



JOURNÉES FRANCOPHONES

ALVÉOLE

CITÉ DES CONGRÈS DE LYON
10 & 11 MARS 2016



AMÉLIORATION DES PERFORMANCES À L'EXERCICE PAR DES MOYENS MÉCANIQUES



GRAVIER Francis-Edouard
MKDE – ADIR Association (ROUEN)

Conflits d'intérêt

Aucun

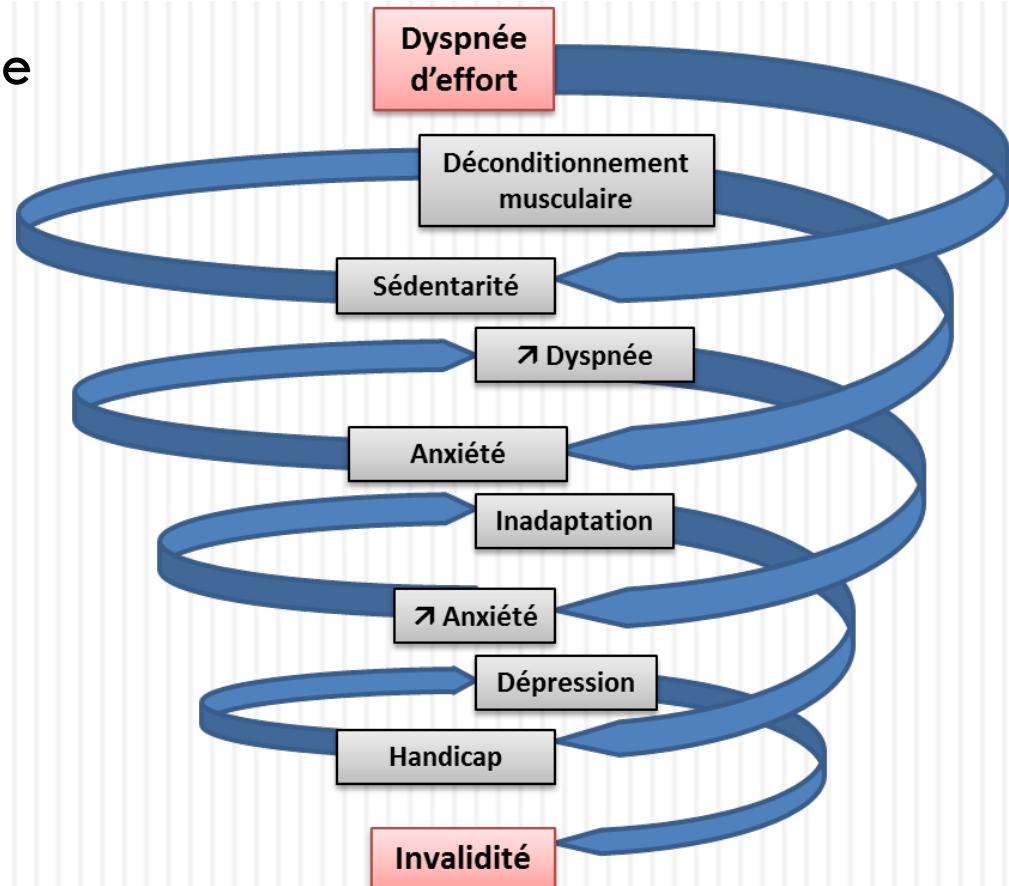
Plan

- Introduction
- Les adjuvants mécaniques à la RR
 - ▣ Ventilation Non Invasive
 - ▣ Haut débit nasal
 - ▣ Electrostimulation
- Conclusion

Introduction

La Réhabilitation Respiratoire

- Traitement à part entière reconnu dans la BPCO
- Recommandations internationales
- Autres pathologies respiratoires



SPLF. Recommendation for the clinical practice management of COPD. *Revue des maladies respiratoires* 2010; 27: 522-548

Bolton CE et al. British Thoracic Society guideline on pulmonary rehabilitation in adults. *Thorax* 2013; 68 Suppl 2: ii1-30

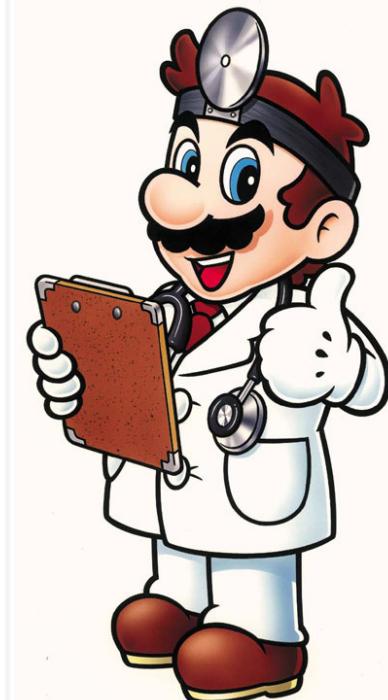
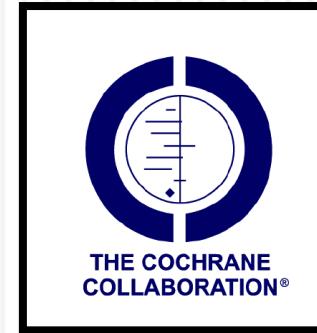
Nici L et al. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation.

American journal of respiratory and critical care medicine 2006; 173: 1390-1413

La Réhabilitation Respiratoire

- Améliore
 - ▣ Dyspnée
 - ▣ Tolérance à l'effort
 - ▣ Qualité de vie

- Nombre et durée des hospitalisations
- Effet sur la mortalité au décours d'une exacerbation



Lacasse et al. Pulmonary rehabilitation for chronic obstructive pulmonary disease.

The Cochrane database of systematic reviews 2006: CD003793.IF 2014

Puhan et al. Pulmonary rehabilitation following exacerbations of chronic obstructive pulmonary disease.

The Cochrane database of systematic reviews 2011: CD005305.IF

Une course contre la montre

□ TABLE 3
EFFECT OF TRAINING ON THE RESPONSES TO IDENTICAL LEVELS OF HEAVY EXERCISE*

	High Constant Work Rate Test			
	High Work Rate Training Group (n = 11)		Low Work Rate Training Group (n = 8)	
	Before	After	Before	After
Lactate, mEq/L	6.0 ± 1.8	4.0 ± 1.8†‡	4.8 ± 1.0	4.1 ± 1.1§
VE, L/min	52.5 ± 6.6	45.5 ± 6.0†	46.5 ± 10.8	45.4 ± 11.4
VE drift, L/min	9.5 ± 4.2	2.8 ± 2.6†	6.1 ± 1.6	4.8 ± 2.2
f, breaths/min	31 ± 4	29 ± 6	30 ± 5	29 ± 5†
VCO ₂ , L/min	1.62 ± 0.24	1.46 ± 0.15¶	1.35 ± 0.25	1.37 ± 0.26
VCO ₂ drift, L/min	0.26 ± 0.11	0.11 ± 0.06¶	0.17 ± 0.05	0.16 ± 0.06
VO ₂ , L/min	1.55 ± 0.19	1.46 ± 0.14§	1.37 ± 0.25	1.34 ± 0.21
VO ₂ drift, L/min	0.14 ± 0.08	0.04 ± 0.06‡§	0.13 ± 0.06	0.04 ± 0.08
VE/VO ₂	34.4 ± 5.4	30.5 ± 4.4†**	34.1 ± 5.0	33.1 ± 5.1
Heart rate, beats/min	147 ± 17	136 ± 14†	135 ± 13	135 ± 10
Blood pressure, mm Hg	201/101 ± 31/9	190/106 ± 36/17	191/103 ± 37/11	187/101 ± 23/14
Pao ₂ , mm Hg	86 ± 13	78 ± 13†	80 ± 15	77 ± 10
Paco ₂ , mm Hg	43 ± 8	46 ± 10	42 ± 6	41 ± 8
pHa	7.33 ± 0.03	7.33 ± 0.04	7.32 ± 0.03	7.34 ± 0.03¶
Exercise duration, min	6.6 ± 2.3	11.4 ± 4.0†‡	6.9 ± 3.2	7.5 ± 3.0

Casaburi R et al. *The American review of respiratory disease* 1991; 143: 9-18

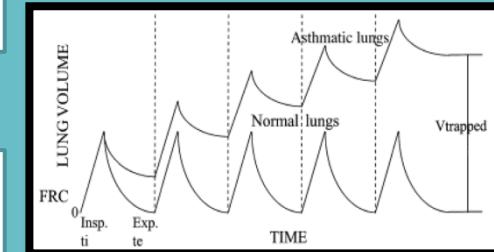
Gimenez M et al. *Archives of physical medicine and rehabilitation* 2000; 81: 102-109

Punzal PA, et al. *Chest* 1991; 100: 618-623.IF 2014

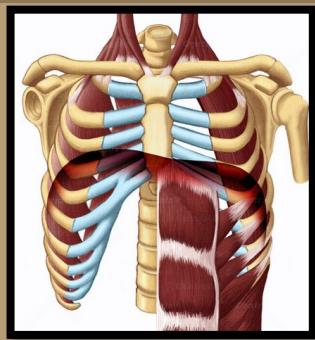
La dyspnée : un obstacle de taille



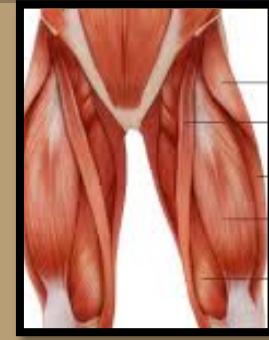
Hyperinflation dynamique



Fatigue des
muscles
respiratoires



Fatigue des
muscles
Périphériques



+++ Dyspnée +++

Quels recours?

- Diminuer l'intensité?
- Intervalle training?
- Réentraînement sur 1 membre?
- Supplémentation en oxygène ?
- Ventilation Non Invasive?
- Haut débit nasal?
- Electrostimulation ?

Moyens
mécaniques

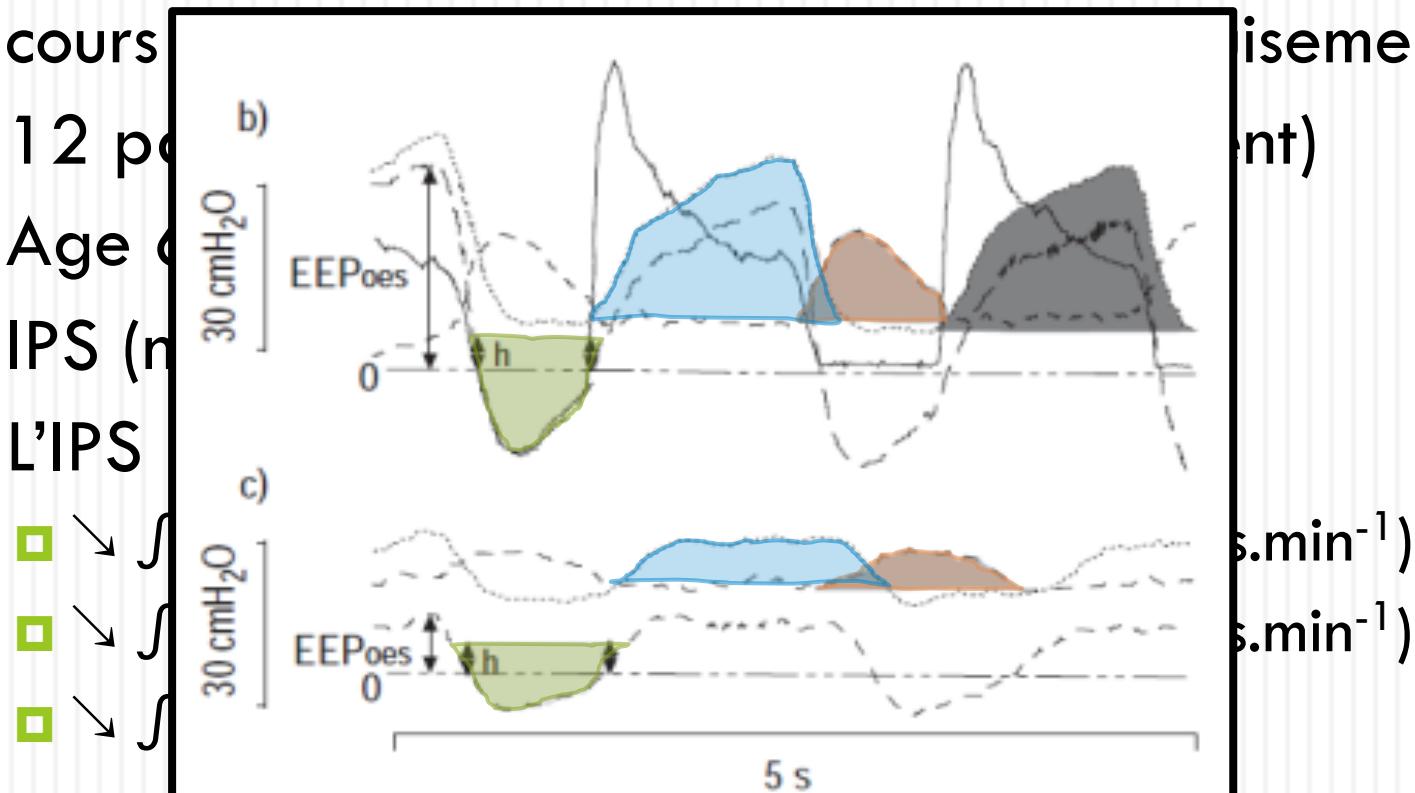
Ventilation non invasive

**Effets aigus
(Tests d'endurance)**



Diminution du travail respiratoire

- Observation des pressions diaph., œs. et gas. au cours de l'effort
- 12 patients
- Age moyen : 62 ans
- IPS (n = 12)
- L'IPS



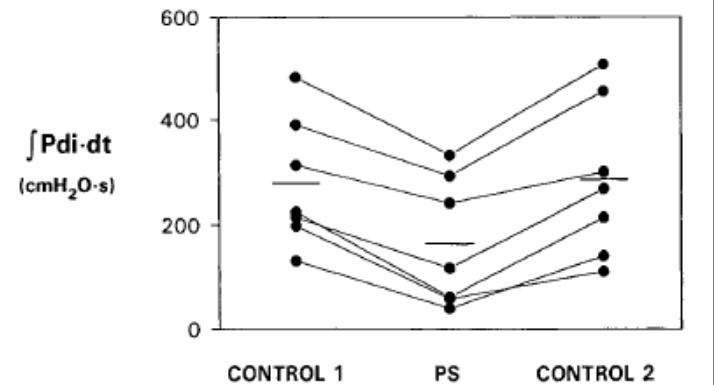
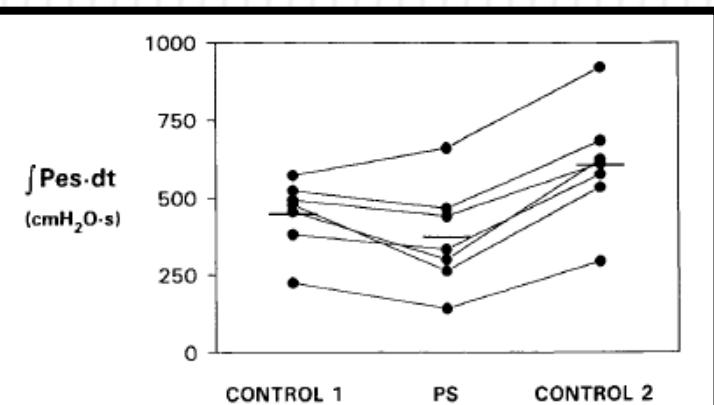
KYROUSSIS D., et al Respiratory muscle activity in patients with COPD walking to exhaustion with and without pressure support. EurRespir J 2000; 15:649-655

Diminution du travail respiratoire

- Observation des pressions diaphragmatiques, œsophagiennes et gastriques su
- 7 patients obstructifs (VEAMSC 20)

TABLE 3
EFFECT OF PRESSURE SUPPORT ON BREATHING PATTERN*

	Control 1	Pressure Support	Control 2
VT, L	0.88 ± 0.10	1.06 ± 0.14†	0.89 ± 0.13
RR, breaths/min	21.4 ± 1.9	23.8 ± 3.1‡	24.1 ± 2.5§
VE, L/min	18.1 ± 1.7	23.2 ± 2.0†	20.2 ± 2.1
TI, s	1.06 ± 0.11	0.92 ± 0.10‡	0.91 ± 0.10§
TE, s	1.87 ± 0.13	1.84 ± 0.24	1.73 ± 0.16
TI/TTOT	0.36 ± 0.02	0.34 ± 0.02	0.34 ± 0.09
VT/TI, L/s	0.83 ± 0.06	1.14 ± 0.05†	0.98 ± 0.09§
VT/TE, L/s	0.47 ± 0.05	0.61 ± 0.07†	0.52 ± 0.06



Maltais F et al. Pressure support reduces inspiratory effort and dyspnea during exercise in chronic airflow obstruction. Am J Respir Critical Care 1995 ; 151: 1027-33

Hypoxémie et distance de marche

- VNI et oxygénothérapie à la marche
- N=20 ; TDM6 O₂ vs VNI+O₂
- ↗ PaO₂ et ↗ distance de marche ▲

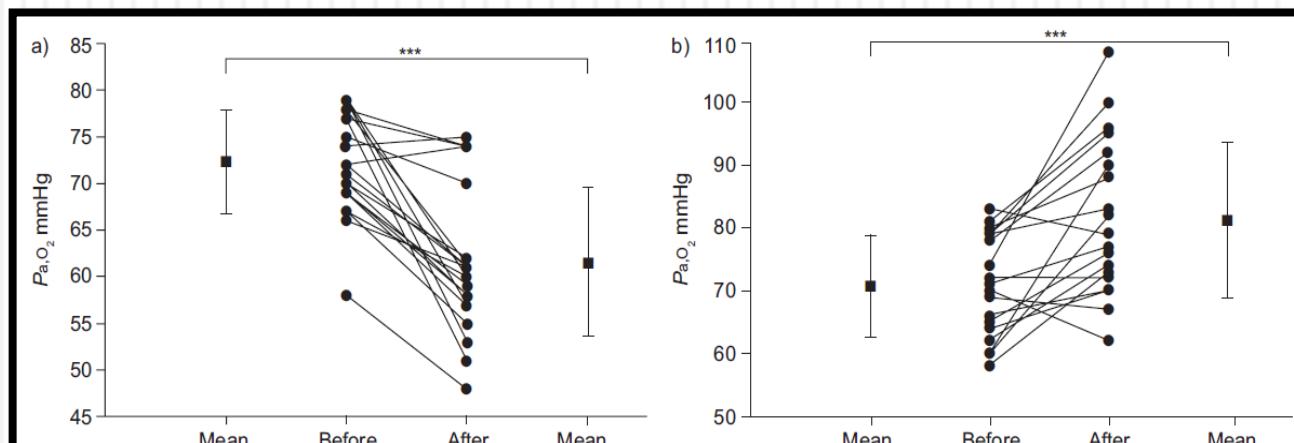


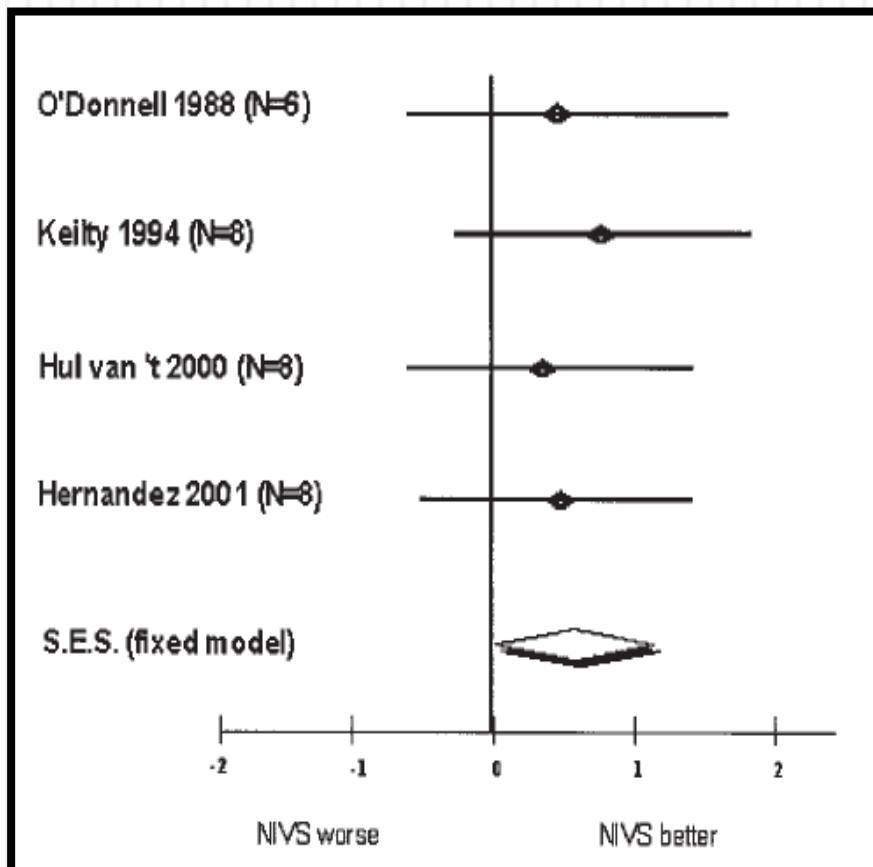
FIGURE 2. Changes in arterial oxygen tension (PaO_2) before and after 6-min walking test while on a) supplemental oxygen and b) noninvasive positive-pressure ventilation in addition to supplemental oxygen. The whiskers represent sd. ***: $p<0.001$



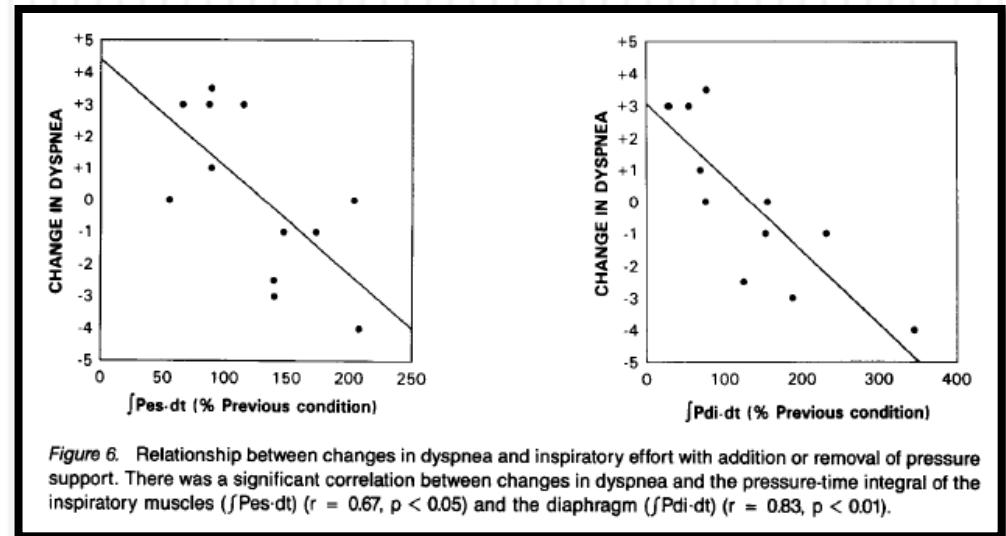
Dreher M. et al. Non-invasive ventilation during walking in patients with severe COPD: a randomized cross-over trial. Eur Respir J 2007;29:930-936 ▲

Dreher M. et al, Preserving Oxygenation during Walking in Severe Chronic Obstructive Pulmonary Disease: Noninvasive Ventilation versus Oxygen Therapy. Respiration 2009;78:154-160

Amélioration de la dyspnée



□ Corrélation avec le degré
De ↓ effort respiratoire



Van't Hul A et al. The acute effects of noninvasive ventilator support during exercise on exercise endurance and dyspnea in patients with chronic obstructive pulmonary disease : a systematic review. *J Cardiopulm Rehabil* 2002 ; 22 : 290-7

Maltais et al. Pressure support reduces inspiratory effort and dyspnea during exercise in chronic airflow obstruction. *Am J Respir Crit Care Med* 1995 ; 151 : 1027-30

Amélioration fatigue des MI

Observations

16

CW

Table 2 Effects of proportional assisted ventilation (PAV) and sham ventilation on oxygen transport/utilisation variables at isotime (the shortest test between the two experimental conditions in a given subject) and at exercise cessation (Tlim) (N = 16)

Variables	At isotime		At Tlim	
	Sham ventilation	PAV	Sham ventilation	PAV
<i>Cardiovascular/haemodynamics</i>				
Cardiac output				
Absolute (l/min)	12.8 (2.5)	13.0 (3.0)	12.9 (2.5)	13.0 (2.8)
Δ exercise-rest (l/min)	6.5 (2.6)	6.8 (2.8)	6.6 (2.5)	6.9 (2.5)
Stroke volume				
Absolute (ml)	88 (20)	93 (18)	97 (15)	95 (15)
Δ exercise-rest (ml)	18 (13)	20 (14)	22 (12)	22 (15)
Heart rate				
Absolute (bpm)	134 (18)	133 (20)	136 (19)	139 (18)
Δ exercise-rest (bpm)	53 (23)	50 (20)	54 (22)	57 (19)
Oxygen pulse				
Absolute (ml/min/beat)	8.2 (2.0)	8.3 (2.0)	8.2 (1.9)	8.2 (2.0)
<i>Systemic oxygenation</i>				
SpO ₂				
Absolute (%)	90.4 (3.8)	92.3 (1.1)	89.3 (3.6)	90.6 (4.9)
Δ exercise-rest	-4.6 (3.4)	-3.7 (4.4)	-5.7 (3.7)	-5.4 (4.9)
Cao _{2est} (mL%)				
Absolute	18.7 (4.5)	18.2 (3.9)	18.1 (3.6)	18.8 (4.1)
Δ exercise-rest	-2.4 (0.3)	-2.5 (0.6)	-2.3 (0.8)	-2.7 (0.7)
Do _{2est} (l/min)				
Absolute	2.8 (0.4)	2.7 (0.5)	2.5 (0.4)	2.4 (0.3)
Δ exercise-rest	1.9 (0.2)	2.0 (0.3)	1.9 (0.2)	1.8 (0.5)
<i>Leg muscle oxygenation</i>				
Δ[HHb] (% MVC)	88.7 (15.4)	72.9 (16.4)*	90.7 (14.1)	71.8 (15.9)*
Δ[O ₂ Hb] (% MVC)	-85.4 (19.4)	-70.4 (18.8)*	-87.7 (18.7)	-69.3 (19.4)*
Δ[Hb _{tot}] (% recovery)	58.3 (10.9)	74.3 (16.5)*	58.4 (12.3)	77.6 (17.1)*
TOI (%)	35.7 (17.1)	48.7 (18.7)*	34.3 (16.7)	50.2 (19.0)*
<i>Blood lactate</i>				
Absolute ($\mu\text{mol/l}$)	-	-	3.8 (1.3)	3.9 (1.2)
Lactate/time ($\mu\text{mol/l/min}$)	-	-	0.99 (0.40)	0.85 (0.35)*

Values are mean (SD).

*p<0.05 (paired t test for between-group differences at a given time point).

Cao_{2est}, estimated arterial oxygen content; Do_{2est}, estimated oxygen delivery; HHb, reduced haemoglobin; Hb_{tot}, total haemoglobin; MVC, maximum voluntary contraction; O₂Hb, oxyhaemoglobin; SpO₂, oxyhaemoglobin saturation by pulse oximetry; TOI, tissue oxygenation index.

Amélioration du temps d'endurance

- 7 études sur tests d'endurance 60-80% P_{max}
- Effet résumé correspondant à 3.3 min (55%)

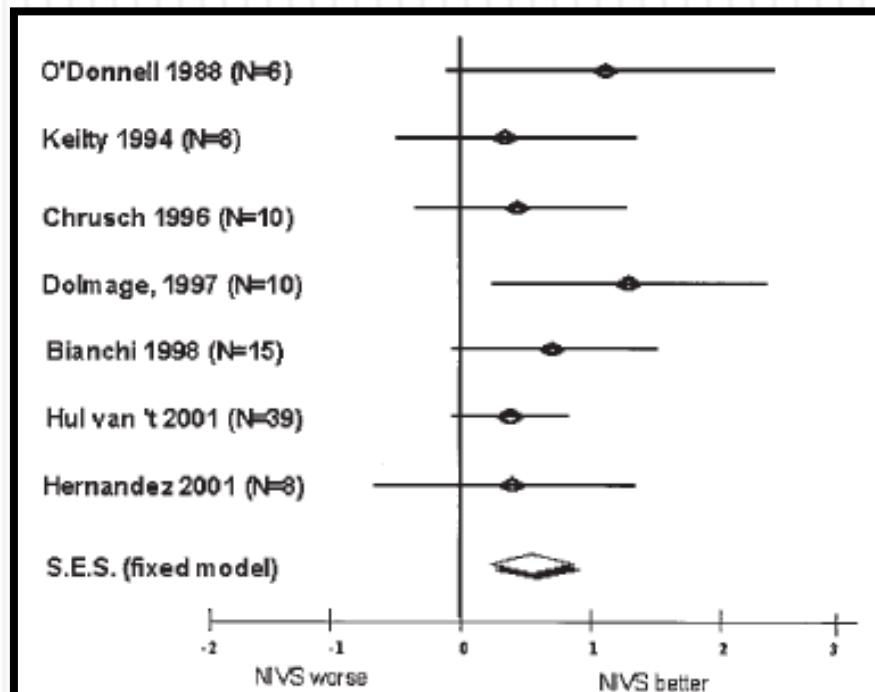


Figure 2. Effect sizes based on Glass δ (and 95% confidence intervals [CI]) for exercise endurance in the best-case scenario. (See Figure 1 for a detailed explanation.) A moderate but significant effect size was found after pooling of the mean effect sizes of all studies (0.58; 95% CI 0.29-0.87; $P < .001$; $n = 97$ patients with chronic obstructive pulmonary disease).

van't Hul A et al. The acute effects of noninvasive ventilator support during exercise on exercise endurance and dyspnea in patients with chronic obstructive pulmonary disease : a systematic review. *J Cardiopulm Rehabil* 2002 ; 22 : 290-7

Ventilation non invasive (2)

**Effets au terme d'un
programme**



Effets sur la performance à l'exercice

Figure 4. Forest plot of comparison: I Non-invasive ventilation during exercise training versus exercise training alone or exercise training with sham non-invasive ventilation, outcome: I.3 Exercise capacity: percentage change.

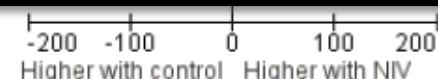


Figure 6. Forest plot of comparison: I Non-invasive ventilation during exercise training versus exercise training alone or exercise training with sham non-invasive ventilation, outcome: I.6 Training intensity: Final training session (% baseline peak work capacity).

Study or Subgroup	NIV			Control			Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% CI
	Mean	SD	Total	Mean	SD	Total	Weight	
Bianchi 2002	88.8	14	9	88.8	12.3	10	33.8%	0.00 [-11.91, 11.91]
Hawkins 2002	111.7	14	10	92.9	6	9	37.5%	18.80 [9.28, 28.32]
van 't Hul 2006	97	26.5	15	75.2	13.9	14	28.8%	21.80 [6.54, 37.06]
Total (95% CI)	34			33			100.0%	13.31 [0.05, 26.57]

Heterogeneity: $\tau^2 = 98.64$; $\text{Chi}^2 = 7.26$, $df = 2$ ($P = 0.03$); $I^2 = 72\%$

Test for overall effect: $Z = 1.97$ ($P = 0.05$)



Mais des résultats qui restent à confirmer

- **Essentiellement des tendances**
 - ▣ QDVLS
 - ▣ VO₂
 - ▣ Dyspnée
- **Manque de puissance**
 - ▣ Nb d'études et effectifs
- **Hétérogénéité des études disponibles**
 - ▣ Modes/interfaces de ventilation
 - ▣ Programmes de réhabilitation

Ventilation non invasive (3)

Quels réglages?



Mode de ventilation

- CPAP seule semble insuffisante
- Pas de supériorité entre PAV et IPS
- ↳ Intérêt de la combinaison PAV+CPAP ou CPAP+IPS ++

- En pratique courante utilisation BIPAP ++
- ↳ Peu de ventilateur proposant la PAV
- ↳ Pratique plus accessible / connu de certains patients

- Mérite plus d'exploration avec effectifs plus élevés

Réglages

- PEP
 - Trigger inspi
 - Pente
 - (IPAP) AI
 - Trigger expi
 - /Cyclage
 - Surveiller Vt / VE (Vol au seuil ventilatoire EFX)
-
- The diagram illustrates the ventilation cycle with two main plots sharing a common vertical axis:
- Pressure Plot:** The top plot shows a blue horizontal baseline. Orange trapezoidal waves represent pressure changes. The first wave is triggered by an orange vertical line (Trigger inspi). Subsequent waves occur at regular intervals, triggered by orange vertical lines.
 - Flow Plot:** The bottom plot shows a blue horizontal baseline. Orange bell-shaped curves represent flow. The first curve is triggered by a purple vertical line (Trigger expi). Subsequent curves occur at regular intervals, triggered by blue vertical lines.

Ventilation non invasive (4)

Quels freins?



Les freins rencontrés

- Temps (Chronophage ++)
 - ▣ Initiation-familiarisation (1 thérapeute / 1 patient)
 - ▣ Surveillance plus étroite

CIBLER

- Activité statique
 - ▣ Diminution périmètre de marche si matériel porté

- MAIS



ABANDON (Men...)

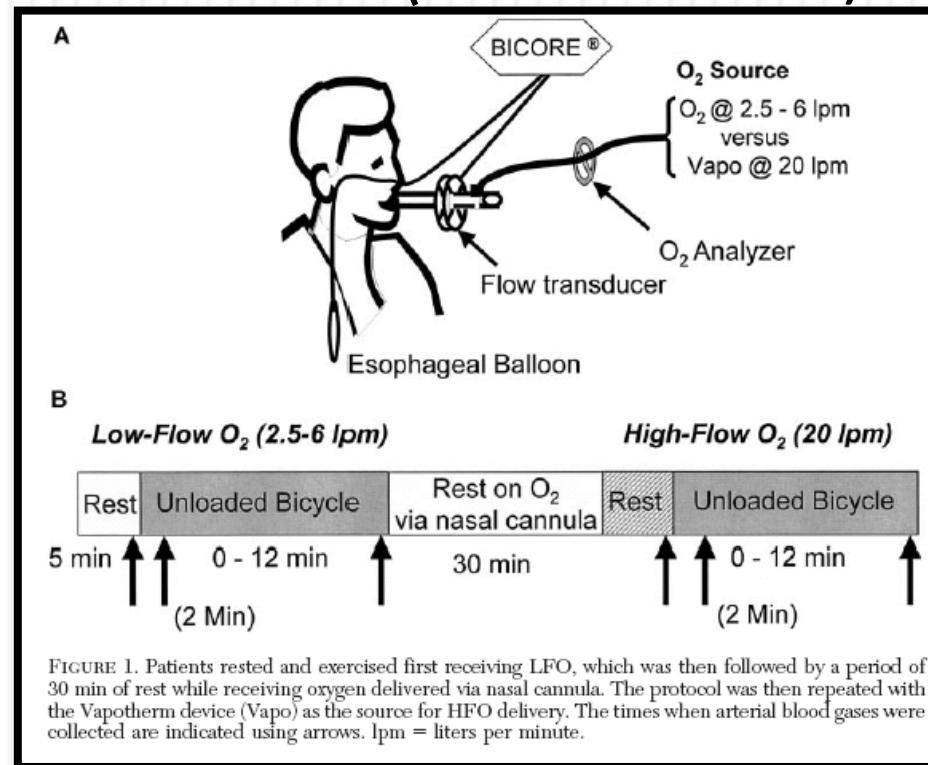


Haut débit nasal



Oxygénothérapie à haut débit nasal

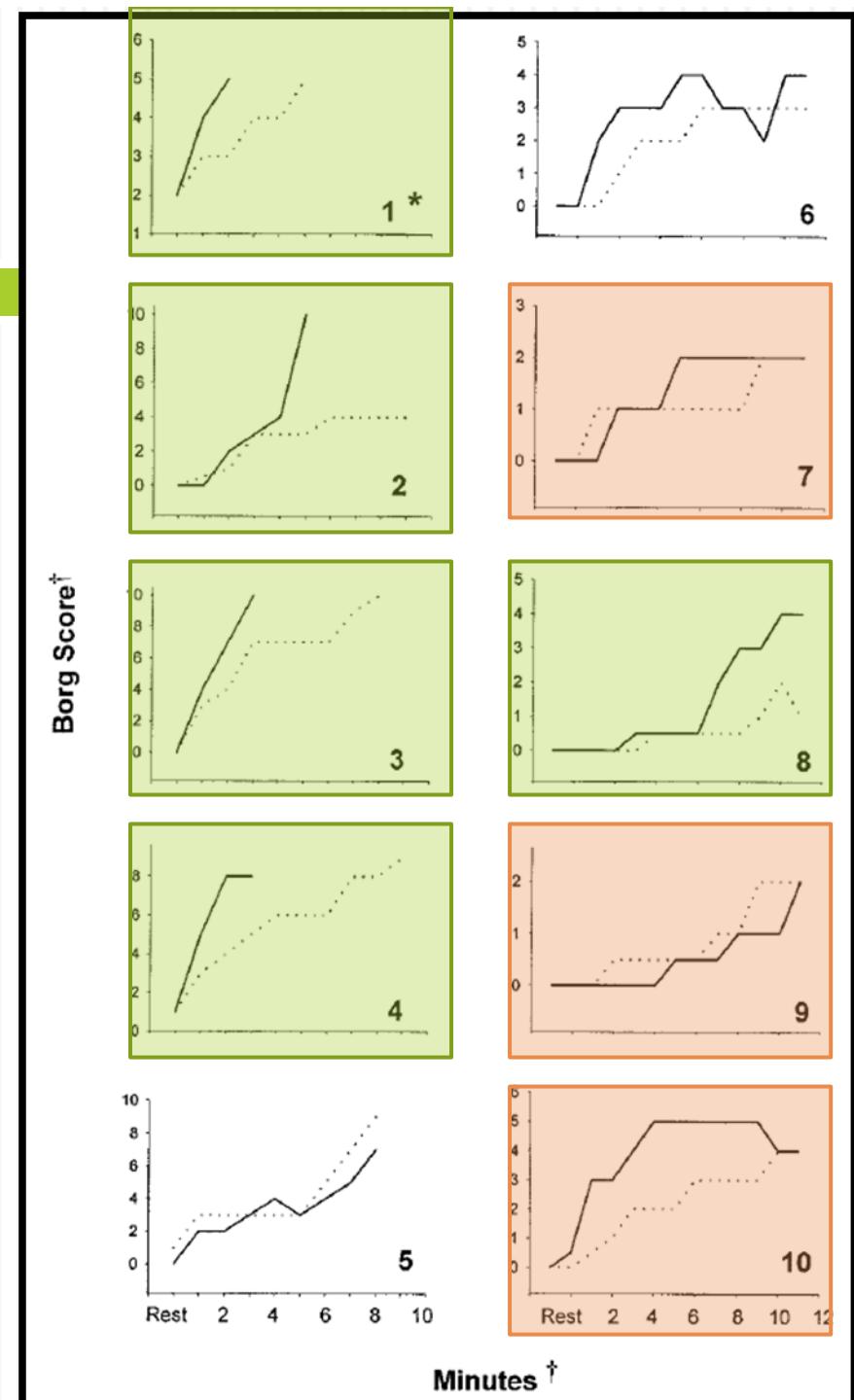
- Etude prospective; randomisée; non aveugle
- 10 patients BPCO IV (VEMS $23 \pm 6\%$)



Chatila et al. The effects of high-flow vs low-flow oxygen on exercise in advanced obstructive airways disease. CHEST 2004; 126:1108–1115

Oxygénothérapie à haut débit nasal

- Amélioration du temps d'endurance
 - ▣ $10+/- 2.4\text{min}$ vs $8.2+/- 4.3\text{min}$,
 $p<0,05$
- Amélioration de la dyspnée
 $P=0,03$
- Pas de modification P_{oes}



Quelle FiO₂ ? (étude sans Haut Débit)

Table 2.– Responses to constant work rate exercise with different inspired oxygen fractions in patients with chronic obstructive pulmonary disease

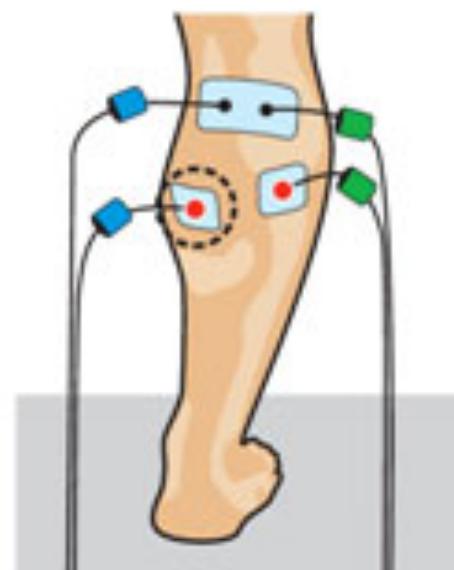
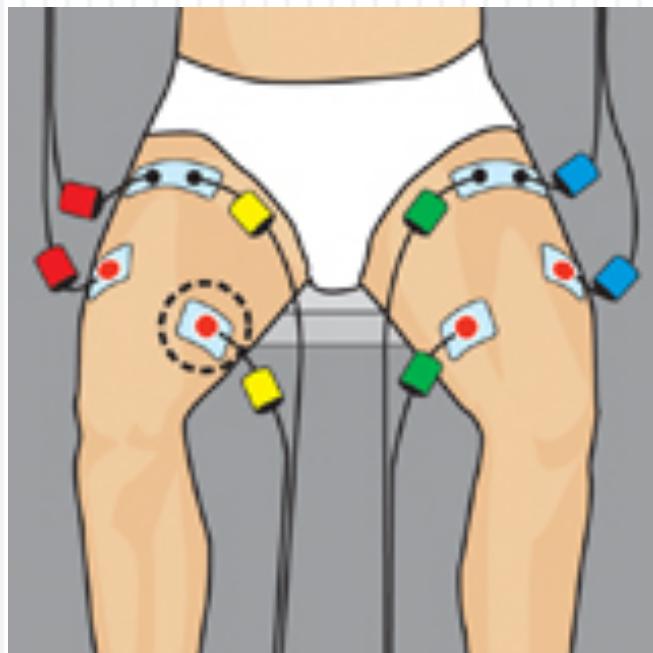
Parameter		<i>Fl,O₂</i>	0.21	0.30	0.50	0.75	1.00
Endurance min			4.2±0.5	7.8±1.0*	10.3±1.9*,#	10.8±1.0*,#	9.6±0.8*,#
Isotime values							
Breathlessness Borg			6.7±0.6	4.4±0.4*	4.0±0.4*	3.3±0.4*	4.4±0.5*
HR bpm			121±4	111±5*	107±3*	105±3*	105±3*
<i>V'</i> CO ₂ L·min ⁻¹			0.95±0.11	0.85±0.11	0.85±0.12	0.86±0.14	0.85±0.12
PET,CO ₂ mmHg			41.2±1.4	43.7±1.5	42.9±1.3	41.5±1.3	41.5±1.3
IC L			1.39±0.14	1.59±0.14*	1.72±0.14*	1.68±0.12*	1.71±0.11*
IRV L			0.29±0.05	0.48±0.06*	0.54±0.06*	0.53±0.04*	0.55±0.07*
<i>V'</i> E L·min ⁻¹			30.6±3.3	26.4±3.4*	26.1±3.6*	25.4±2.9*	24.2±3.5*
VT L			1.10±0.11	1.12±0.12	1.18±0.12	1.15±0.09	1.06±0.12
VT/IC %			79.9±3.0	69.6±3.5*	65.5±4.3*	68.4±2.1*	64.0±4.7*
TI/Ttot			0.36±0.02	0.36±0.01	0.38±0.01	0.37±0.01	0.36±0.02
TE s			1.44±0.12	1.69±0.16*	1.83±0.15*	1.75±0.11*	1.78±0.16*
VT/TI L·s ⁻¹			1.47±0.14	1.20±0.11*	1.17±0.12*	1.11±0.11*	1.09±0.12*
Sa,O ₂ %			91.0±1.1	98.0±0.8*	99.7±0.2*	99.7±0.2*	99.9±0.1*

Isotime refers to the time at which the room air test ended. HR: heart rate; *V'*CO₂: carbon dioxide output; PET,CO₂: end-tidal partial pressure for CO₂; IC: inspiratory capacity; IRV: inspiratory reserve volume; *V'*E: minute ventilation; VT: tidal volume; VT/IC: tidal volume as a % of IC; TI/Ttot: duty cycle; TE: expiratory time; VT/TI: mean inspiratory flow; Sa,O₂: arterial oxygen saturation; *: p<0.05 versus 0.21 *Fl,O₂*; #: p<0.05 versus 0.30 *Fl,O₂*.

Oxygénothérapie à haut débit nasal

- Recherche littérature => 1 seule étude
 - ↳ nécessite plus d'investigation
- « Effet PEP »
 - ↳ lutte efficace contre l'hyperinflation dynamique?
 - ↳ dépend du débit
- FiO₂ 30 à 50% => contraintes matérielles?
- A la frontière entre l'Oxygénothérapie conventionnelle et la VNI ?

ElectroMyoStimulation (EMS)



EMS => pourquoi?

- Meilleure tolérance d'un travail segmentaire par rapport à un exercice en endurance (cyclo/tapis)
- EMS = demande ventilatoire inférieure

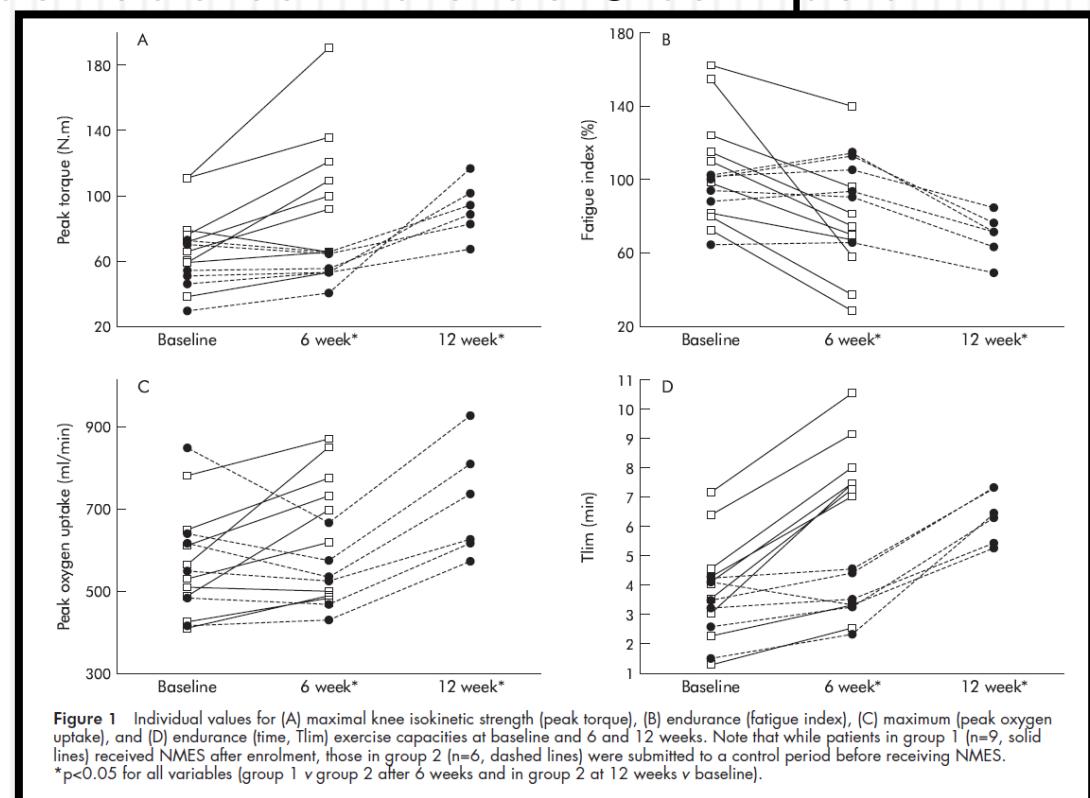
Table 2 Resistance training (RT) versus NMES.

	RT	NMES	p-Value
Resting VO ₂ (ml/min)	273 (229-311)	241 (208-283)	0.099
Peak VO ₂ (ml/min)	497 (443-592)	311 (238-359)	0.001
Peak VO ₂ (% peak VO ₂ CPET)	57 (45-84)	34 (30-42)	0.001
Resting VE (l)	14 (12-18.5)	13 (11.5-15)	0.023
Peak VE (l)	28 (22.0-32.5)	14 (12.5-19.5)	0.001
Peak VE (% MVV)	58 (43-78)	31 (25-37)	0.001
Borg dyspnoea (points)	3 (2-4)	1 (1-3)	0.005
Borg fatigue (points)	3 (2.5-5)	2 (0.8-3.5)	0.031

The data shown (median (IQR)) are the results obtained before and after a session of resistance training (RT) or neuromuscular electrical stimulation (NMES) in 13 COPD patients. VO₂ = oxygen uptake in ml/min; % peak VO₂ CPET = oxygen uptake expressed as a percentage of the peak VO₂ obtained at the end of a symptom-limited cardiopulmonary exercise test; peak VE = peak minute ventilation in litre; % MVV = percentage maximal voluntary ventilation.

EMS => applicable à domicile?

- 15 patients BPCO
- N=9 EMS 6sem ; n=6 période contrôle de 6 sem puis EMS 6sem
- Programme réalisé en intégralité (suivi régulier par physiothérapeute)



NEDER JA et al. Home based neuromuscular electrical stimulation as a new rehabilitative strategy for severely disabled patients with chronic obstructive pulmonary disease (COPD) Thorax 2002;57:333–337

EMS => bénéfices réels?

OPEN ACCESS Freely available online

PLOS ONE

Metabolic and Structural Changes in Lower-Limb Skeletal Muscle Following Neuromuscular Electrical Stimulation: A Systematic Review

Maurice J.H. Sillen^{1*}, Frits M.E. Franssen¹, Harry R. Gosker², Emiel F.M. Wouters^{1,2,3}, Martijn A. Spruit¹

- => mars 2012
- Compile 18 études
- Pas de mété-analyse
(hétérogénéité)

Official Journal of the Asian Pacific Society of Respirology

Respirology



Lack of efficacy of neuromuscular electrical stimulation of the lower limbs in chronic obstructive pulmonary disease patients:
A meta-analysis

LEI PAN,^{1,*} YONGZHONG GUO,^{2,**} XUNCHAO LIU³ AND JUNHONG YAN⁴

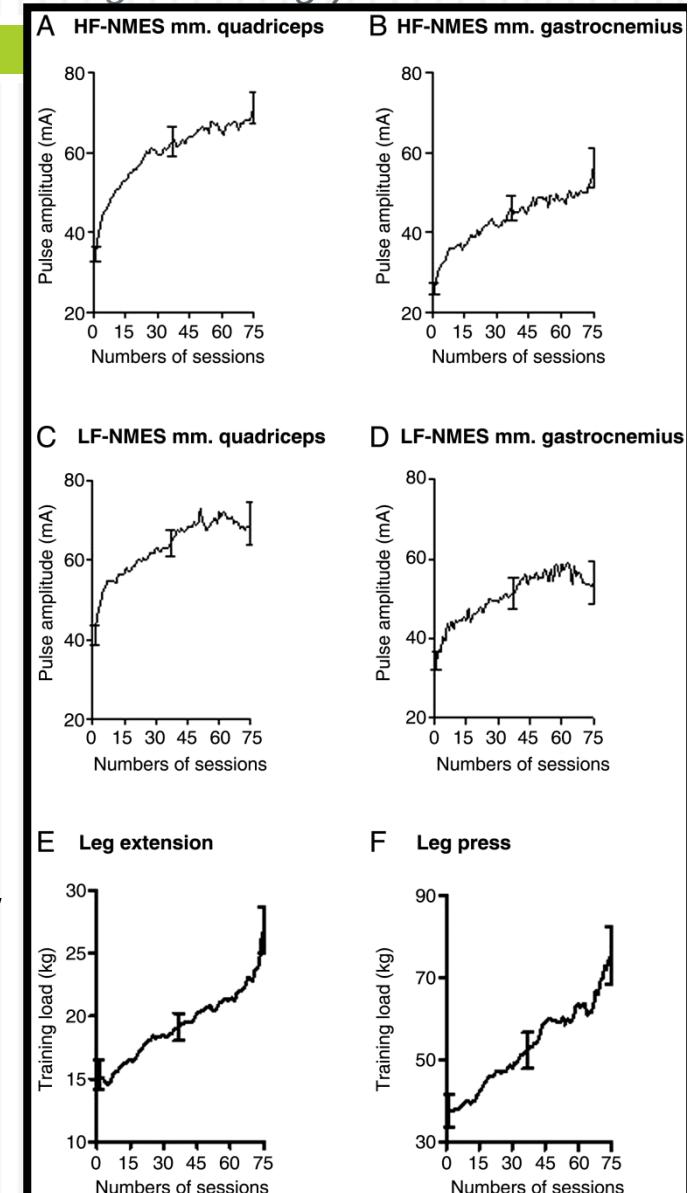
- => décembre 2012
- Compile 8 études
- Peu de résultats significatifs

Manque d'évidence sur les bénéfices de l'EMS
Analyses limitées => puissance / hétérogénéité +++

DICES Trial

(Dyspnoeic Individuals with COPD: Electrical stimulation or Strength training)

- DICES trial => RCT simple aveugle.
- 120 patients BPCO III-IV(VEMS
33+/-1%)
- HF-NMES(75Hz) =41 /
LF-NMES(15Hz)=39 /
Strength Training=40
- Programme de 8 semaines
comportant environ 75 sessions pour
chacun des groupes



DICES Trial

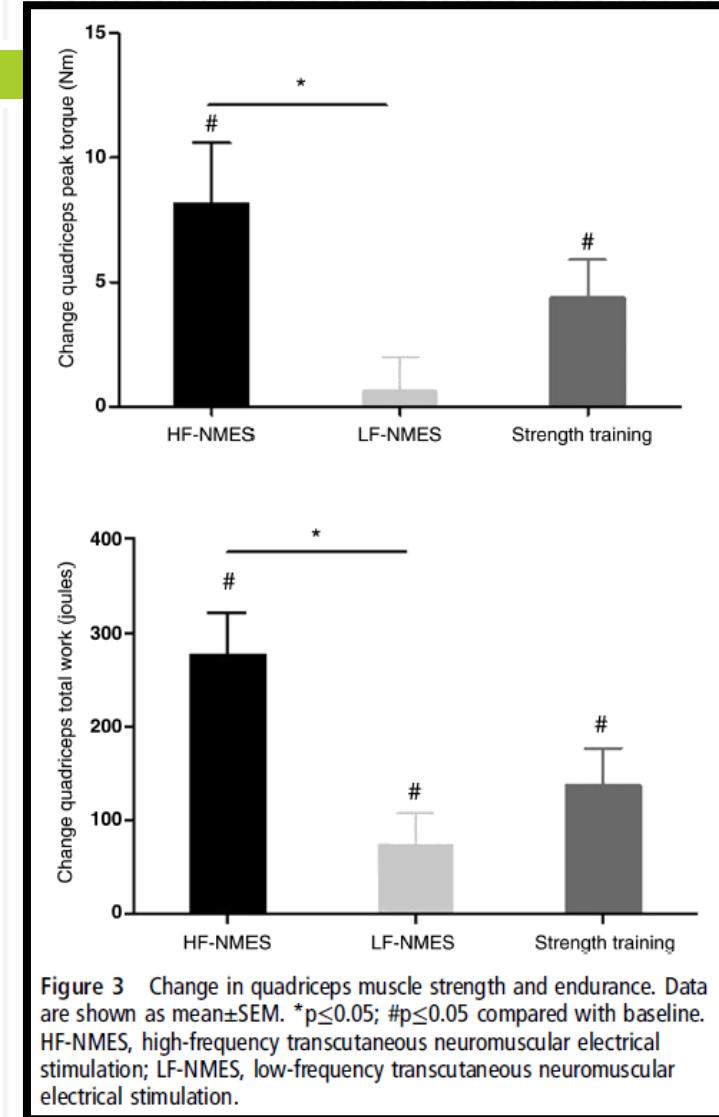
(Dyspnoeic Individuals with COPD: Electrical stimulation or Strength training)

P
E
R
F
O
R
M
A
N
C
E

- Amélioration de la force quadriceps
 - ▣ HF-NMES (10.8 ± 2.9 Nm; $p < 0.01$)
 - ▣ strength training (6.1 ± 2.0 Nm; $p < 0.01$)
 - ▣ LF-NMES (1.4 ± 1.8 Nm; $p = 0.43$)
- TDM6 $p < 0.03$; NS entre les groupes
 - ▣ HF-NMES: 66 ± 14 m;
 - ▣ LF-NMES: 51 ± 15 m;
 - ▣ strength training: 29 ± 12 m.
- CWRT $p < 0.03$; NS entre les groupes
 - ▣ HF-NMES: 171 ± 58 s;
 - ▣ LF-NMES: 167 ± 46 s;
 - ▣ strength training: 69 ± 30 s.

EMS => quels réglages?

- Privilégier Haute Fréquence?
 - ▣ HF-NMES > LF-NMS $p=0.03$
 - ▣ ≠ sur la performance à l'exercice entre les 3 modalités
- Intensité
 - ▣ La plus haute supportable par le patient



Sellen MJH. et al. Efficacy of lower-limb muscles training modalities in severely dyspnoeic individuals with COPD and quadriceps muscle weakness: results from the DICES trial. THORAX 2014;0:1–7.

Conclusion

LES MOYENS MÉCANIQUES



Merci de votre
attention

- Améliorent les performances au cours de l'exercice
- Nécessitent un temps d'initiation et de surveillance accru
- Doivent encore montrer leur bénéfices à long terme
- Des adjutants à cibler dans un programme personnalisé