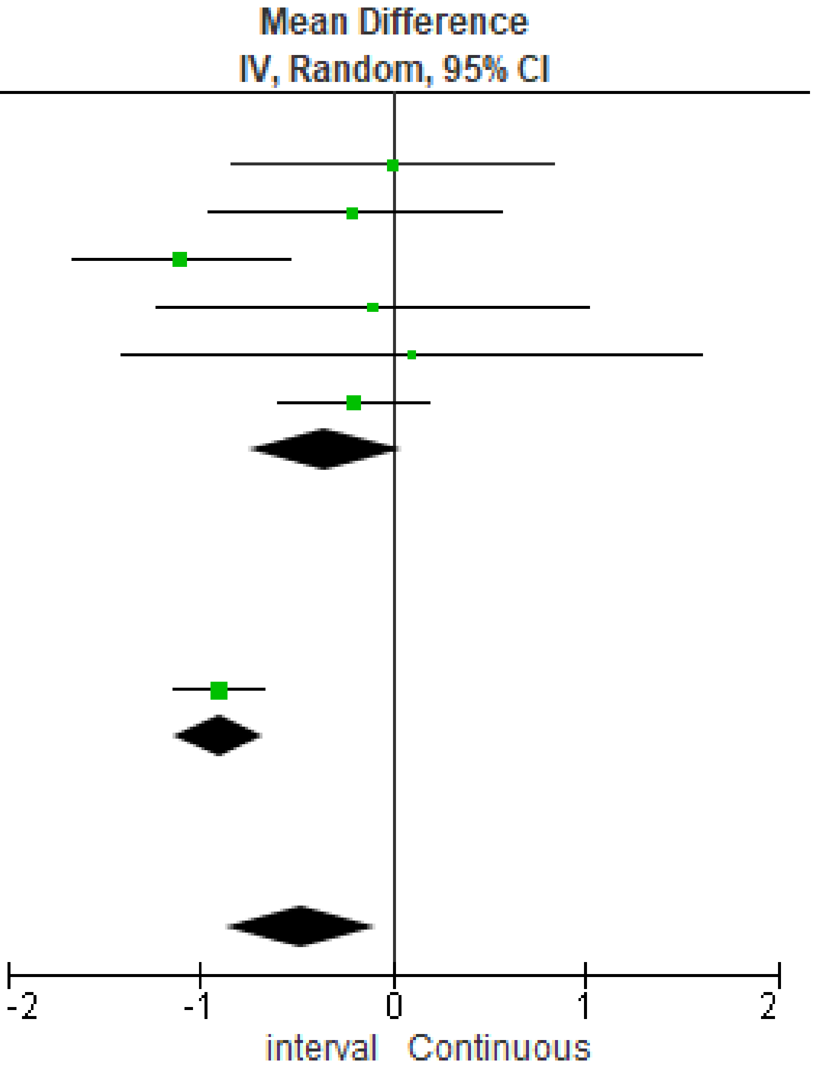
	Interval			Continuous				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Arnardottir et al., 2007	11	7	28	11	12	32	10.3%	0.00 [-4.90, 4.90]
Coppoolse et al., 1999	12	17	10	5	18	11	1.1%	7.00 [-7.97, 21.97]
Ercin et al., 2020	52	7	24	46.7	2	23	29.0%	5.30 [2.38, 8.22]
Gloeckl et al., 2012	14	7	30	13	6	30	22.6%	1.00 [-2.30, 4.30]
Kaltsakas et al., 2017	19	4	12	16	10	12	6.6%	3.00 [-3.09, 9.09]
Mador et al., 2009	10	13	21	11.5	13.1	20	3.9%	-1.50 [-9.49, 6.49]
Nasis et al., 2009	14	9.2	21	10	9.2	21	8.0%	4.00 [-1.56, 9.56]
Puhan et al., 2006	8.5	12	43	8.7	10.4	44	11.1%	-0.20 [-4.92, 4.52]
Varga et al., 2007	14	12	17	12	9	22	5.3%	2.00 [-4.83, 8.83]
Vogiatzis et al., 2002	14	15.2	18	13	23.5	18	1.5%	1.00 [-11.93, 13.93]
Vogiatzis et al., 2005	10	15.2	10	9	23.5	9	0.8%	1.00 [-17.01, 19.01]
Total (95% CI)			**234**			**242**	**100.0%**	**2.40 [0.83, 3.97]**

Heterogeneity: Tau² = 0.00; Chi² = 8.29, df = 10 (P = 0.60); I² = 0%
Test for overall effect: Z = 3.00 (P = 0.003)



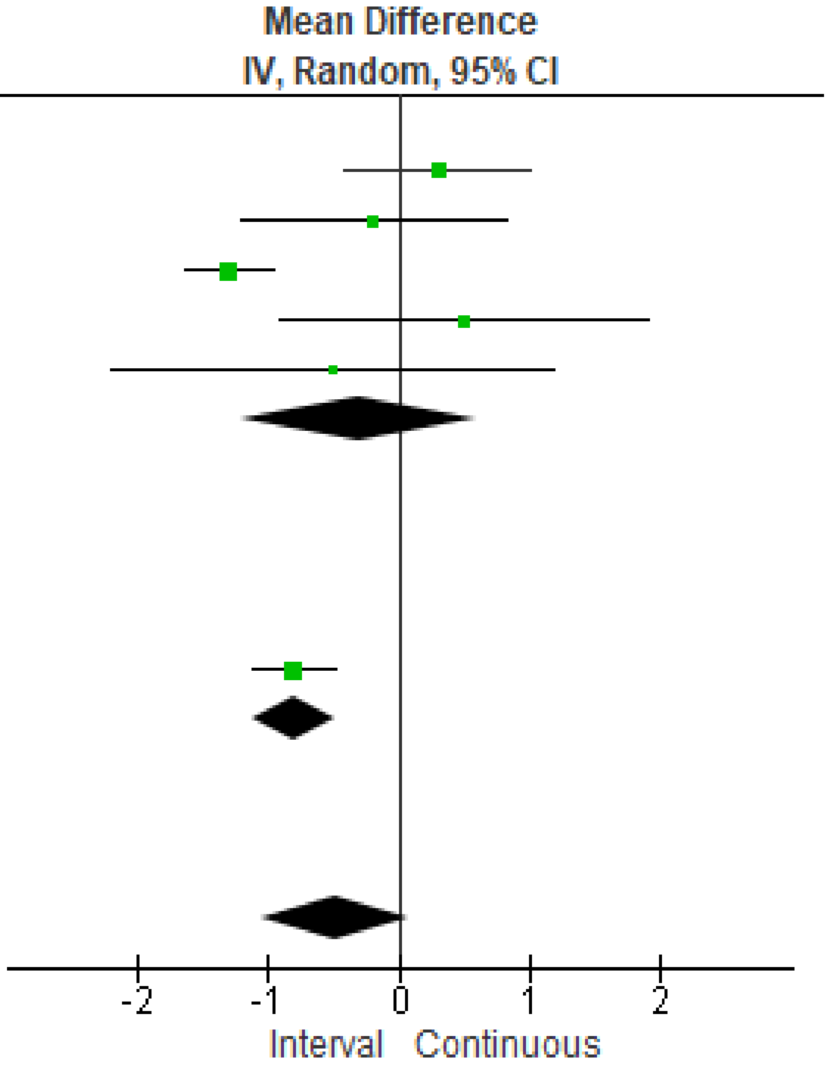
Comparison of the effect of interval versus continuous exercise on Dyspnoea (Borg 1-10)

Study or Subgroup	Interval Mean	Interval SD	Interval Total	Continuous Mean	Continuous SD	Continuous Total	Weight	Mean Difference IV, Random, 95% CI
5.1.1 BMI<30Kg/m2								
Arnardottir et al., 2007	-0.7	1.7	28	-0.7	1.6	32	11.8%	0.00 [-0.84, 0.84]
Gloeckl et al., 2012	-0.8	1.6	30	-0.6	1.4	30	13.0%	-0.20 [-0.96, 0.56]
Kaltsakas et al., 2017	0	0.6	12	1.1	0.8	12	16.9%	-1.10 [-1.67, -0.53]
Nasis et al., 2009	-0.3	1.9	21	-0.2	1.8	21	8.2%	-0.10 [-1.22, 1.02]
Varga et al., 2007	-0.6	2.2	17	-0.7	2.6	22	5.3%	0.10 [-1.41, 1.61]
Vogiatzis et al., 2002	-1.9	0.6	18	-1.7	0.6	18	20.8%	-0.20 [-0.59, 0.19]
Subtotal (95% CI)			**126**			**135**	**75.9%**	**-0.35 [-0.75, 0.05]**
Heterogeneity: Tau² = 0.10; Chi² = 8.65, df = 5 (P = 0.12); I² = 42%								
Test for overall effect: Z = 1.72 (P = 0.09)								
5.1.2 BMI>30 Kg/m2								
Ercin et al., 2020	-3.5	0.5	24	-2.6	0.3	23	24.1%	-0.90 [-1.13, -0.67]
Subtotal (95% CI)			**24**			**23**	**24.1%**	**-0.90 [-1.13, -0.67]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 7.52 (P < 0.00001)								
Total (95% CI)			**150**			**158**	**100.0%**	**-0.47 [-0.86, -0.09]**
Heterogeneity: Tau² = 0.15; Chi² = 17.35, df = 6 (P = 0.008); I² = 65%								
Test for overall effect: Z = 2.40 (P = 0.02)								
Test for subgroup differences: Chi² = 5.49, df = 1 (P = 0.02), I² = 81.8%								



Comparison of the effect of interval versus continuous exercise on leg discomfort (Borg 1-10)

Study or Subgroup	Interval Mean	Interval SD	Interval Total	Continuous Mean	Continuous SD	Continuous Total	Weight	Mean Difference IV, Random, 95% CI
6.1.1 BMI<30Kg/m2								
Arnardottir et al., 2007	-0.3	1.4	28	-0.6	1.3	28	18.8%	0.30 [-0.41, 1.01]
Gloeckl et al., 2012	-0.9	1.9	30	-0.7	2.1	30	14.4%	-0.20 [-1.21, 0.81]
Kaltsakas et al., 2017	-1.3	0.1	12	0	0.6	12	24.3%	-1.30 [-1.64, -0.96]
Nasis et al., 2009	0.3	1.4	21	-0.2	3	21	10.0%	0.50 [-0.92, 1.92]
Varga et al., 2007	-0.8	2.4	17	-0.3	3	22	7.8%	-0.50 [-2.20, 1.20]
Subtotal (95% CI)			**108**			**113**	**75.3%**	**-0.30 [-1.20, 0.60]**
Heterogeneity: Tau² = 0.78; Chi² = 21.95, df = 4 (P = 0.0002); I² = 82%								
Test for overall effect: Z = 0.65 (P = 0.52)								
6.1.2 BMI>30Kg/m2								
Ercin et al., 2020	-3	0.5	24	-2.2	0.6	23	24.7%	-0.80 [-1.12, -0.48]
Subtotal (95% CI)			**24**			**23**	**24.7%**	**-0.80 [-1.12, -0.48]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 4.95 (P < 0.00001)								
Total (95% CI)			**132**			**136**	**100.0%**	**-0.48 [-1.04, 0.09]**
Heterogeneity: Tau² = 0.31; Chi² = 22.01, df = 5 (P = 0.0005); I² = 77%								
Test for overall effect: Z = 1.65 (P = 0.10)								
Test for subgroup differences: Chi² = 1.05, df = 1 (P = 0.30), I² = 5.2%								



Conclusions

Benefits of intermittent versus continuous exercise:

- Prolongs endurance time
- Reduces ventilatory requirement and breathlessness
- *Reduces metabolic acidosis and leg discomfort*
- *Interval exercise affords greater work intensities with reduced symptoms*
- *Implementation of high-intensity interval exercise may maximize the magnitude of the physiological training effects*

BTS Guidelines for Pulmonary Rehabilitation

Interval and continuous aerobic training

- Interval and continuous training can be applied safely and effectively within the context of pulmonary rehabilitation to patients with COPD. (Grade A)
- The choice of interval or continuous training will be down to the patient and/or therapist preference. (√)
- In clinical practice, interval training may require a higher therapist to patient ratio to ensure adequate work rate and rest intervals are achieved compared with continuous training. (√)

Thorax
AN INTERNATIONAL JOURNAL OF RESPIRATORY MEDICINE

BTS Guideline on Pulmonary Rehabilitation in Adults

British Thoracic Society Pulmonary Rehabilitation Guideline Group

September 2013 Volume 68 Supplement 2

BMJ