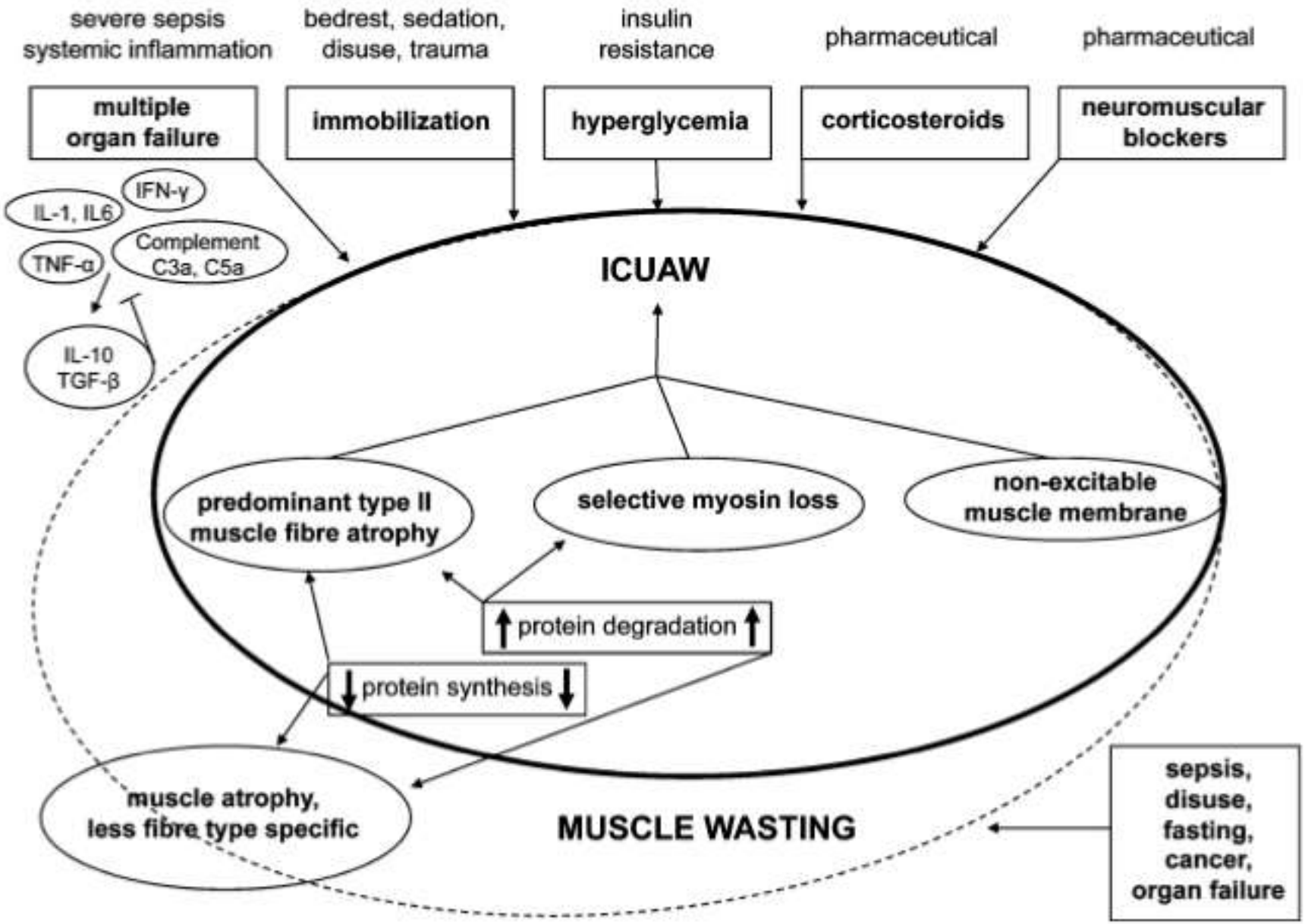
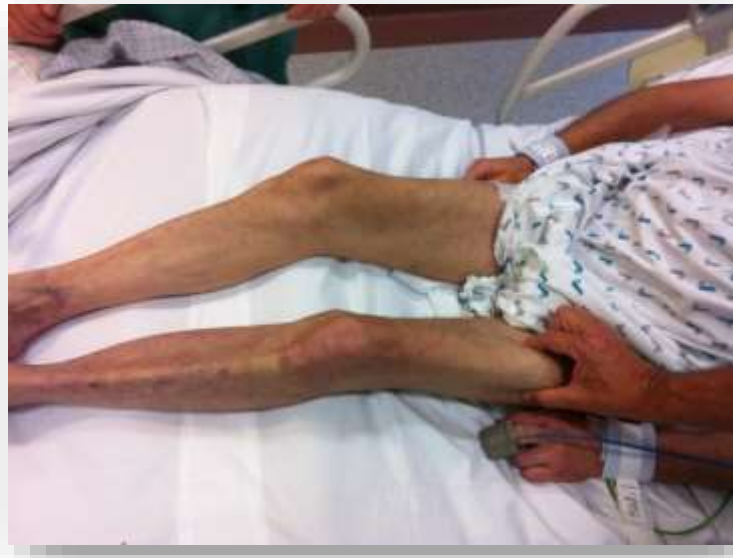
Mobilisations en réa : indications, limites

La mobilisation Passive

Cheryl Hickmann, PT, PhD

No conflicts of interest.

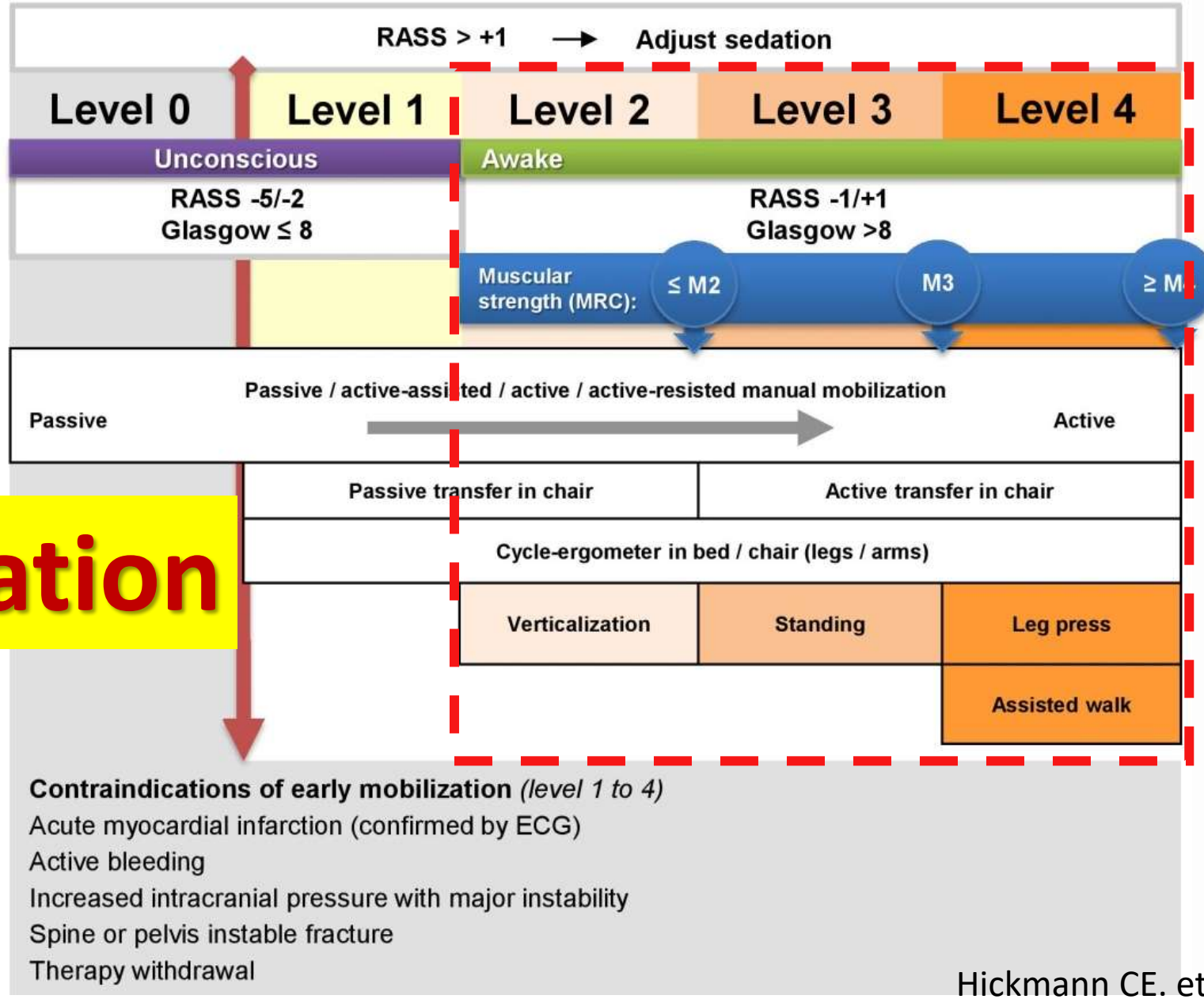




J Cachexia Sarcopenia Muscle (2010) 1:147–157

Early mobilization protocol

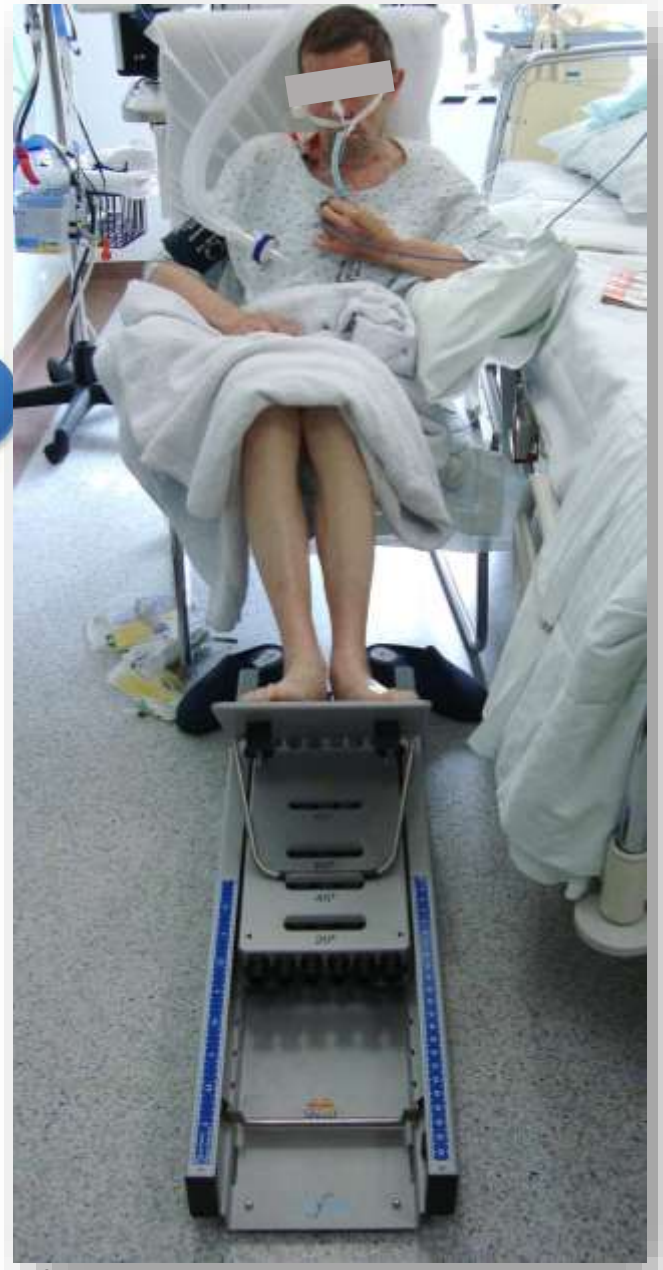
M. Patri, CE. Hickmann, E. Bialais, J. Dugernier, P-F Laterre , J. Roeseler
Intensive care unit, Saint Luc university hospital, Brussels.



↓Sedation

Contraindications of early mobilization *(level 1 to 4)*

Acute myocardial infarction (confirmed by ECG)
Active bleeding
Increased intracranial pressure with major instability
Spine or pelvis instable fracture
Therapy withdrawal



Hickmann CE. et al, Ann int care 2016

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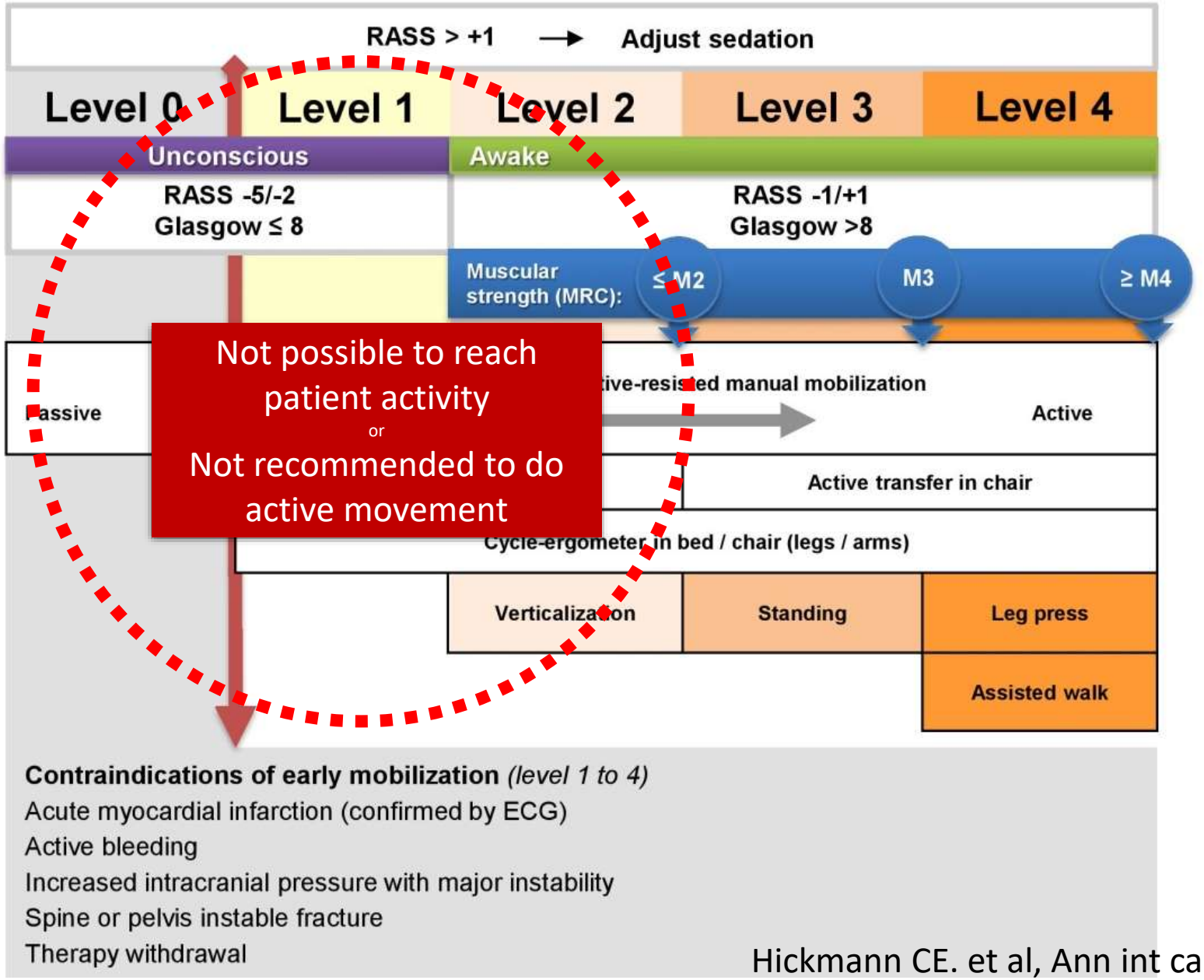
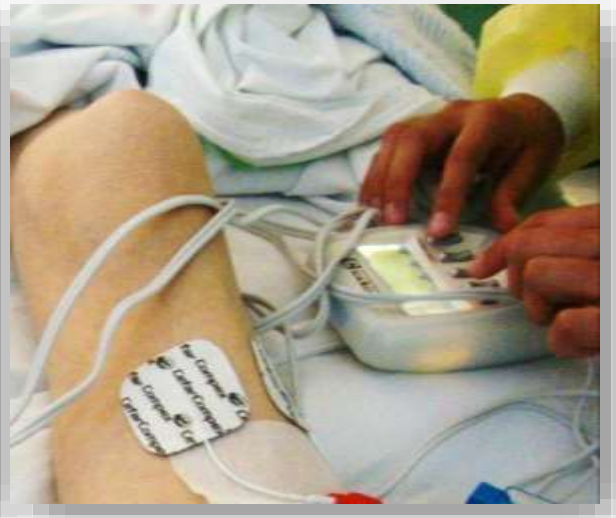
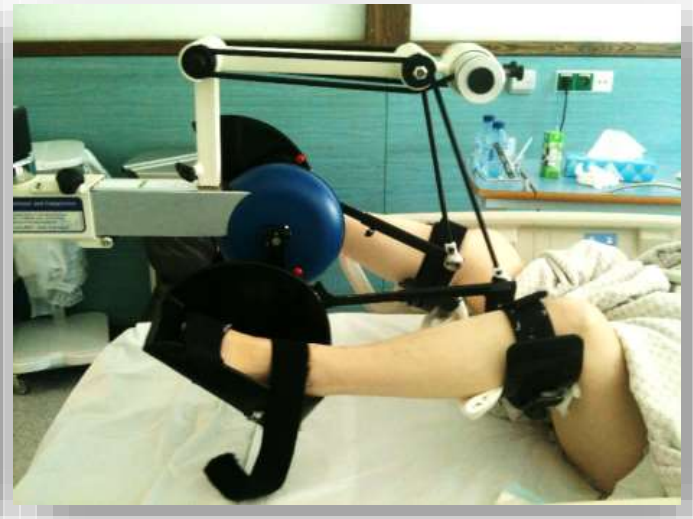


Contraindications of early mobilization *(level 1 to 4)*

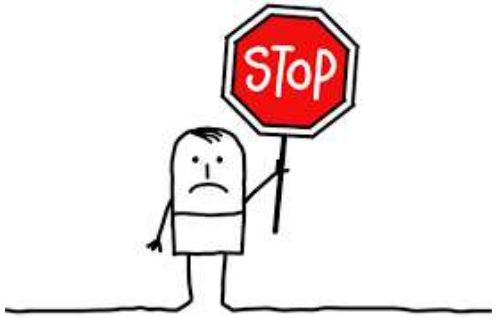
Acute myocardial infarction (confirmed by ECG)
Active bleeding
Increased intracranial pressure with major instability
Spine or pelvis instable fracture
Therapy withdrawal

Hickmann CE. et al, Ann int care 2016





Really useful?



Limits!

Effects of Bilateral Passive Range of Motion Exercise on the Function of Upper Extremities and Activities of Daily Living in Patients with Acute Stroke

Acute stroke patients:
Control (n=18) → PROM from week 2
Intervention (n=19) → <72h PROM 15-minute
twice a day, 5 times a week, for 4 weeks

Table 3. Comparison of range of motion of affected shoulder between experimental and control groups

Variables		Baseline		After 2 wks		After 4 wks
		Mean±SD				
Flexion (°)	Exp (n=19)	114.1±13.0[a]	↗	116.7±12.8[b]	↗	119.0±12.6[c]
	Cont (n=18)	109.1±20.2[a]	→	109.8±20.7	↗	111.1±21.1[b]
Extension (°)	Exp (n=19)	25.2±5.2[a]	↗	27.1±4.9[b]	↗	29.5±5.3[c]
	Cont (n=18)	31.2±4.7	→	31.3±4.7	→	31.9±4.8
Abduction (°)	Exp (n=19)	94.2±12.0[a]	↗	96.3±12.1[b]	↗	98.4±12.5[c]
	Cont (n=18)	92.7±13.0[a]	→	93.0±13.1	→	94.2±13.4[b]
Internal rotation (°)	Exp (n=19)	51.3±19.8[a]	↗	53.8±19.5[b]	↗	55.6±19.6[c]
	Cont (n=18)	57.7±14.8[a]	→	58.3±14.8[b]	→	58.8±15.2[c]
External rotation (°)	Exp (n=19)	44.8±24.9[a]	↗	46.7±25.3[b]	↗	48.6±25.5[c]
	Cont (n=18)	35.0±18.2[a]	→	35.4±18.3	→	36.0±18.3[b]

Exp=Experimental group, Cont=Control group, [a,b,c] =Bonferroni test

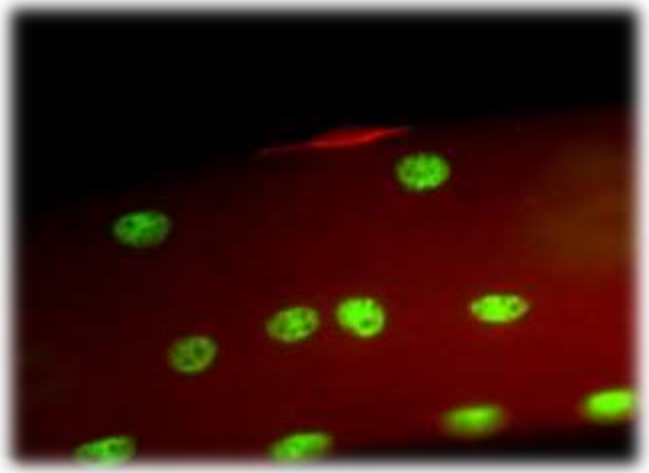
↑ ROM upper limbs
↓ Level of edema at 2 and 4 weeks
↑ The self-care skills (eating and dressing)

Kim HJ, J Phys Ther Sci 2014

In other populations PROM:

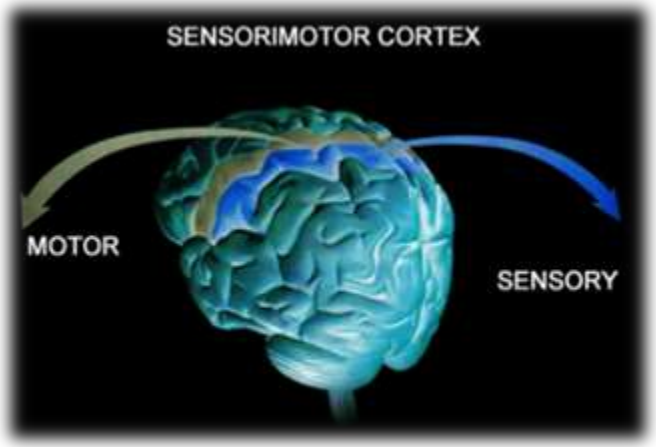
Promote muscle regeneration by activating satellite cells

Relaix F, Zammit PS (2012) Satellite cells are essential for skeletal muscle regeneration: the cell on the edge returns centre stage. Development 139:2845–2856



Induce a reorganization of sensorimotor representation

Carel C, Loubinoux I, Boulanouar K, Manelfe C, Rascol O, Celsis P, Chollet F (2000) Neural substrate for the efects of passive training on sensorimotor cortical representation: a study with functional magnetic resonance imaging in healthy subjects. J Cereb Blood Flow Metab 20:478–484 39.



Infuence the excitability of the corticomotor pathway

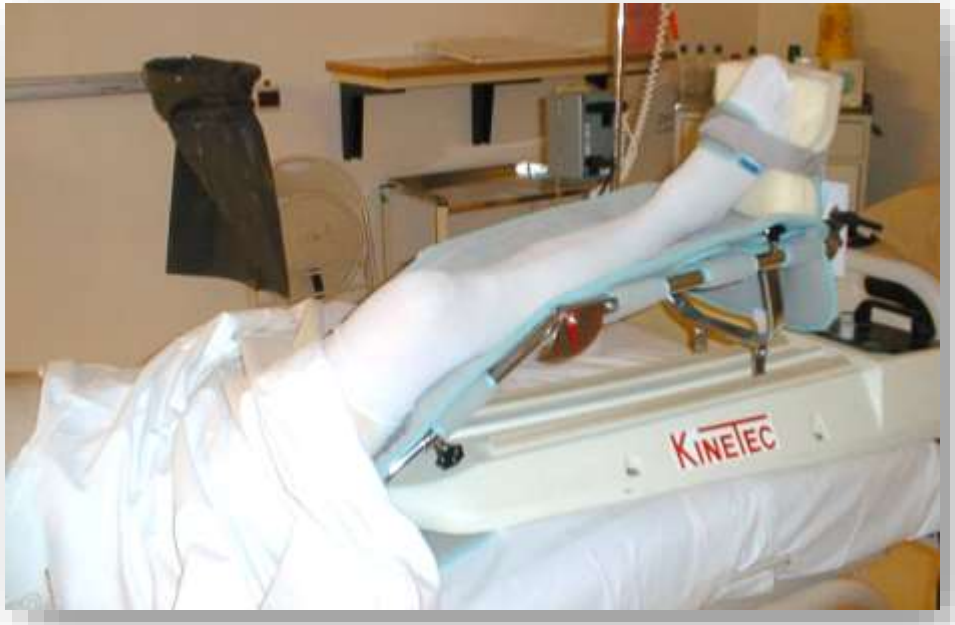
Edwards DJ, Thickbroom GW, Byrnes ML, Ghosh S, Mastaglia FL (2002) Reduced corticomotor excitability with cyclic passive movement: a study using transcranial magnetic stimulation. Hum Mov Sci 21:533–540

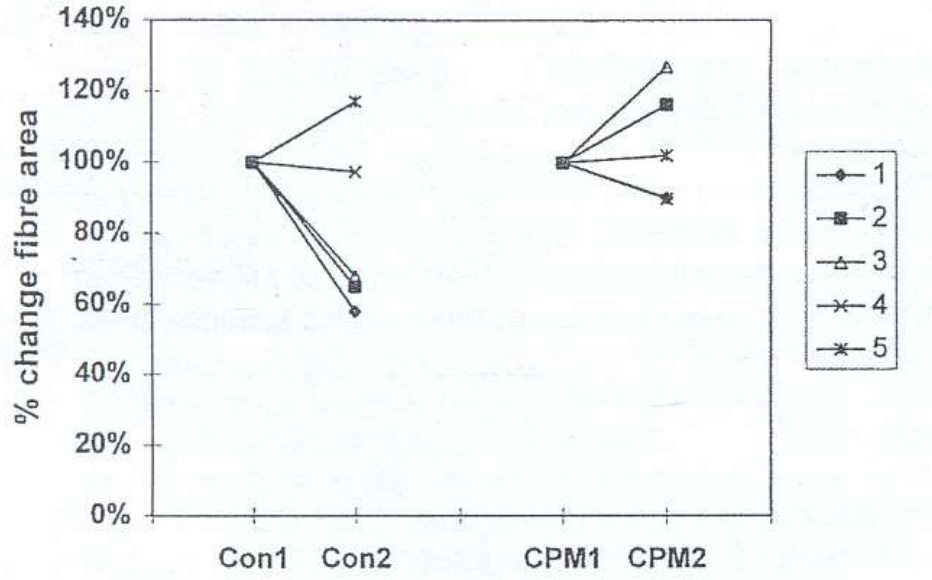
Effect of Passive Stretching on the Wasting of Muscle in the Critically Ill

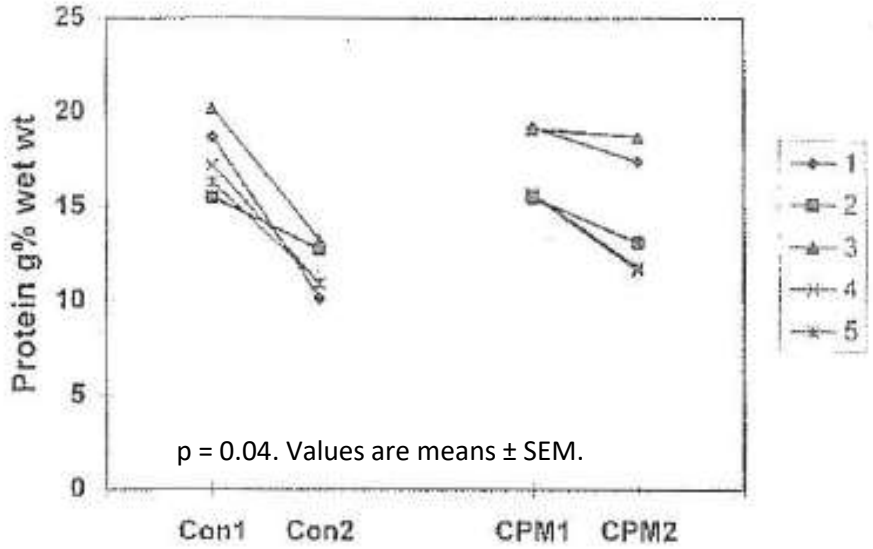
5 patients – neuromuscular blockade for 7 days.
3 severe sepsis

Continuous passive motion (CMP) therapy

3 x 3h/day → 7 days







Muscle fiber atrophy was prevented with passive motion in the more severely ill patients

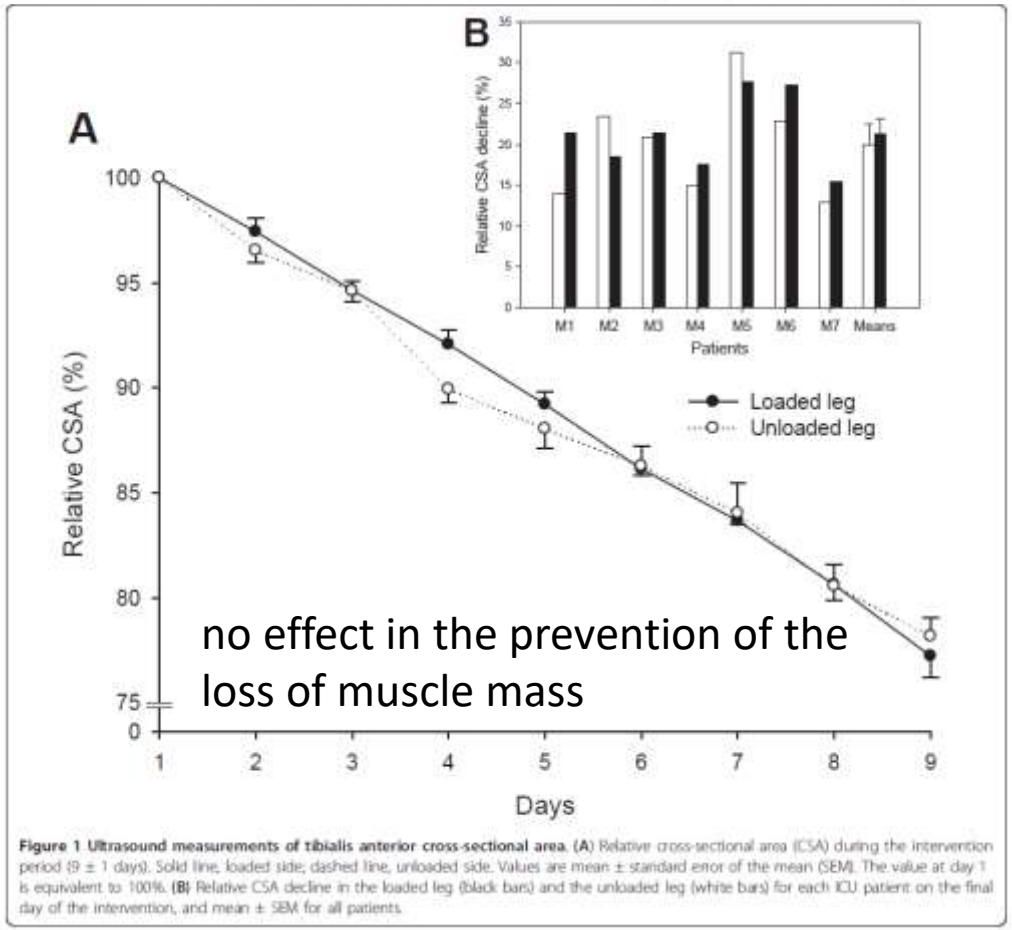
Griffiths RD et al, Nutrition 1995

Mechanisms underlying ICU muscle wasting and effects of passive mechanical loading

n =7 fully sedated and MV patients
(without neuromuscular blockade)

CPM
4 x 2.5 hours
during 7 to 11 days
(start 1.7 ± 0.9 days)

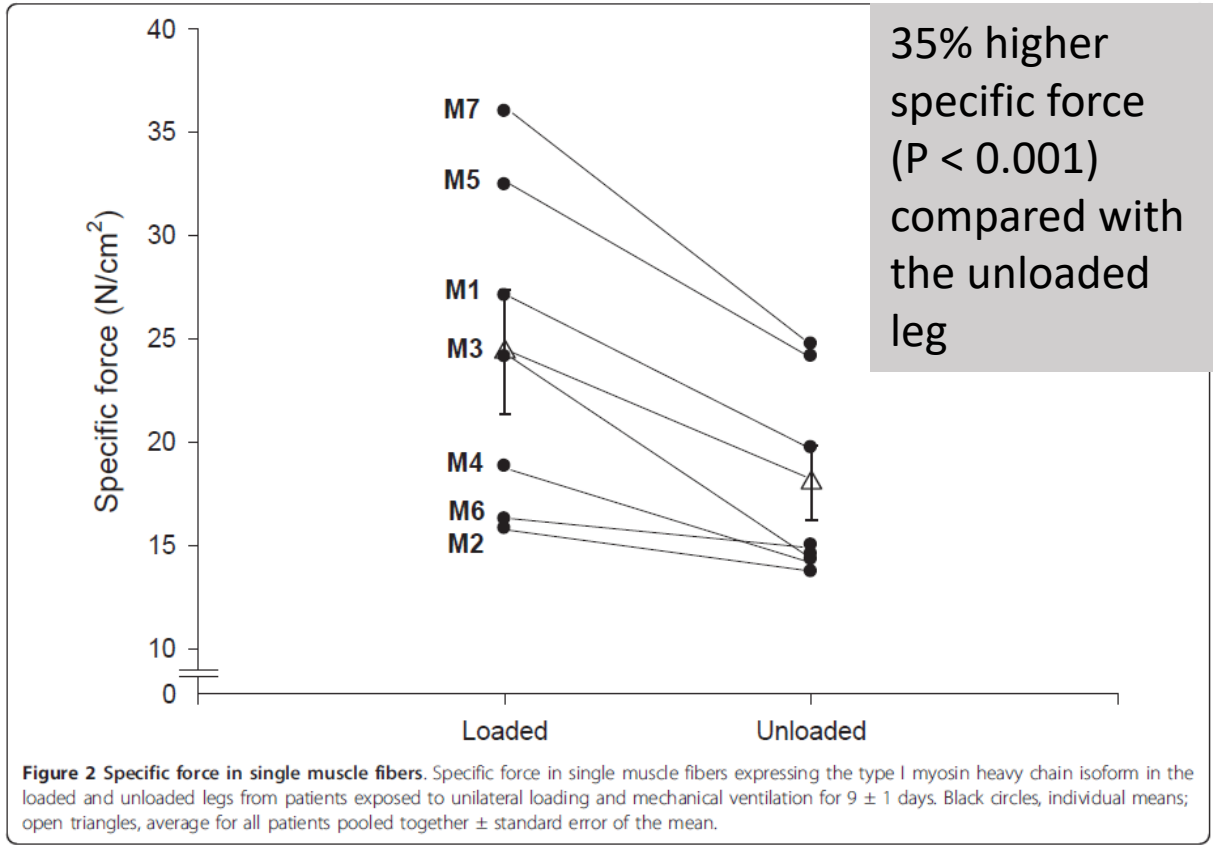
Ultrasound measurements of tibialis anterior cross-sectional area.



no effect in the prevention of the loss of muscle mass

Figure 1 Ultrasound measurements of tibialis anterior cross-sectional area. (**A**) Relative cross-sectional area (CSA) during the intervention period (9 ± 1 days). Solid line, loaded side; dashed line, unloaded side. Values are mean ± standard error of the mean (SEM). The value at day 1 is equivalent to 100%. (**B**) Relative CSA decline in the loaded leg (black bars) and the unloaded leg (white bars) for each ICU patient on the final day of the intervention, and mean ± SEM for all patients.

Specific force in single muscle fibers.



35% higher specific force ($P < 0.001$) compared with the unloaded leg

Figure 2 Specific force in single muscle fibers. Specific force in single muscle fibers expressing the type I myosin heavy chain isoform in the loaded and unloaded legs from patients exposed to unilateral loading and mechanical ventilation for 9 ± 1 days. Black circles, individual means; open triangles, average for all patients pooled together ± standard error of the mean.

Llano-Diez et al. Critical Care 2012

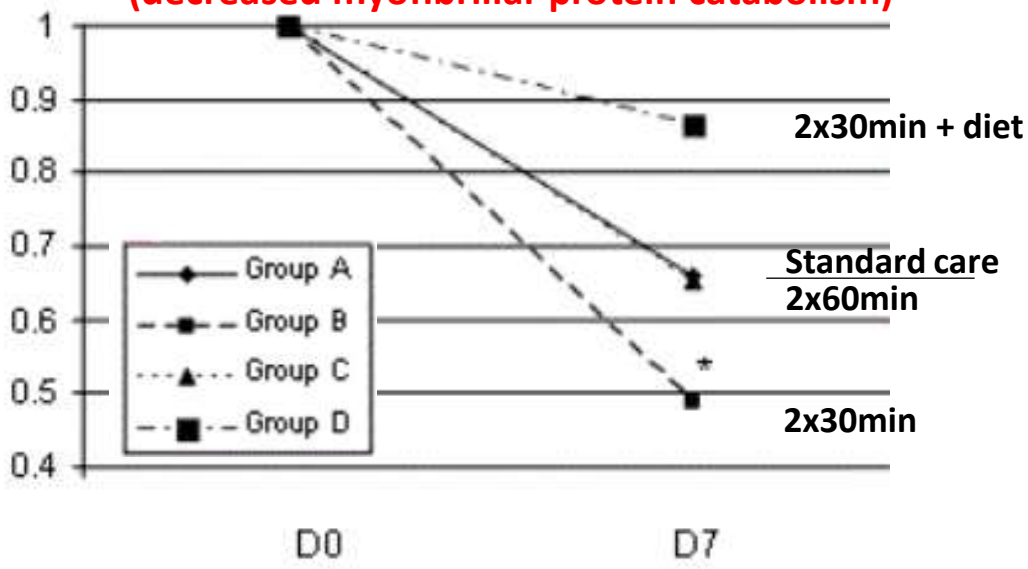
Passive Cycling Limits Myofibrillar Protein Catabolism in Unconscious Patients: A Pilot Study

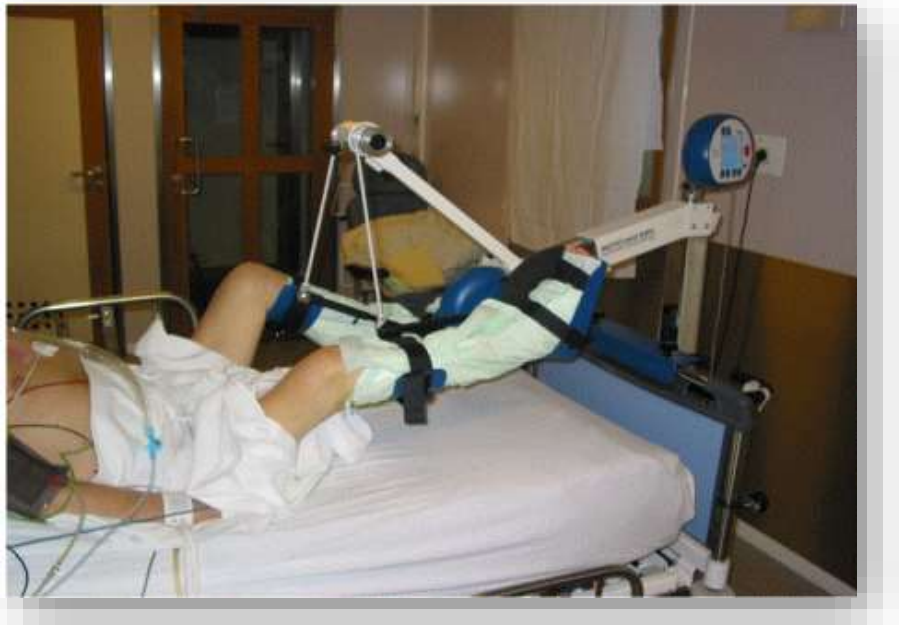
n = 27 patients: respiratory insufficiency with prolonged sedation (21 neuro)
7 days (whitout neuromuscular blockade)

- Standard care (n=8)
- Passive cycling **2x30 min** (n=7)
- Passive cycling **2x60 min** (n=6)
- Passive cycling **2x30 min + hypercaloric hyperprotein diet** (n=6)

Muscle thickness by US = no changes
Electromyographic examination = no changes

Time course of the 3-methylhistidine/creatinine ratio
(decreased myofibrillar protein catabolism)



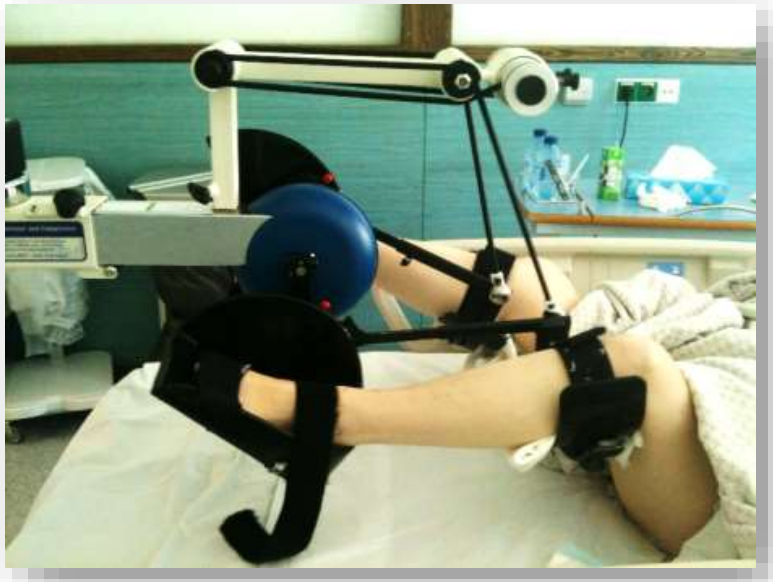


Preiser JC, et al., J Nov Physiother 2014

Effects that passive cycling exercise have on muscle strength, duration of mechanical ventilation, and length of hospital stay in critically ill patients: a randomized clinical trial

38 patients on MV: control (n = 16) conventional physical therapy
intervention (n = 22) **Passive cycling exercise**

First assessment (by the MRC scale): days 2.5 days in both groups
Second assessment at ICU discharge ~2 weeks



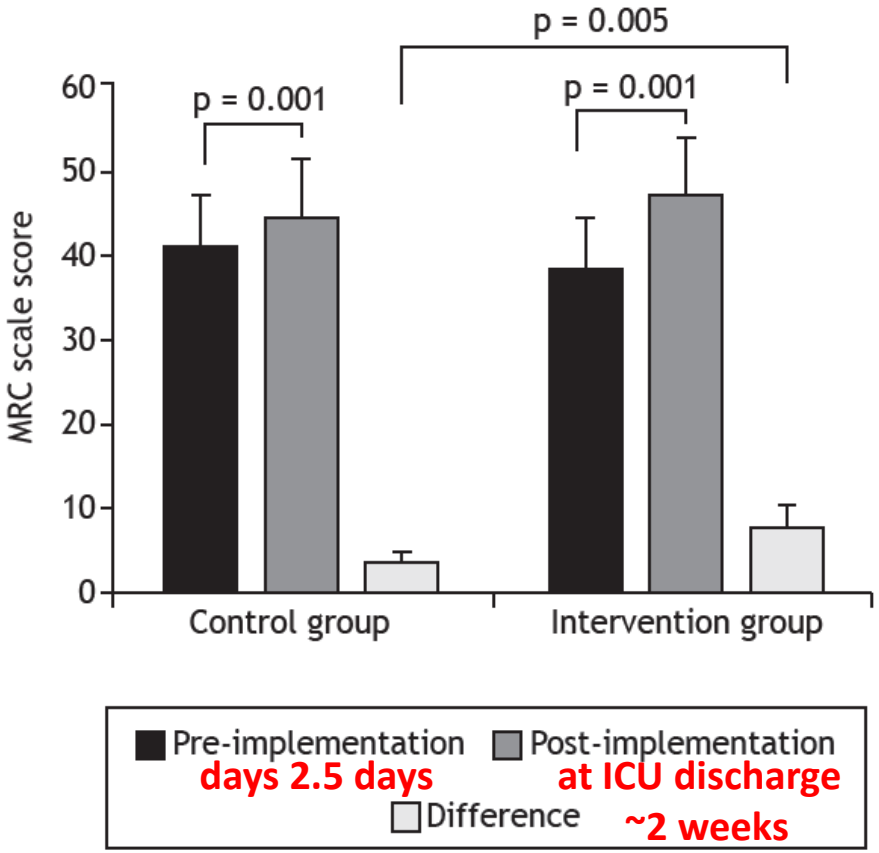


Figure 2. Peripheral muscle strength, as measured by the Medical Research Council (MRC) scale, before and after the implementation of the study protocol. Student's t-test.

Machado AS, J Bras Pneumol. 2017

Electrical muscle stimulation prevents critical illness polyneuromyopathy: a randomized parallel intervention trial

n= 52 ICU patients (APACHEII>13)

n= 24 in the EMS group

n= 28 in the control group.

EMS 55 min daily (from day-2 to ICU discharge)

- Higher MRC score at discharge
- Shorter weaning period
- Prevents the development of CIPNM

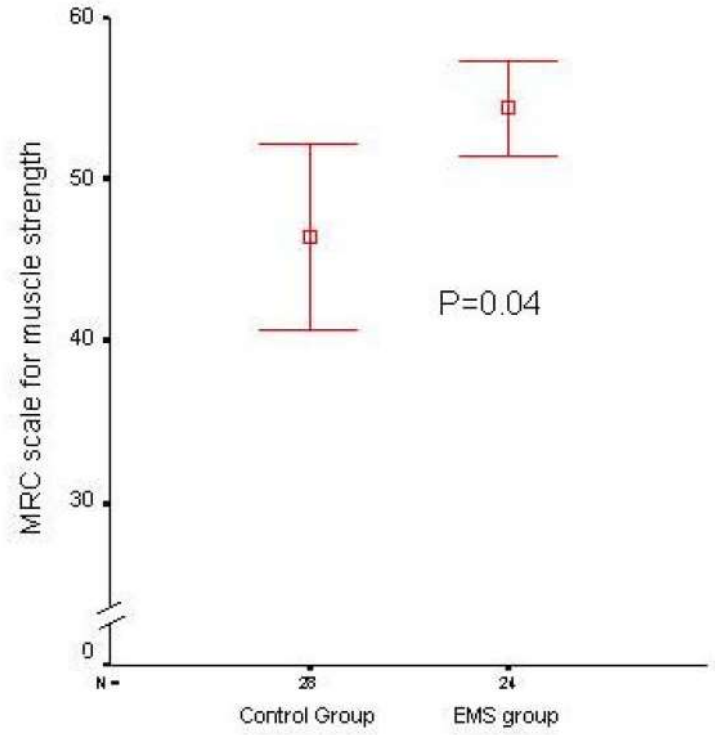


Figure 2 Difference in the MRC scale for muscle strength between patients assigned to the EMS group as compared with patients assigned to the control group (mean ± 2 standard errors). *P* = 0.04. EMS, electrical muscle stimulation; MRC, Medical Research Council.

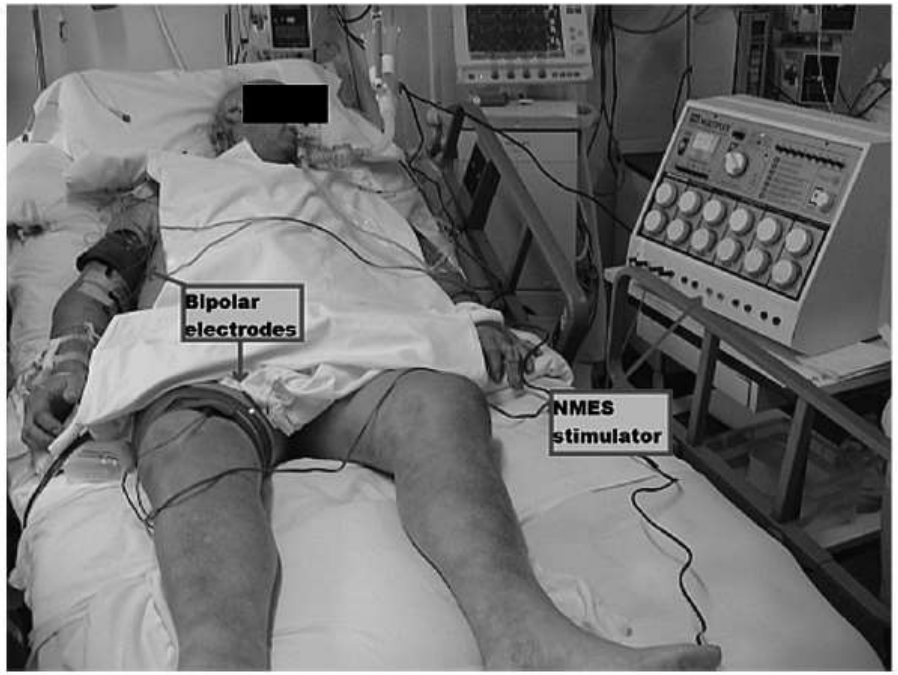
Table 2: Diagnosis of CIPNM in patients assigned to the EMS group as compared with patients assigned to the control group (*P* = 0.04)

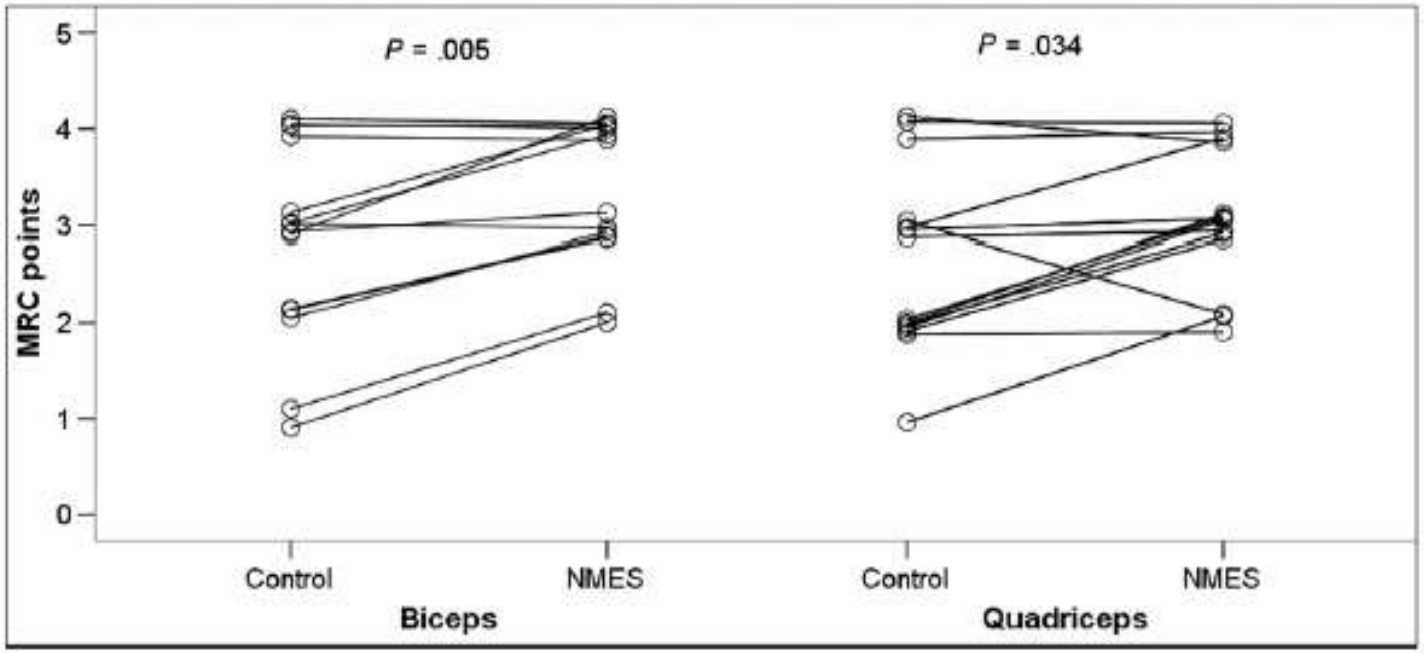
	EMS group (n) (%)	Control group (n)(%)	Total
CIPNM	3 (12.5)	11 (39.3)	14
	(OR = 0.22; CI: 0.05 to 0.92, *P* = 0.04).		
No CIPNM	21 (87.5)	17 (60.7)	38
Total	24	28	52

CIPNM, critical illness polyneuromyopathy; EMS, electrical muscle stimulation.

Routsi *et al. Critical Care* 2010

Muscle weakness in septic patients requiring mechanical ventilation: Protective effect of transcutaneous neuromuscular electrical stimulation☆





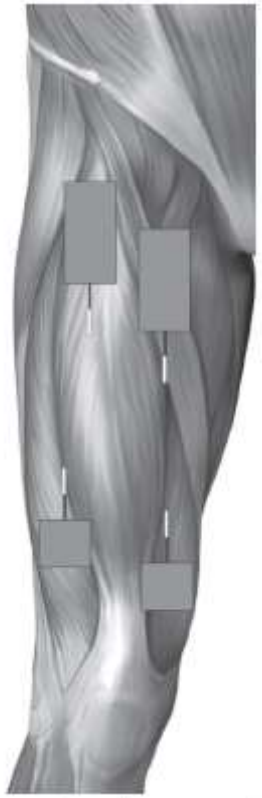
n= 16 septic patients
EMS 30 min twice at day, one side:
- ✓ Vastus medialis
- ✓ Brachial biceps

For 13 days (IQR, 7-30)
Start: day 2 (IQR, 1-2) after ICU admission

- ✓ Biceps (P = .005) and quadriceps (P = .034) strengths were significantly higher on the stimulated side
- ✓ Improvement mainly observed in more severe and weaker patients
- ✓ Arm circumference decreased only in non stimulated side

Rodriguez PO, Journal of Critical Care, 2012

Effect of transcutaneous electrical muscle stimulation on muscle volume in patients with septic shock*



n= 8 ICU patients with septic shock
EMS 60 min per day (7 days)
Start: 72h of sepsis diagnosis
Mean intensity 30-40 mA

Loss of muscle mass was unaffected by EMS

No increases in plasma levels of creatinine kinase or myoglobin were observed

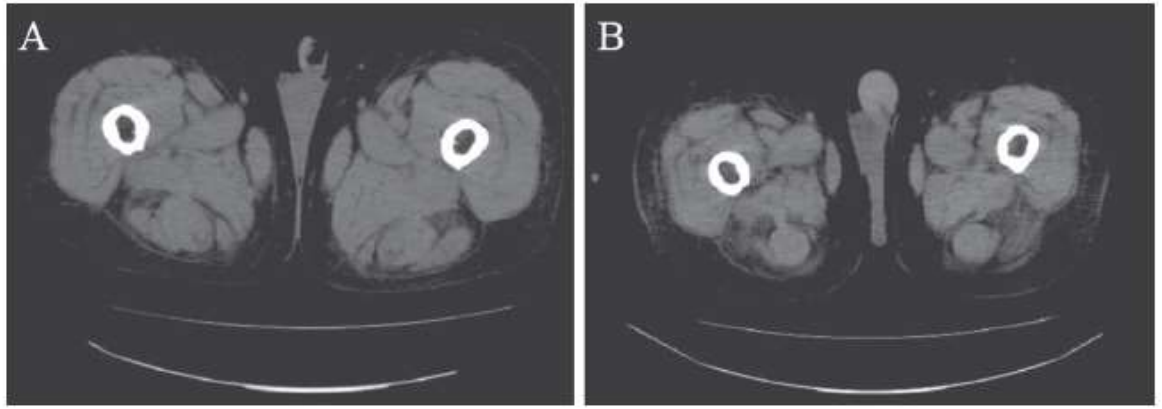


Figure 2. Computed tomographic scans of the thigh in a patient with septic shock at baseline (*A*) and 7 days later (*B*) showing the changes in muscle volume.

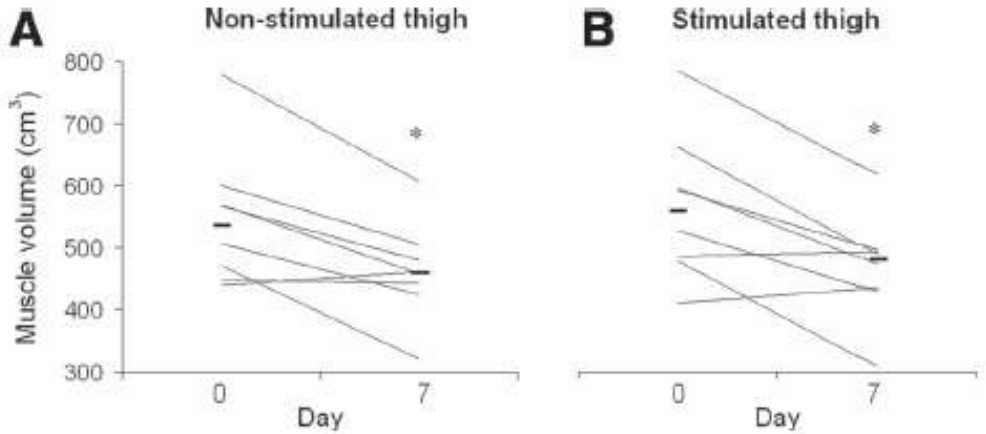


Figure 3. Quadriceps muscle volume in individual patients (bars represent medians) from start of intervention at day 0 to day 7 in the nonstimulated (*A*) and stimulated leg (*B*). *$p < .05$ vs. the same group at baseline. No significant differences were observed between groups.

Poulsen JB, Critical Care Med, 2014

Early neuromuscular electrical stimulation reduces the loss of muscle mass in critically ill patients – A within subject randomized controlled trial

n = 47 medical/surgical ICU
7 days of unilateral NMES
mean intensity **75mA**

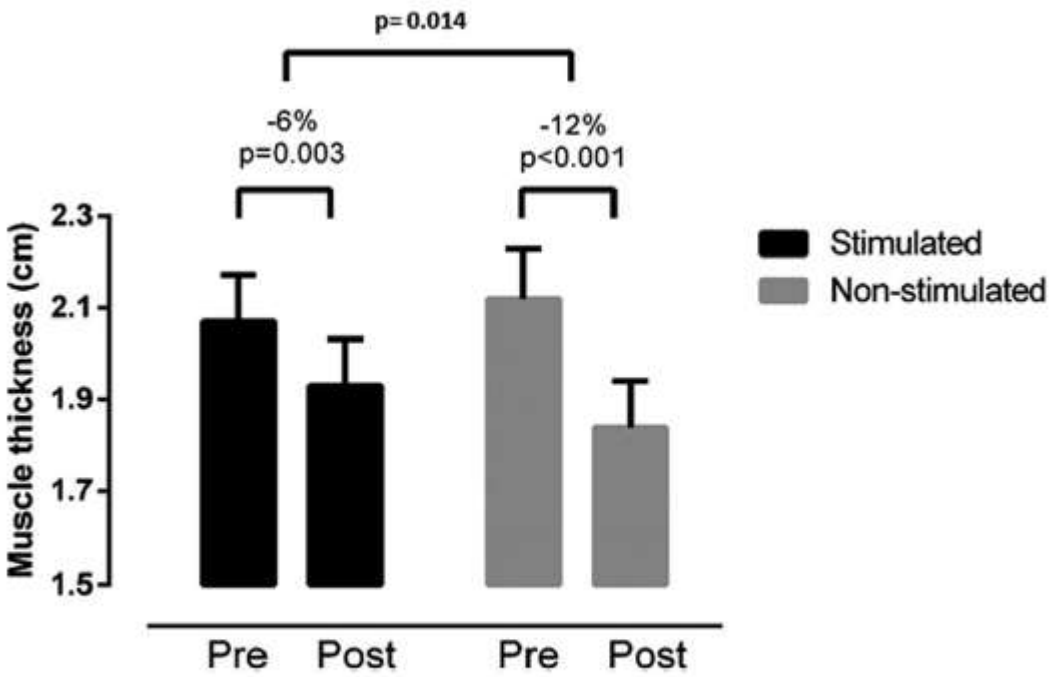


Fig. 2. Quadriceps muscle thickness assessed with ultrasonography before and after the intervention period. The bar represents the mean, the whisker the standard error of the mean (n = 47).

Table 3
Multivariable analysis identifying factors associated with the difference in muscle loss between stimulated and non-stimulated muscle.

Factors included in the multivariable analysis	Unstandardized β	p
Edema*	−4.068	0.398
Administration of vasopressors*	−5.907	0.250
Sepsis*	2.062	0.666
Administration of opioids*	10.931	0.018
Type of contraction, good*	−11.933	0.027
Muscle thickness change in non-stimulated muscle**	−16.383	0.006

- Prevent atrophy by US
- No differences in muscle strength (n=18 cooperative patients)

Patients with the worst type of contraction were the more beneficiated with the intervention.

- No effect of NMES on necrosis or inflammation in the muscles

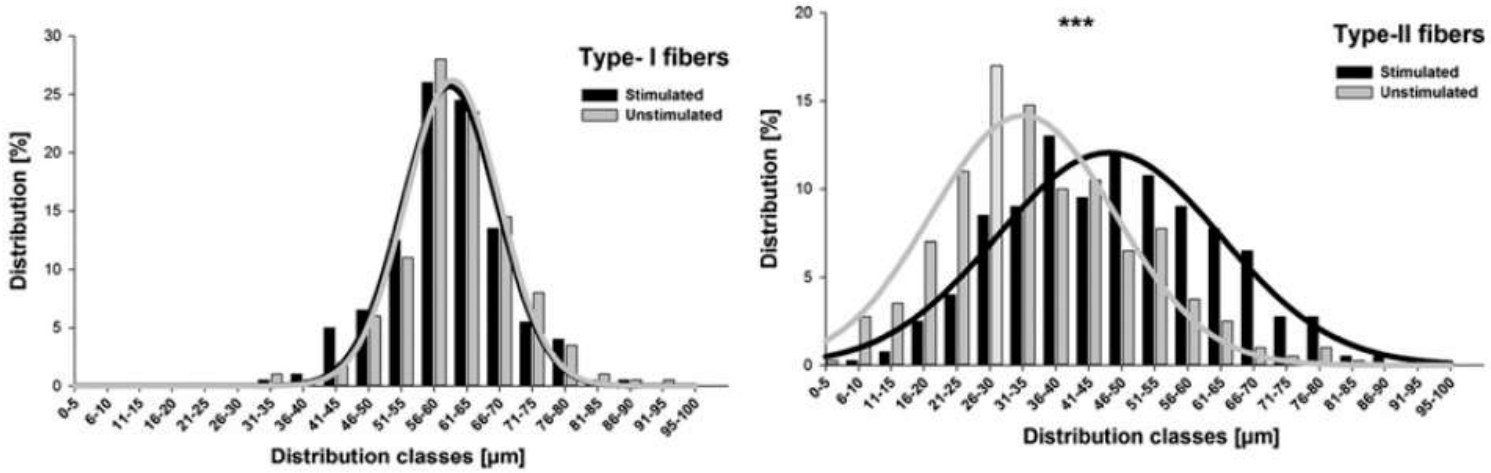
J. Segers, et al. Journal of Critical Care 2021

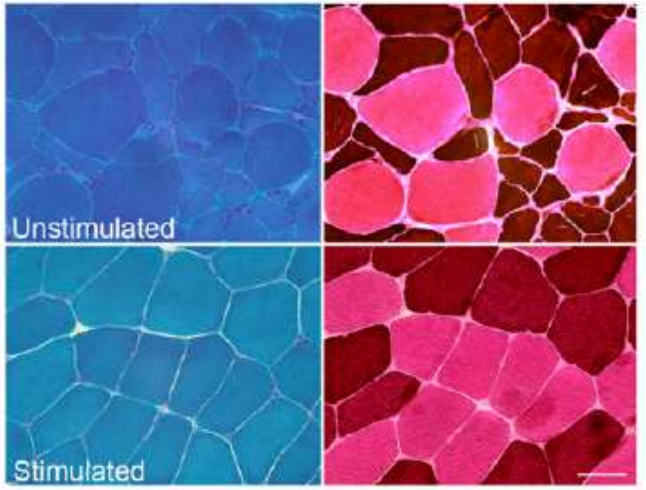
Critical Illness Myopathy and GLUT4

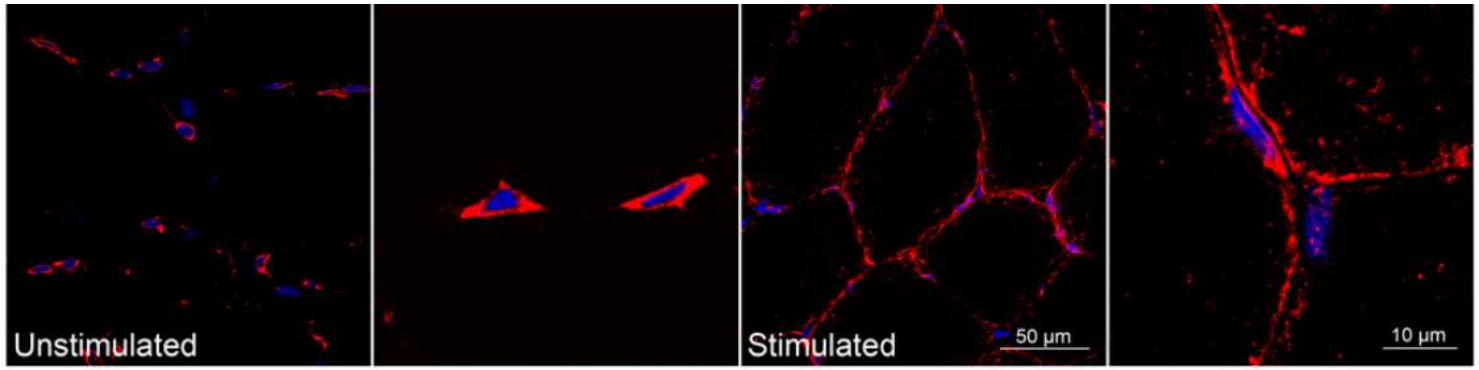
Significance of Insulin and Muscle Contraction

Electrical muscle stimulation

n=4, ARDS and sepsis







(GLUT4, red; nuclei, blue)

EMS may:

- Diminish protein breakdown
- Prevent muscle-specific AMPK failure
- Restore GLUT4 disposition

Weber-Carstens S, et al. AJRCCM 2013

USE OF NEUROMUSCULAR ELECTRICAL STIMULATION TO PRESERVE THE THICKNESS OF ABDOMINAL AND CHEST MUSCLES OF CRITICALLY ILL PATIENTS: A RANDOMIZED CLINICAL TRIAL

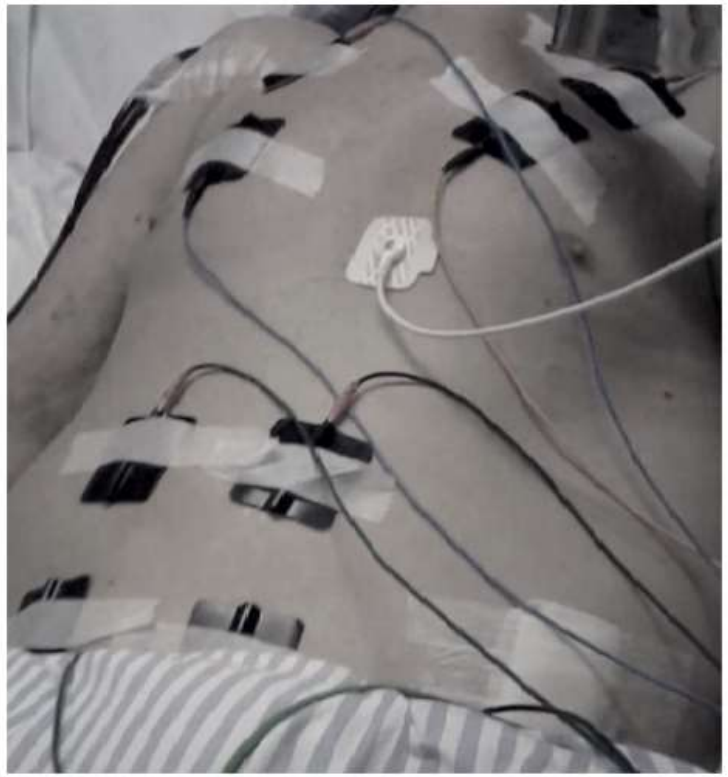


Fig. 2. Representative image of the positioning of electrodes on the straight muscles of the abdomen and chest to perform the protocol.

n = 11 patients **EMS** + conventional PT
n = 14 patients sham + conventional PT
For ~5 days, 1 x 30 min
From first 48 h of MV

Chest muscle thickness

Abdominal muscle thickness

Intervention Group

Control Group

Thickness preservation

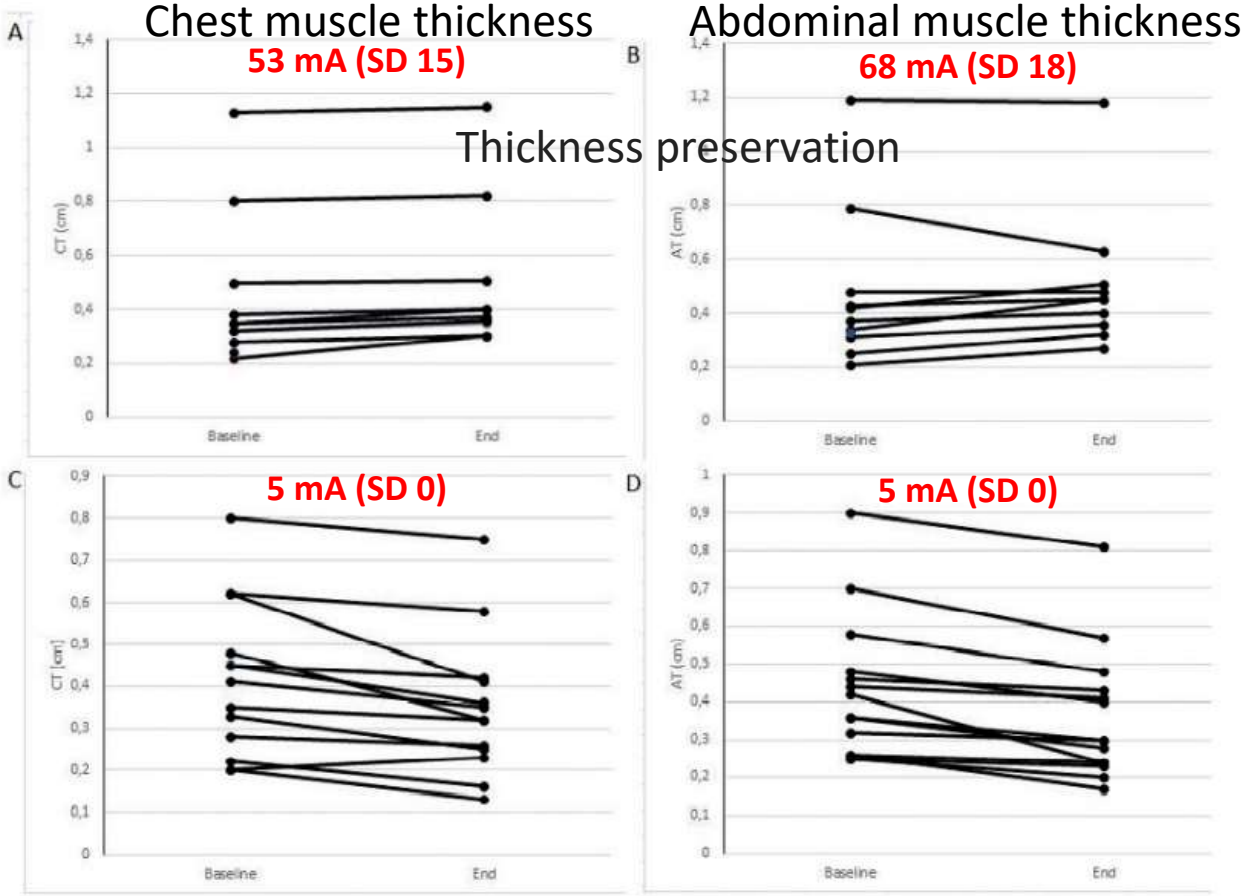
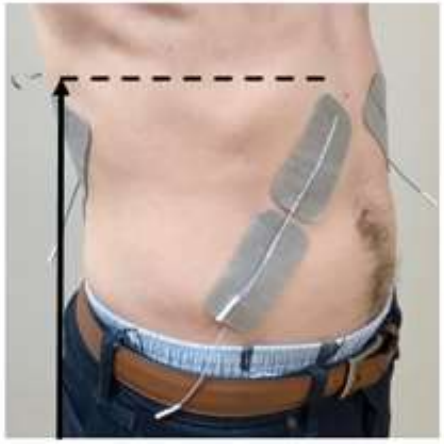


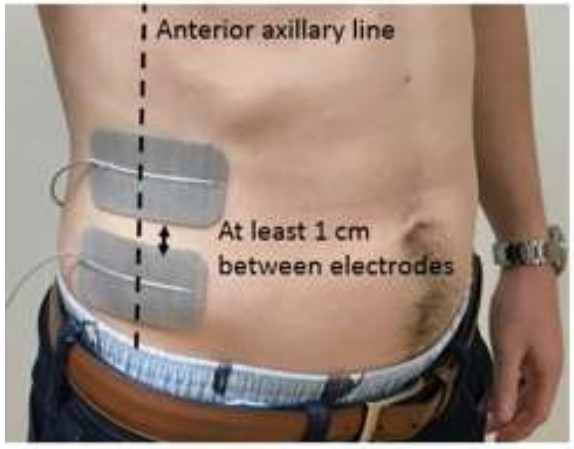
Fig. 4. Individual behaviour of the thickness of chest and abdominal muscles at baseline and at the end of the study for each group. (A) Variation in chest muscle thickness (CT) in the intervention group. (B) Variation in abdominal muscle thickness (AT) in the intervention group. (C) Variation of CT in the control group. (D) Variation of AT in the control group.

↓ in length of stay in the ICU
= MV duration

A.M. Dall' Acqua et al. J Rehabil Med 49, 2017

Breath-synchronized electrical stimulation of the expiratory muscles in mechanically ventilated patients: a randomized controlled feasibility study and pooled analysis





n = 10 patients= **breath-synchronized EMS** (60-100mA)
n = 10 patients= sham (10mA)
expiratory muscle FES (30 min, twice daily, 5 days/week until weaned)

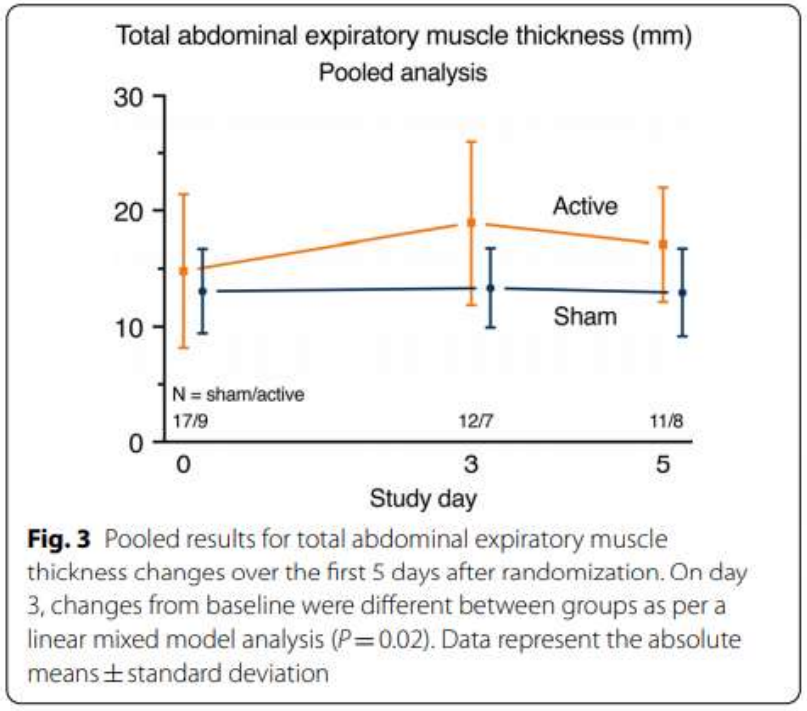


Fig. 3 Pooled results for total abdominal expiratory muscle thickness changes over the first 5 days after randomization. On day 3, changes from baseline were different between groups as per a linear mixed model analysis ($P = 0.02$). Data represent the absolute means ± standard deviation

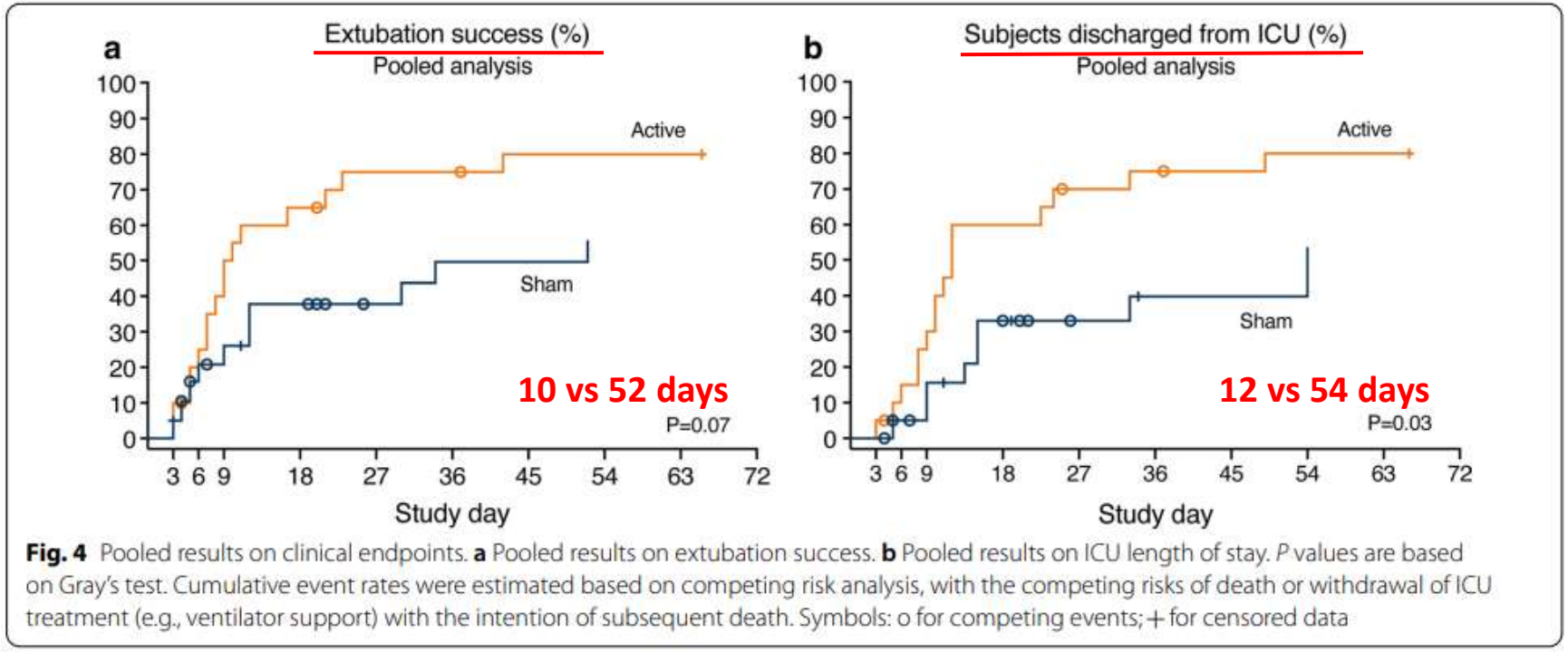


Fig. 4 Pooled results on clinical endpoints. **a** Pooled results on extubation success. **b** Pooled results on ICU length of stay. *P* values are based on Gray's test. Cumulative event rates were estimated based on competing risk analysis, with the competing risks of death or withdrawal of ICU treatment (e.g., ventilator support) with the intention of subsequent death. Symbols: o for competing events; + for censored data

Early FES did not induce systemic inflammation (plasma cytokines levels)

Jonkman et al. Crit Care 2020

Addition of blood flow restriction to passive mobilization reduces the rate of muscle wasting in elderly patients in the intensive care unit: a within-patient randomized trial

metabolic accumulation

↑ anabolic growth factors

↑ protein synthesis through mTOR

↓ Myostatin

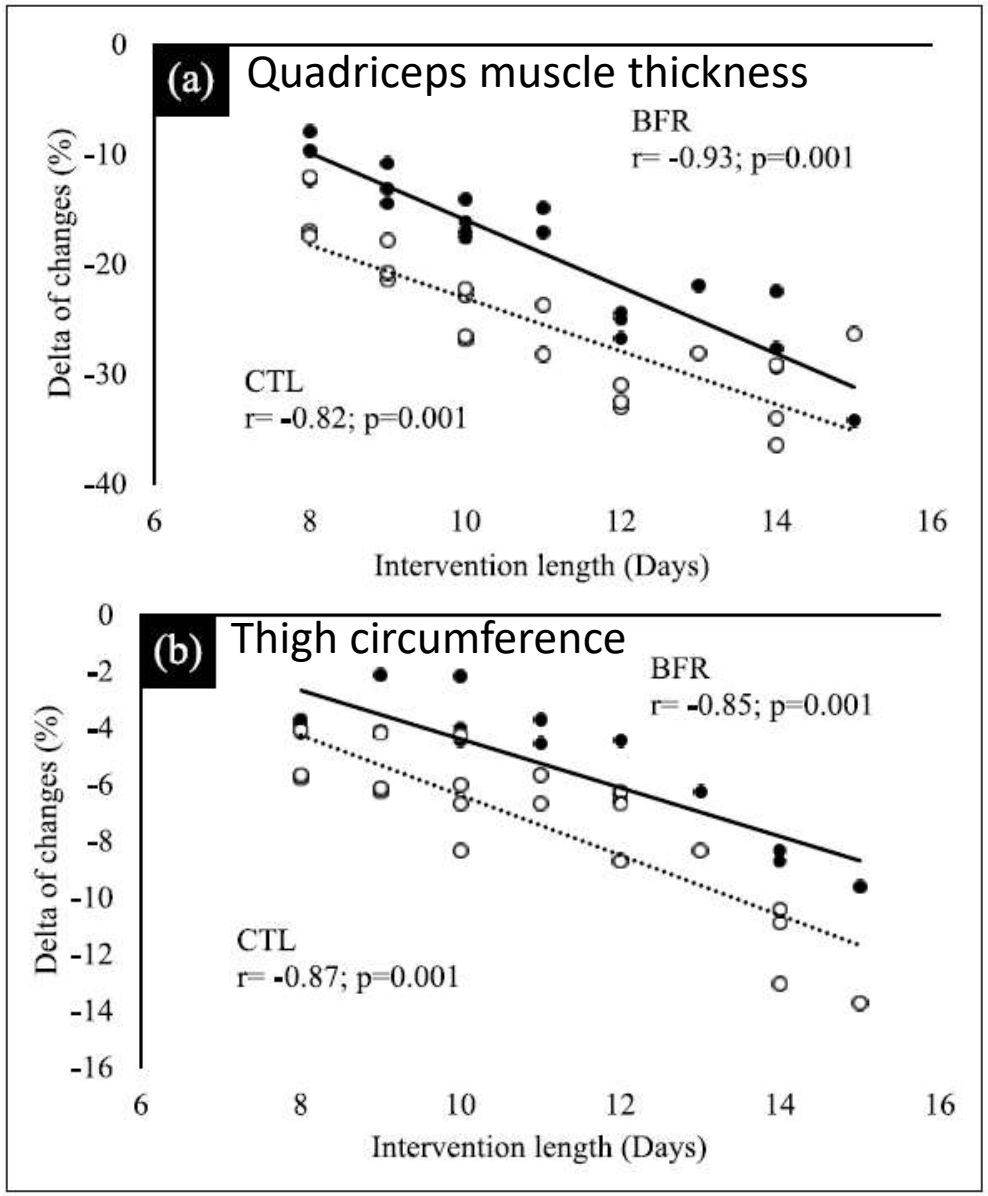
n = 20 ICU patients (age: 66 ± 4.3y)
every day during the ICU stay
US at ICU discharge

Control Leg:
Passive mobilization:
3x 15 knee flexion-extension

Intervention Leg:
Passive mobilization + blood flow restriction:
(80% of the patient's anterior tibial artery systolic blood pressure)

Cuff placed in the thigh's proximal region

Blood flow restriction prevented **6.5% of** muscle wasting



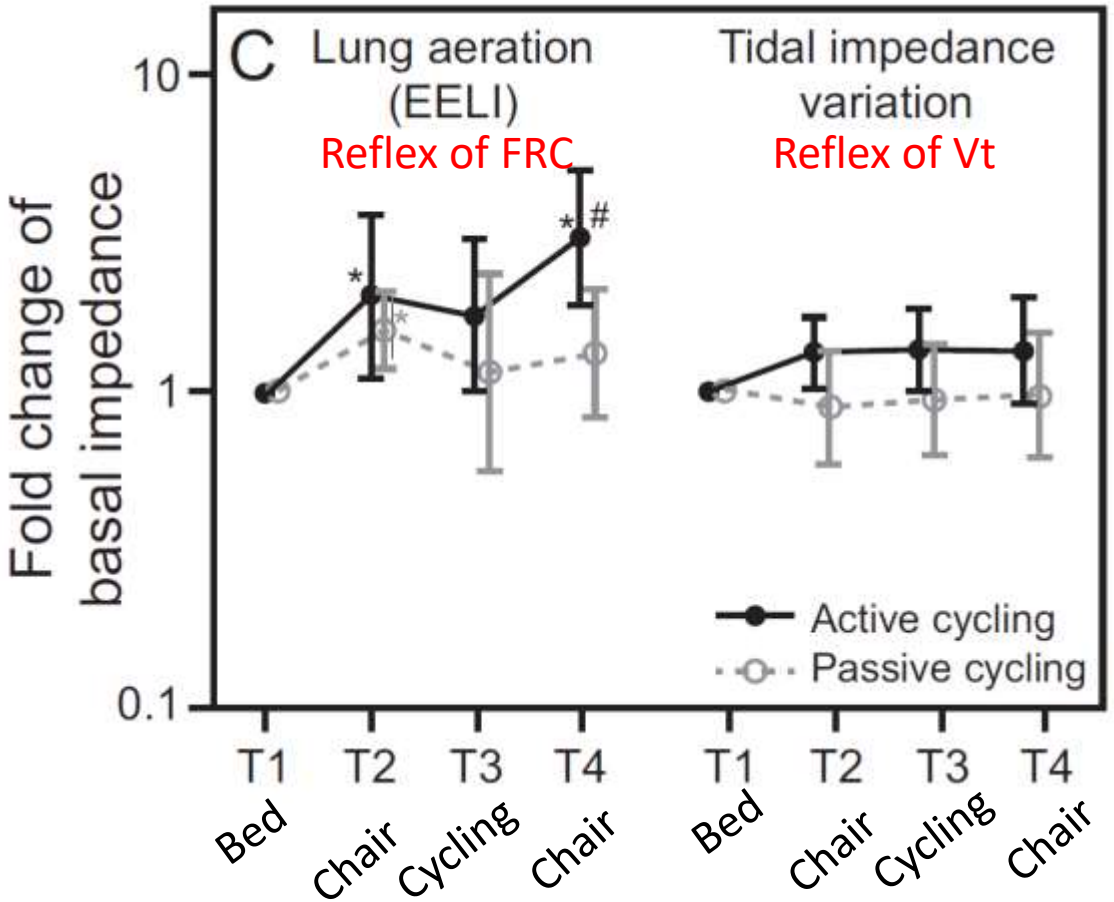
Barbalho et al. Resp Care (2021)

Acute Effects of Sitting Out of Bed and Exercise on Lung Aeration and Oxygenation in Critically Ill Subjects

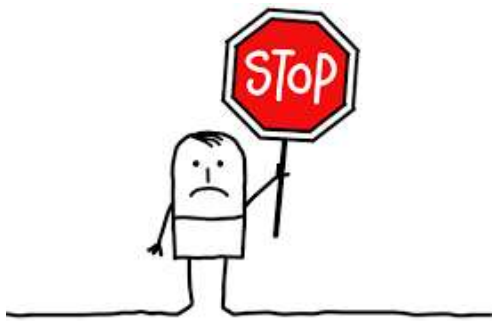
n=17 MV patients

n= 6, active chair-cycling

n= 11 passive chair-cycling



Hickmann CE et al. Resp Care (2021)



Limits?

Hodgson et al. Critical Care (2014) 18:658
DOI 10.1186/s13054-014-0658-y

CRITICAL CARE

RESEARCH Open Access

Expert consensus and recommendations on safety criteria for active mobilization of mechanically ventilated critically ill adults

Carol L Hodgson[1,2*], Kathy Stiller[3], Dale M Needham[4], Claire J Tipping[2], Megan Harrold[5], Claire E Baldwin[6,7], Scott Bradley[2], Sue Berney[8], Lawrence R Caruana[9], Doug Elliott[10], Margot Green[11], Kimberley Haines[8,12], Alisa M Higgins[1], Kirsi-Maija Kaukonen[1,13], Isabel Anne Leditschke[14,15], Marc R Nickels[16], Jennifer Paratz[17,18], Shane Patman[19], Elizabeth H Skinner[20,21], Paul J Young[22,23], Jennifer M Zanni[24], Linda Denehy[25] and Steven A Webb[1,26]

	Low risk of an adverse event. Proceed as usual according to each ICU's protocols and procedures.
	Potential risk and consequences of an adverse event are higher than green, but may be outweighed by the potential benefits of mobilization. The precautions or contraindications should be clarified prior to any mobilization episode. If mobilized, consideration should be given to doing so gradually and cautiously.
	Significant potential risk or consequences of an adverse event. Active mobilization should not occur unless specifically authorized by the treating intensive care specialist in consultation with the senior physical therapist and senior nursing staff.

Comparison of exercise intensity during four early rehabilitation techniques in sedated and ventilated patients in ICU: a randomised cross-over trial

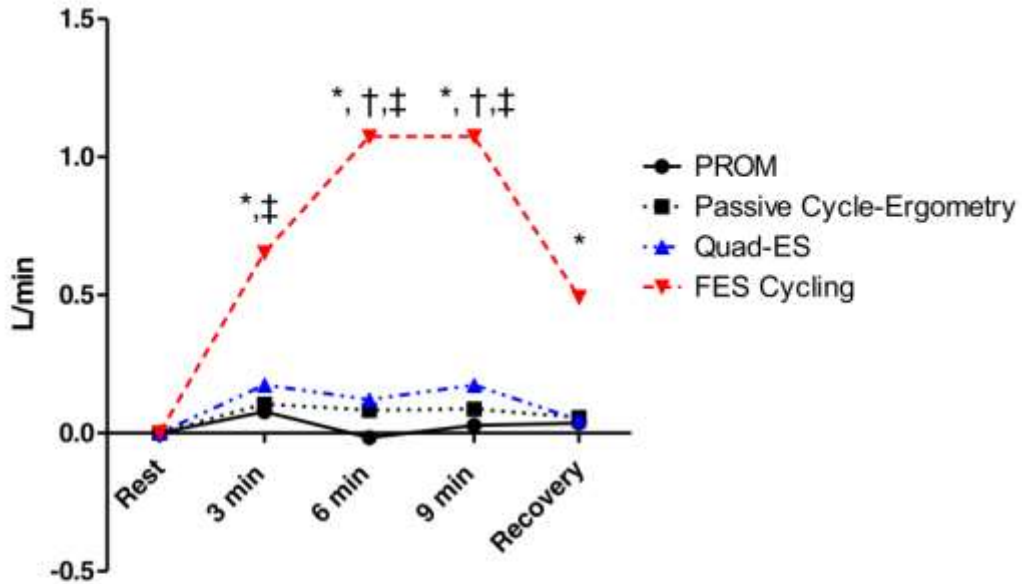
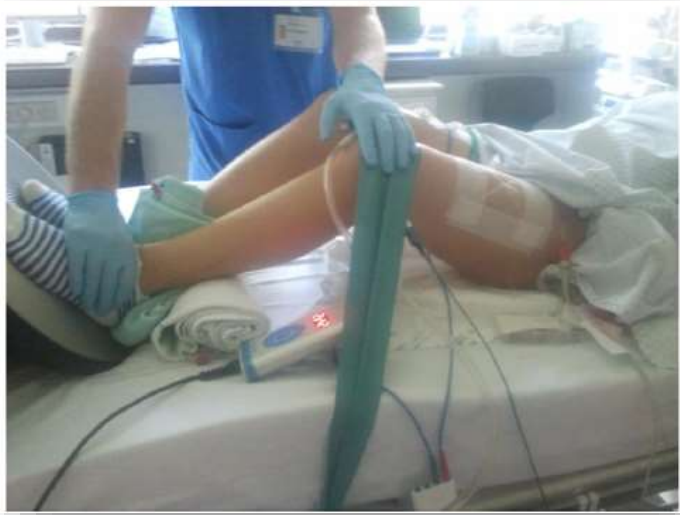


Fig. 2 Cardiac output over time for each exercise. Black circles represent passive range of leg movement (PROM); black squares represent passive cycle-ergometry; blue triangles represent quadriceps electrical stimulation; red triangles represent functional electrical stimulation cycling (FES-Cycling). *Significantly different between PROM and FES-Cycling; †significantly different between passive cycle-ergometery and FES-Cycling; ‡significantly different between quadriceps electrical stimulation and FES-Cycling

Medrinal C. et al. Crit Care 2018

Whole-body vibration t
care unit-acquired weal
feasibility, and metabol

>1000 muscle contraction/min



N= 16 patients
Longitudinal study:
- Baseline
- PROM
- Whole-body vibration
- Rest

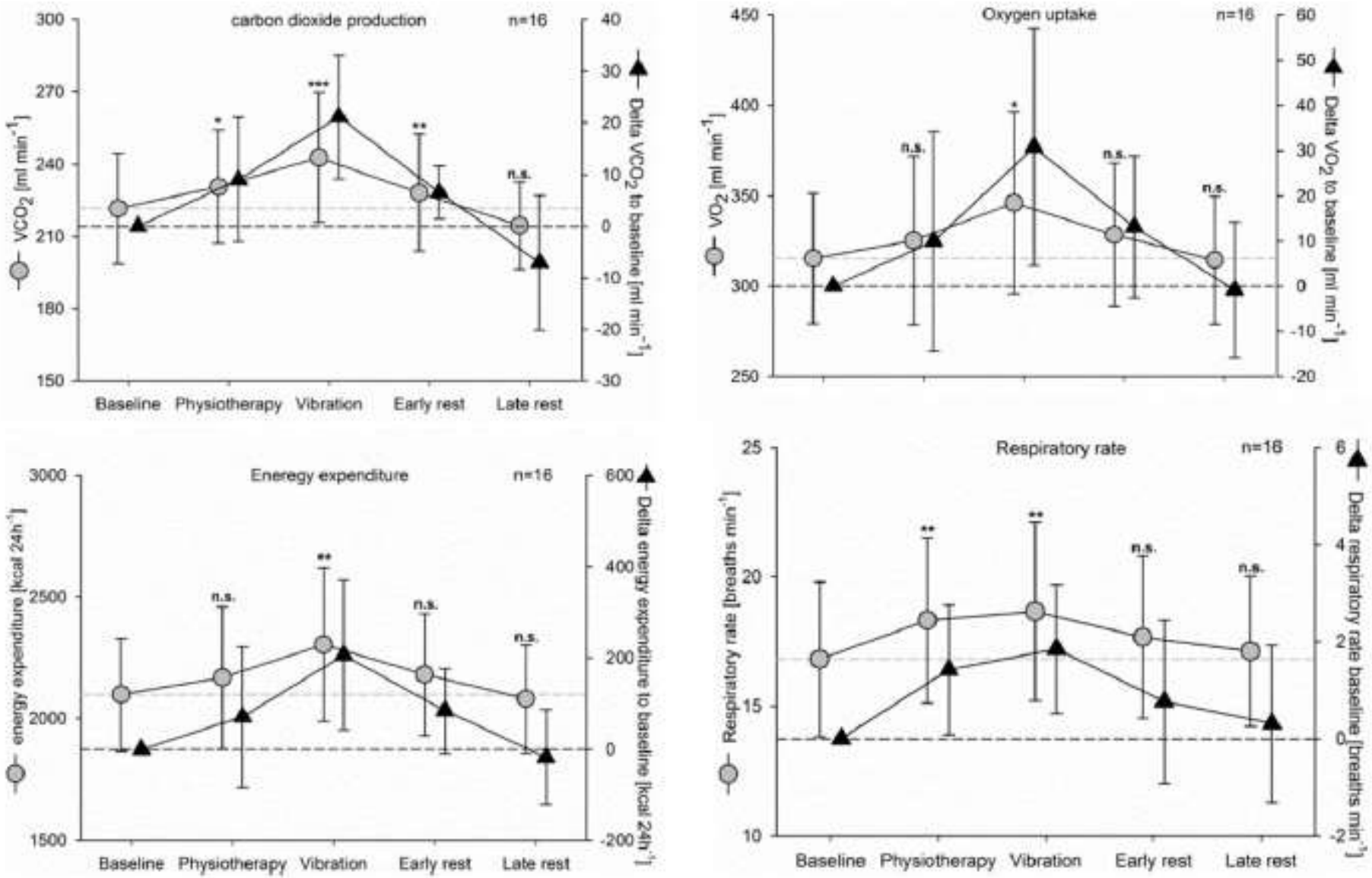
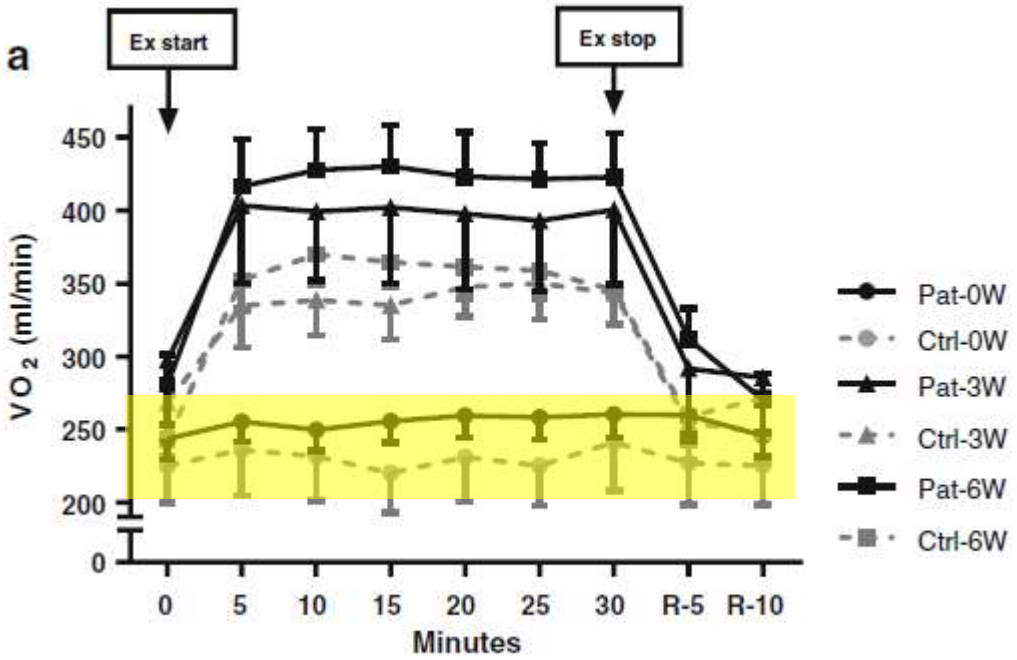


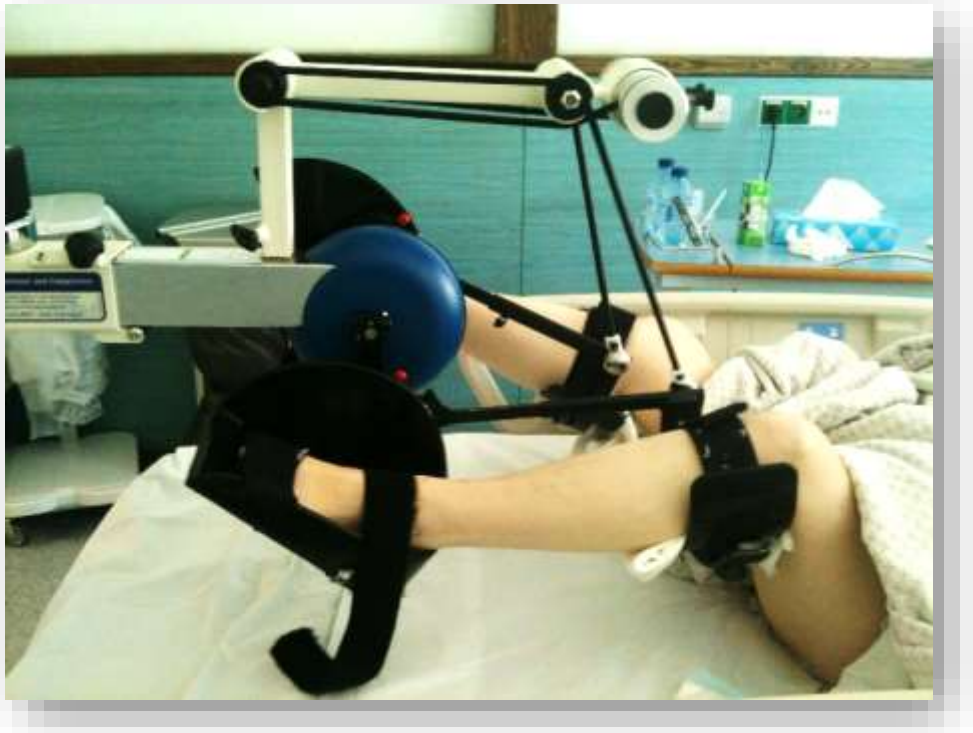
Fig. 4 Energy metabolism measurements for longitudinal observation.

Wollersheim et al. Critical Care (2017)

Energy expenditure in the critically ill performing early physical therapy

Pat-6W (n = 17)
Pat-3W (n = 7)
Pat-0W (n = 15) → 13 MV patients
14 patients with sepsis/septic shock
Continuous Indirect Calorimetry





No change in VO2 during 30 min passive bed cycling was observed

Hickmann CE. Intensive Care Med 2014

Short-term effects of passive mobilization on the sublingual microcirculation and on the systemic circulation in patients with septic shock

Tuanny Teixeira Pinheiro, Flávio Geraldo Rezende de Freitas*, Karla Tuanny Fiorese Coimbra, Vanessa Marques Ferreira Mendez, Heloísa Baccaro Rossetti, Paulo Vinicius Talma, Antônio Tonete Bafi and Flávia Ribeiro Machado

n = 35 septic shock patients.

PROM: 20 min of passive movements
30 movements per minute (digital metronome)

PROM was not associated with relevant changes in sublingual microcirculation or systemic hemodynamics.

Table 2 Systemic hemodynamic and ventilation variables at baseline and after exercise

Variable	Baseline	After exercise	p value
HR (bpm)	95.6 ± 22.0	93.8 ± 22.0	0.040
MAP (mmHg)	75.0 (71.0–85.0)	74.0 (69.0–84.0)	0.859
CVP (mmHg)	9.3 ± 3.6	8.7 ± 3.2	0.077
CI (L/min m^2)	2.5 (1.7–3.6)	2.5 (1.7–3.3)	0.930
Lactate (mg/dL)	15.0 (12.0–24.0)	15.5 (11.7–23.5)	0.554
$SvcO_2$ (%)	73.4 ± 8.6	72.8 ± 9.3	0.315
ΔPCO_2 (torr)	5.3 ± 1.7	5.0 ± 2.1	0.450
Body temperature, (°C)	36.9 ± 1.1	36.7 ± 1.2	0.002
PaO_2 (torr)	91.0 (78.5–99.7)	93.3 (75.9–102.2)	0.973
$PaCO_2$ (torr)	40.1 (33.9–45.7)	39.7 (32.8–48.2)	0.977
Hb (g/dL)	9.7 (8.7–11.8)	10.2 (8.6–11.9)	0.493
BE	−4.2 ± 5.4	−4.0 ± 5.6	0.297

The results are expressed as the mean ± standard deviation or the median (25–75%). Paired t test or paired Wilcoxon test

HR, heart rate; MAP, mean arterial pressure; CVP, central venous pressure; CI, cardiac index; $SvcO_2$, central venous oxygen saturation; ΔPCO_2, carbon dioxide venoarterial gradient; PaO_2, arterial oxygen partial pressure; $PaCO_2$, carbon dioxide partial pressure; Hb, hemoglobin; BE, base excess

Pinheiro *et al. Ann. Intensive Care (2017) 7:95*

"Primum non nocere"

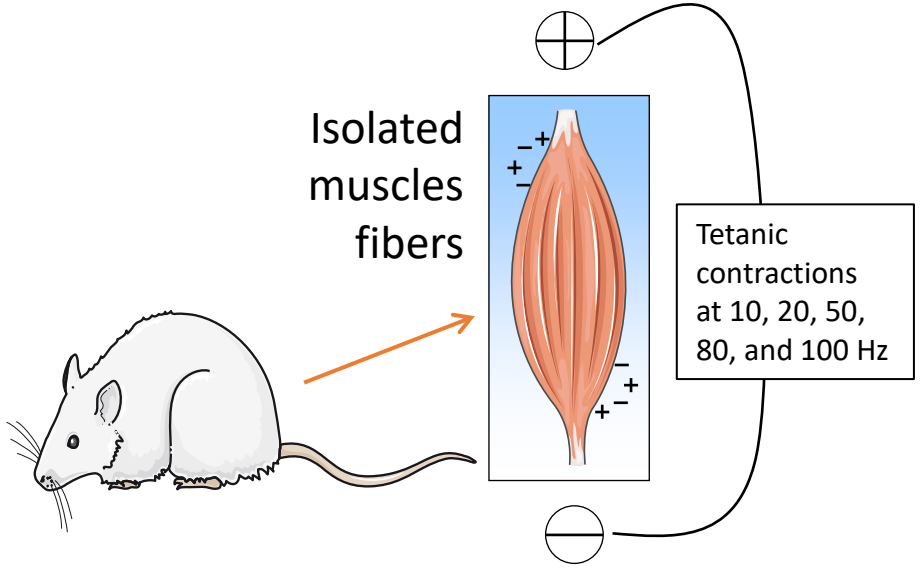
Sepsis-induced myopathy

Leigh Ann Callahan, MD; Gerald S. Supinski, MD

cle are well described; however, exercise increases cytokines and free-radical generation in muscle (86). In addition, Dumont et al recently showed that reloading muscles induces inflammatory cell infiltration and worsens sarcolemmal injury (87). As a result, it is conceivable that exercising patients with damaged muscles could potentially propagate muscle inflammation and injury, or delay recovery. Such issues should be carefully ex-

Callahan LA, *Crit Care Med* 2009

In vitro animal model



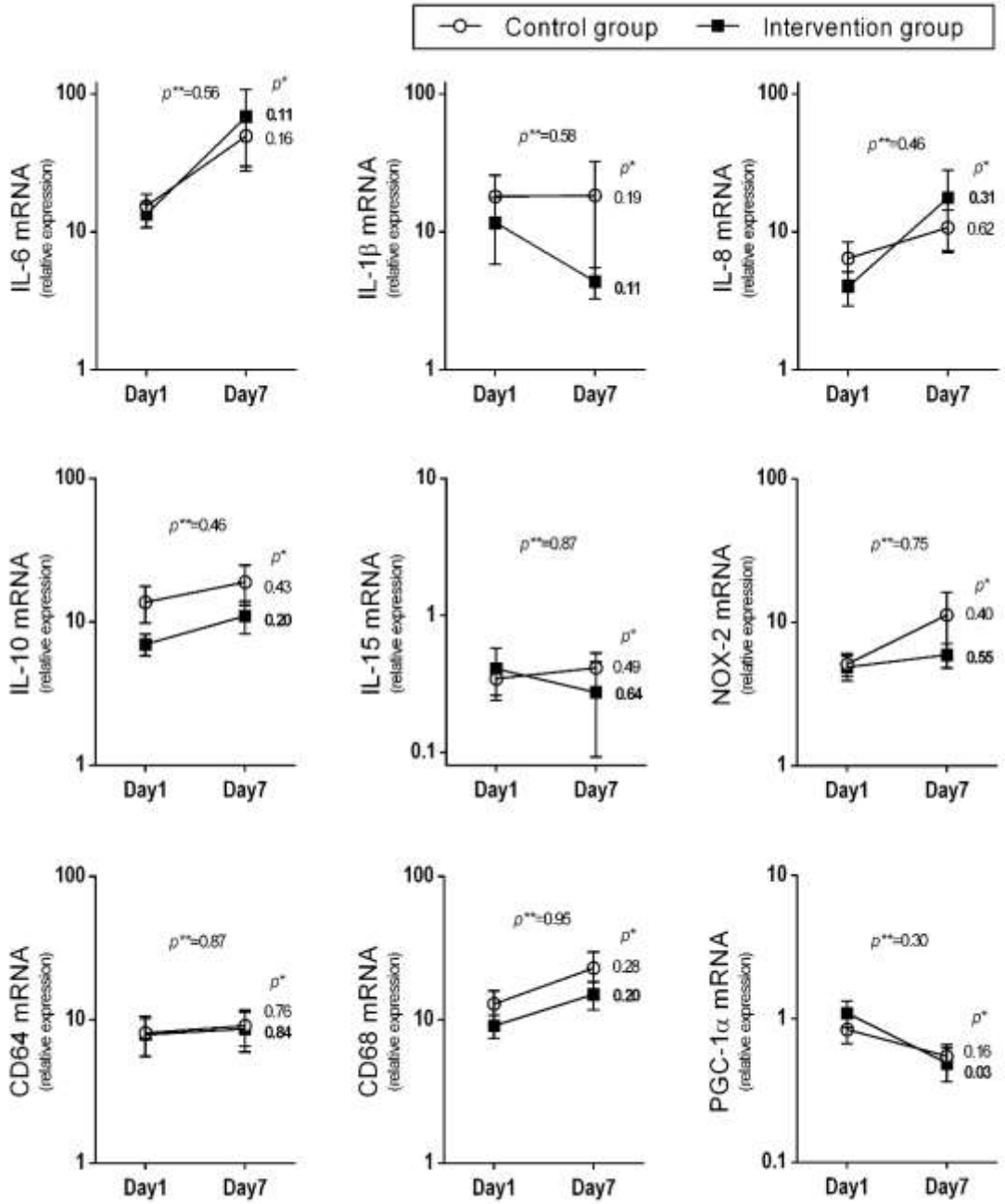
Dummond N, *Am J Physiol Regul Integr Comp Physiol*, 2008

Impact of Very Early Physical Therapy During Septic Shock on Skeletal Muscle: A Randomized Controlled Trial

Inflammation was not enhanced by early exercise

n= 19 septic shock patients
Starting <72h sepsis onset

CCM_46_9_2018_06_12_HICKMANN_CCMED-D-18-00124_SDC1.mp4; [Video] (98.75 MB)



Hickmann CE, *Crit care med 2019*

Oxidative stress and immune system analysis after cycle ergometer use in critical patients

19 MV patients:

Control (n = 10)

Cycle-ergometer (n = 9)

single session => 20 min at 30 cycles/min

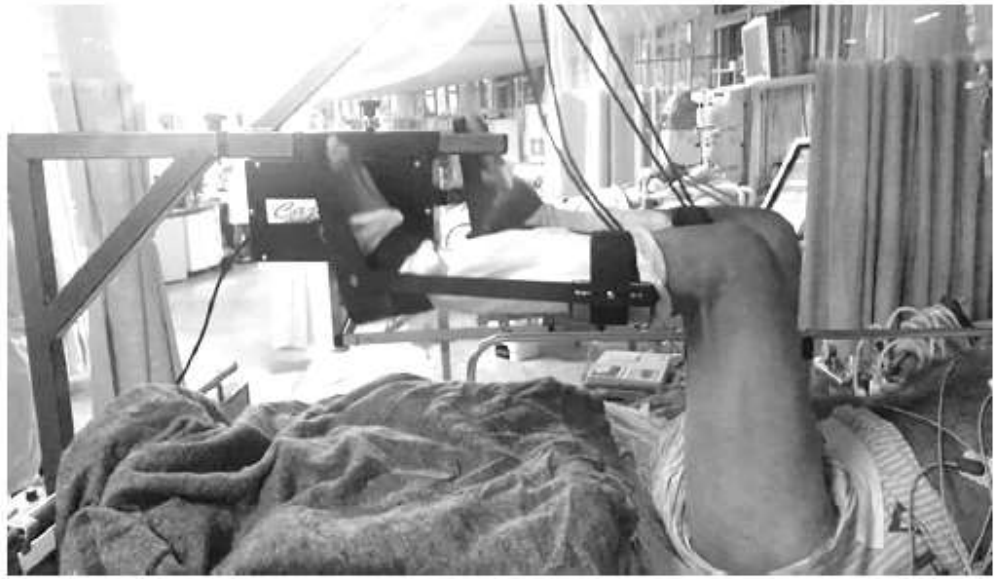
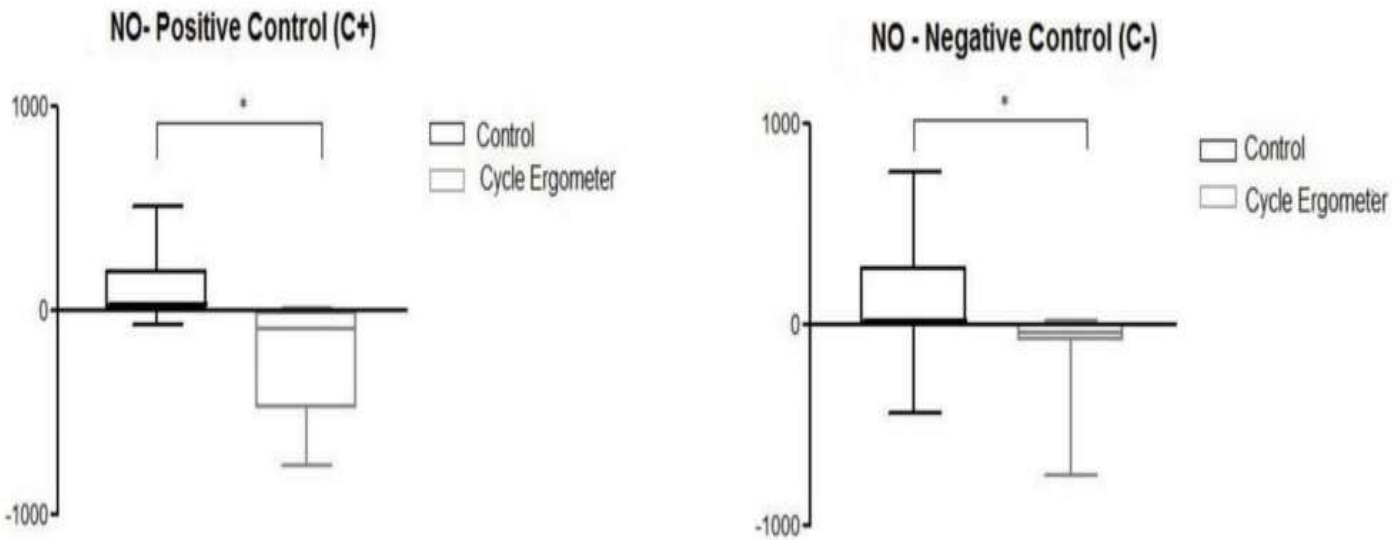


Figure 1. Illustration of the application of lower limb passive cycle-ergometry in critically ill patients under mechanical ventilation.



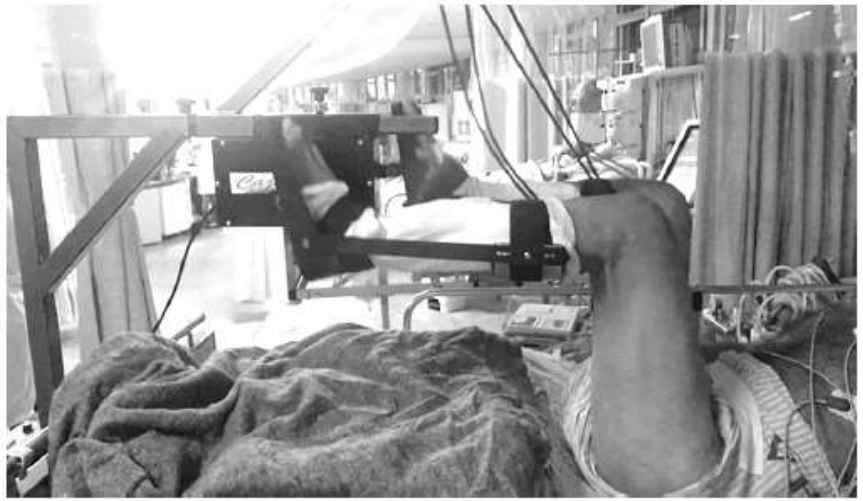
There was no significant difference between the values of TNF-a, IFN-g, IL-6 and IL-10 (before – after cycling)

Nitric oxide = oxidative stress

França EET et al. Clinics 2017

Acute effect of passive cycle-ergometry and functional electrical stimulation on nitrosative stress and inflammatory cytokines in mechanically ventilated critically ill patients: a randomized controlled trial

4 groups:
Control
PCE = Passive cycle-ergometry (20min, 30 cpm)
FES = Functional electrical stimulation (20min) **=> NEMS**
FES + PCE (20min+20min)



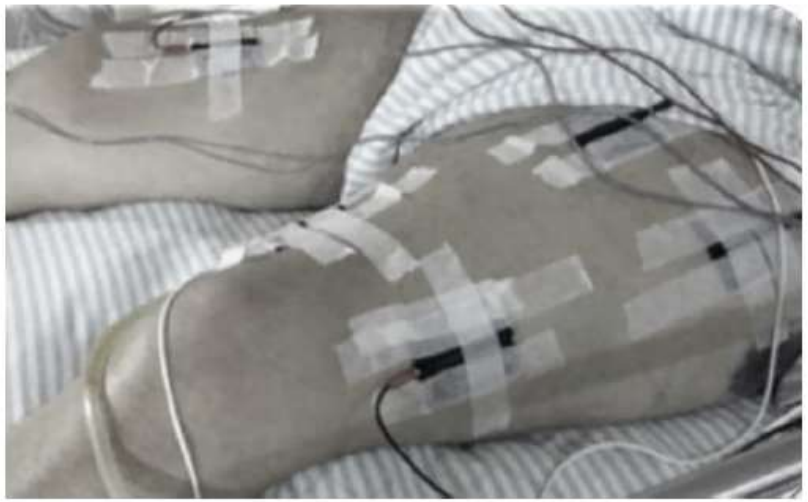


Table S1. Nitric oxide (NO) production in stimulated (C+) and non-stimulated (C-) monocytes assessed before and after applying the study protocol to the four groups.

Nitric oxide	Groups							
	Control (n=10)		FES (n=9)		FES + PCE (n=7)		PCE (n=9)	
	Before	After	Before	After	Before	After	Before	After
NO (C+) (μM)	10.78 ± 10.6	11.51 ± 12.4	8.19 ± 6.4	6.96 ± 5.4	12.95 ± 6.1	13.60 ± 7.1	20.82 ± 16.2	17.72 ± 16.7
	P=0.3123		P=0.0188*		P=0.2644		P=0.0002*	
NO (C-) (μM)	10.30 ± 9.9	11.84 ± 13.2	8.64 ± 6.7	7.49 ± 5.6	14.12 ± 8.5	15.25 ± 9.2	29.90 ± 23.7	18.72 ± 19.6
	P=0.2852		P=0.0258*		P=0.6743		P=0.0007*	

↓ TNF-α only after passive cycling

França E.E.T. , Braz J Med Biol Res 2020

Conclusion

- Passive movement is necessary when active movement is not possible or not allowed.
- Several benefits are described (prevention /maintain) => without muscle damage or inflammatory increase
- Novel techniques such as **FES**, **whole-body vibration**,

  or **passive mobility with blood flow restriction**

  promise us future therapeutic benefits!
- We need more evidence (dose, longer endpoints, specific populations…)