Techniques instrumentales

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Immobility-deconditioning

- 40-50% of human body weight is muscle
- ↘ in muscle strength 1-6% per day of strict bed rest
- Early development of atrophy
- Change in type or density of muscle fibers

ICU acquired weakness

Incidence

25- 60% of mechanically ventilated patients (5-7days) with sepsis, MOF, coma

Denehy L et al Int Care Med 2017

Effect of passive loading

- Early mobilization in deeply sedated or paralyzed ICU patients on mechanical ventilation has been shown to shorten ventilator and ICU days, to reduce health care costs as well as to improve QOL

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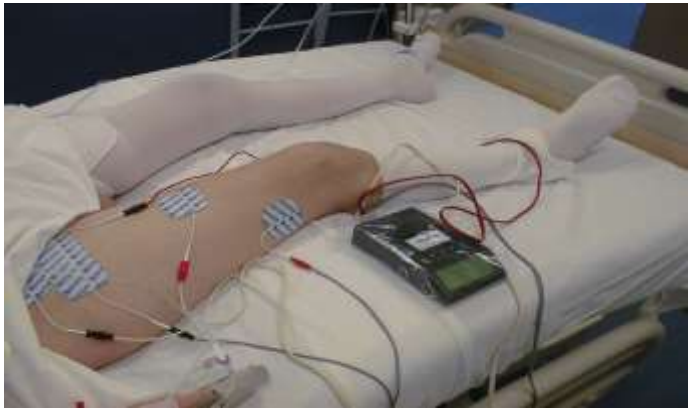
Electrical muscle stimulation

Table 1
Wet weight and relative mass of the tibialis anterior muscle.

	Cont	Den	Den+ES	HU	HU+ES
Body weight (g)	270 ± 15	256 ± 14	241 ± 11	215 ± 24*,†	208 ± 6*,†
Muscle wet weight (mg)	480 ± 35	272 ± 34*	360 ± 25*,†	372 ± 48*,†	381 ± 22*,†
Relative muscle mass (mg/g)	1.77 ± 0.09	1.06 ± 0.1*	1.5 ± 0.09*,†	1.73 ± 0.14†	1.79 ± 0.1†

Values are expressed as the mean ± SEM. Cont, control group; Den, denervation group; Den+ES, denervation plus electrical stimulation group; HU, hindlimb unloading group; HU+ES, hindlimb unloading plus electrical stimulation group.
* Significantly different from the Cont group at $P<0.01$.
† Significantly different from the Den group at $P<0.01$.



Overexpression of Calpain-1,-2 and ubiquitinated protein in denervated is inhibited by EMS, no ≠ in unloaded and unloaded + EMS

→ preventive effect of EMS ≠ denervated or unloaded

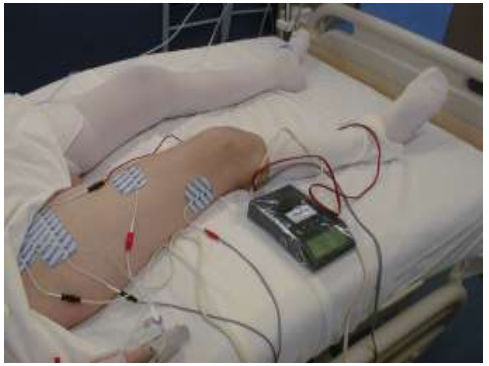
Matsumoto A et al Acta Histochemica 2014

Electrical muscle stimulation

1

		Responder	non-Responder	p-value
patients/stimulations (n)		8/702	13/1122	
Sex (m/f)		7/87.5% / 1/12.5%	9/69.2%/4/30.8%	0.340
Age (years)		56.0 [36.5/71.0]	53.0 [47.0/70.0]	0.645
Weight (kg)		80.0 [70.0/92,5]	92.0 [75.0/109.0]	0.301
Height (m)		1.80 [1.77/1.83]	1.76 [1.70/1.80]	0.500
BMI (kg/m²)		26.5 [22.6/29.0]	27.8 [25.5/33.6]	0.210
Diagnosis responsible for ICU admission	ARDS	2/25%	6/46.2%	0.118
	sepsis	0/0%	3/23.1%	
	multiple trauma	4/50%	3/23.1%	
	neurologic	2/25%	0/0%	
	miscellaneous	0/0%	1/7.7%	
SOFA at ICU admission		12.0 [9.5/13.5]	14 [12.0/16.0]	0.030
APACHE II at ICU admission		24.0 [17.0/27.0]	25.0 [23.0/29.0]	0.414
SAPS2 at ICU admission		43.0 [33.0/61.5]	61.0 [57.0/66.0]	0.089
GCS at ICU admission		5.5 [3.0/7.5]	3.0 [3.0/6.0]	0.456
Time until first awakening (days)		12.0 [7.5/15.5]	20.5 [10.0/42.0]	0.287
ICU length of stay (days)		28.0 [19.0/36.0]	39.0 [25.0/49.0]	0.185
Percent of days with RASS > -3 during ICU stay		50.2 [26.9/94.6]	71.4 [50.0/79.2]	0.750
Noradrenalin (µg/kg*min)		0.08 [0.03/0.10]	0.07 [0.06/0.11]	0.414
Time requiring noradrenalin (days)		12.0 [3.5/15.5]	12.0 [11.0/25.0]	0.595
Survivors/non-Survivors		7/87.5% / 1/12.5%	11/84.6% / 2/15.4%	0.854
Non-excitable muscle membrane/excitable muscle membrane		2/33.3% / 4/66.7%	5/62.5% / 3/37.5%	0.280
Start of NMES treatment after ICU admission (days)		3.0 (2.0/6.0)	4.0 (2.0/6.0)	0.750

2



Grunow J et al submitted Crit Care 2019

Review

Intervention effect of neuromuscular electrical stimulation on ICU acquired weakness: A meta-analysis

Miao Liu [a, b], Jian Luo [b, *], Jun Zhou [a], Xiaomin Zhu [a]

[a] School of Nursing, Yangtze University, Hubei, China
[b] Affiliated Union Hospital of Tongji Medical College, Huazhong University of Science and Technology, Hubei, China

International Journal of Nursing Sciences 7 (2020) 228–237

415 studies => 11 included

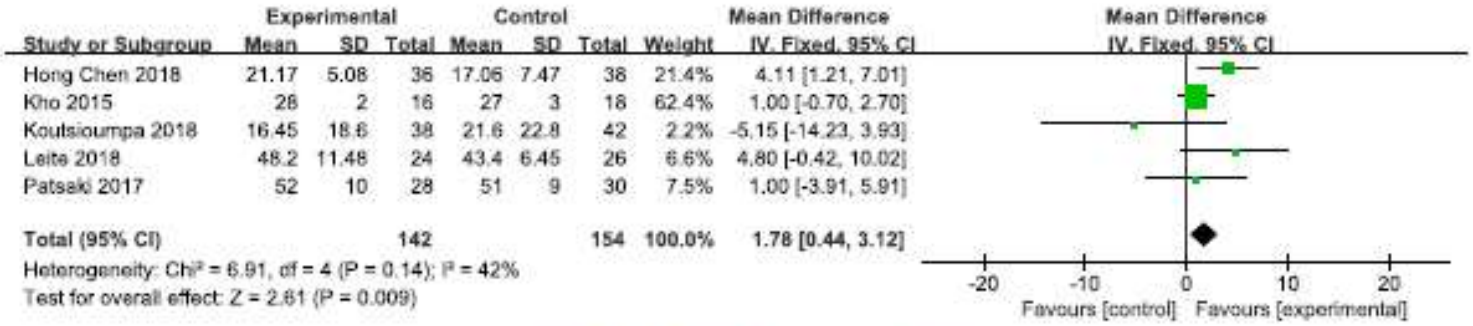


Fig. 3. Effects of NMES on muscle strength of ICU patients.

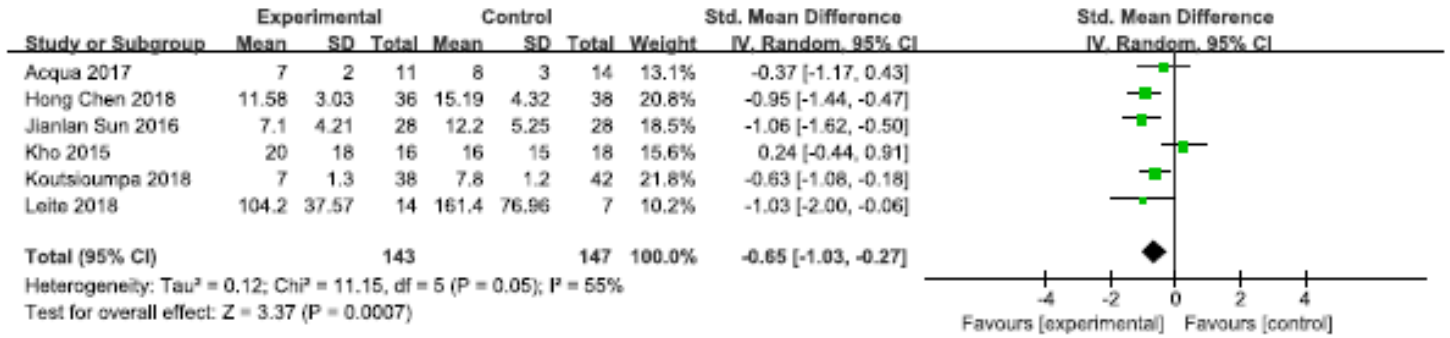


Fig. 4. Effects of NMES on MV duration of ICU patients.

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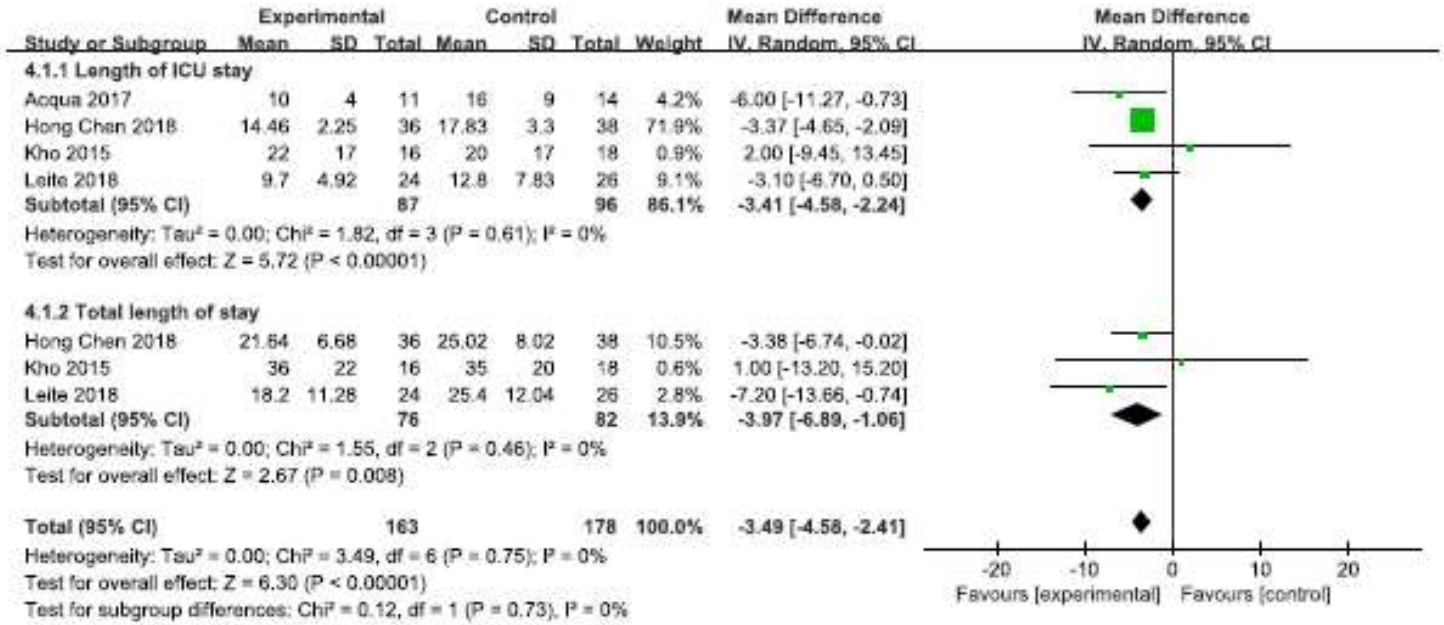


Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
4.1.1 Length of ICU stay								
Acqua 2017	10	4	11	16	9	14	4.2%	-6.00 [-11.27, -0.73]
Hong Chen 2018	14.46	2.25	36	17.83	3.3	38	71.9%	-3.37 [-4.65, -2.09]
Kho 2015	22	17	16	20	17	18	0.9%	2.00 [-9.45, 13.45]
Leite 2018	9.7	4.92	24	12.8	7.83	26	9.1%	-3.10 [-6.70, 0.50]
Subtotal (95% CI)			87			96	**86.1%**	**-3.41 [-4.58, -2.24]**
Heterogeneity: Tau² = 0.00; Chi² = 1.82, df = 3 (P = 0.61); I² = 0%								
Test for overall effect: Z = 5.72 (P < 0.00001)								
4.1.2 Total length of stay								
Hong Chen 2018	21.64	6.68	36	25.02	8.02	38	10.5%	-3.38 [-6.74, -0.02]
Kho 2015	36	22	16	35	20	18	0.6%	1.00 [-13.20, 15.20]
Leite 2018	18.2	11.28	24	25.4	12.04	26	2.8%	-7.20 [-13.66, -0.74]
Subtotal (95% CI)			76			82	**13.9%**	**-3.97 [-6.89, -1.06]**
Heterogeneity: Tau² = 0.00; Chi² = 1.55, df = 2 (P = 0.46); I² = 0%								
Test for overall effect: Z = 2.67 (P = 0.008)								
Total (95% CI)			163			178	**100.0%**	**-3.49 [-4.58, -2.41]**
Heterogeneity: Tau² = 0.00; Chi² = 3.49, df = 6 (P = 0.75); I² = 0%								
Test for overall effect: Z = 6.30 (P < 0.00001)								
Test for subgroup differences: Chi² = 0.12, df = 1 (P = 0.73), I² = 0%								

Fig. 5. Effects of NMES on ICU length of stay and total length of stay.

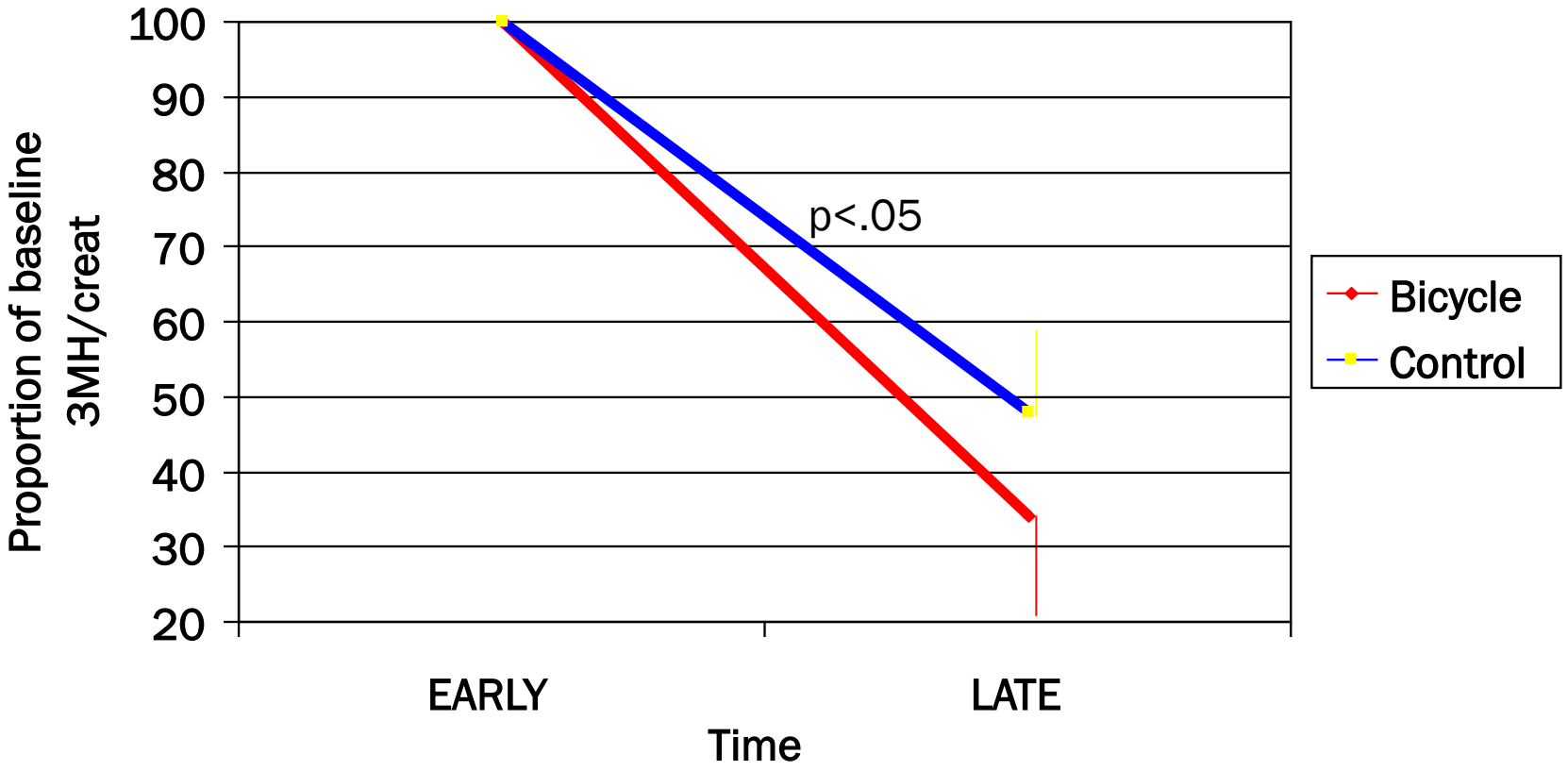
No effect on mortality

Cyclergometer

- Is passive physical activity able to decrease the loss in muscle proteins (nitrogen balance and 3-MH/creatinine ratio)?
- to influence muscle mass (anthropometric)?
- to influence muscle function (electrophysiology)?

De Prato C et al Reanimation 2009;18

Effects of exercise on muscle protein catabolism



De Prato C et al Reanimation 2009;18

Early exercise in critically ill patients enhances short-term functional recovery

90 patients GR control standard PT

GR intervention standard PT + 20 min ergocycle

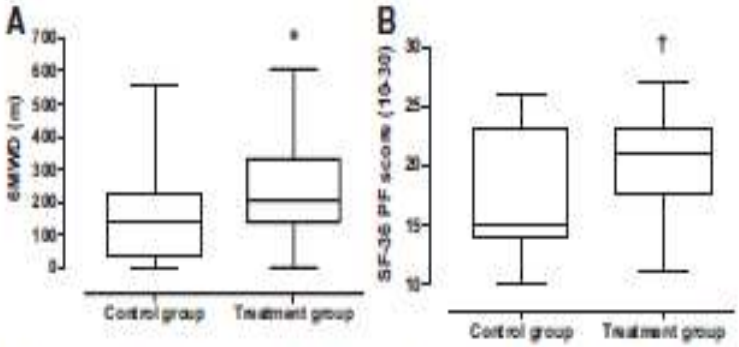


Figure 3. *A, Boxplot* of 6MWD at hospital discharge. *6MWD*, 6-min walking distance. *$p < .05$ compared with control group. *B, Boxplot* of SF-36 PF score at hospital discharge. *SF-36 PF*, "Physical Function" item of Short Form 36 Health Survey Questionnaire. †$p < .01$ compared with control group.

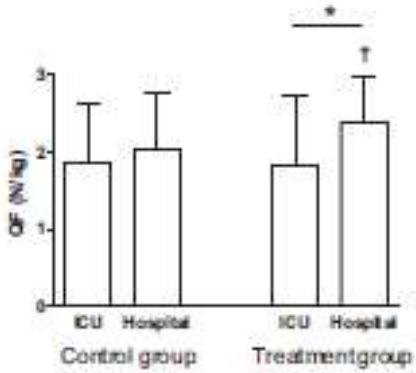


Figure 4. Isometric quadriceps force at intensive care unit (*ICU*) discharge and at hospital discharge. Data are presented as mean and standard deviation. *QF*, quadriceps force; *hospital*, day of hospital discharge. *$p < .01$ between ICU and hospital discharge; †$p < .05$ compared with control group.

Burtin C et al CCM 2009

Functional electrical stimulation in-bed cycle ergometry in mechanically ventilated patients: a multicentre randomised controlled trial

- 162 participants, to FES-cycling (n=80) versus control (n=82).
- Mean of 5 FES-cycling sessions +/- 56 min/day plus 15 min/day of usual care rehabilitation.
- The control group 15 min/day of usual care rehabilitation. Results:
- No significant differences for muscle strength at hospital discharge, no difference of cognitive impairment at 6 months (OR 1.1 (95% CI 0.30 to 3.8)) or secondary outcomes measured in-hospital and at 6 and 12 months follow-up.

Berney S et al Thorax 2020

Functional electrical stimulation-assisted cycle ergometry-based progressive mobility programme for mechanically ventilated patients: randomised controlled trial with 6 months follow-up

Petr Waldauf,[1] Natália Hrušková,[2] Barbora Blahutova,[1] Jan Gojda,[3] Tomáš Urban,[1] Adéla Krajčová,[1] Michal Fric,[1] Kateřina Jiroutková,[1] Kamila Řasová,[2] František Duška[1]

150 patients

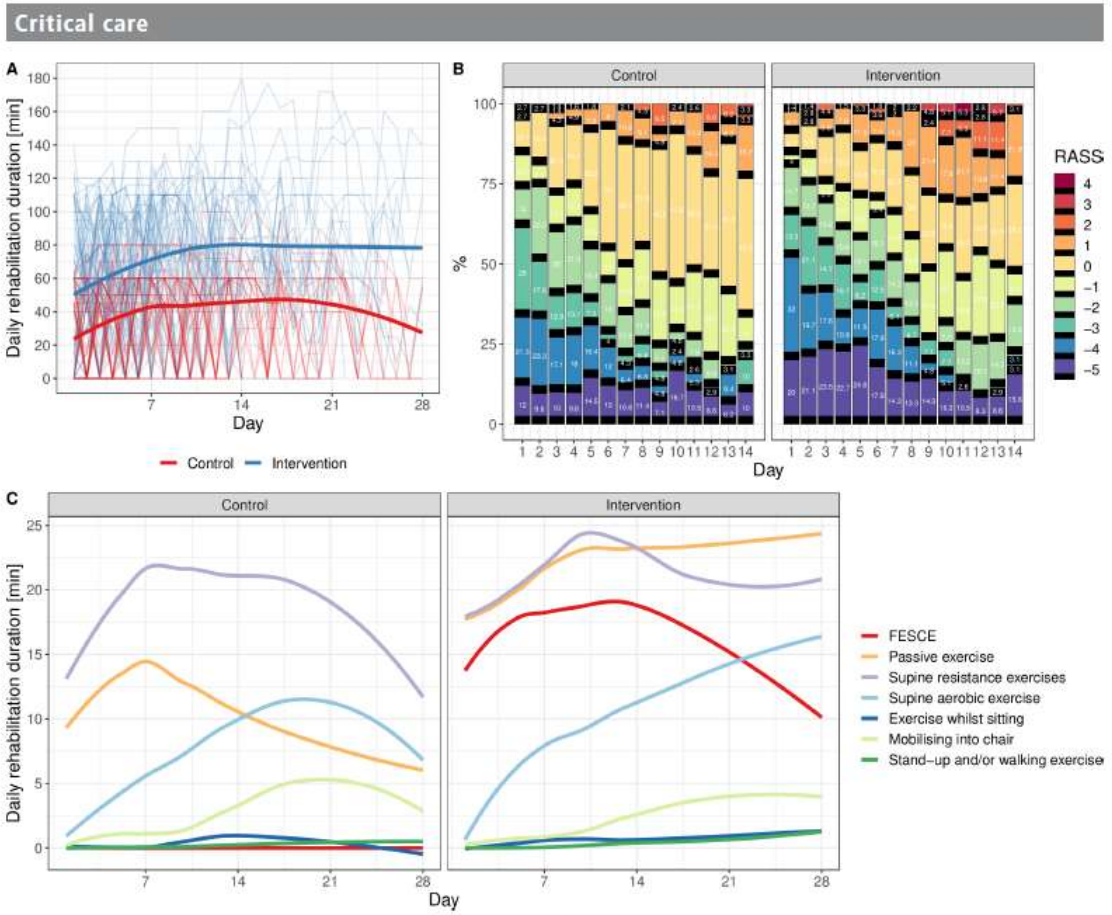


Figure 2 Protocol implementation indices. (A) Average duration of rehabilitation in intervention (blue line) and control (red line) groups in all days of all patients (ie, including days without rehabilitation). Thin lines are individual patients (one outlier received up to 180 min of rehabilitation a day due to protocol violation). (B) Sedation level heatmap. (C) Average types of exercise delivered daily. FESCE, functional electrical stimulation-assisted cycle ergometry; RASS, Richmond Agitation-Sedation Scale, where 0 (alert and calm) or −1 (drowsy) were target levels of sedation management.

Thorax May 2021

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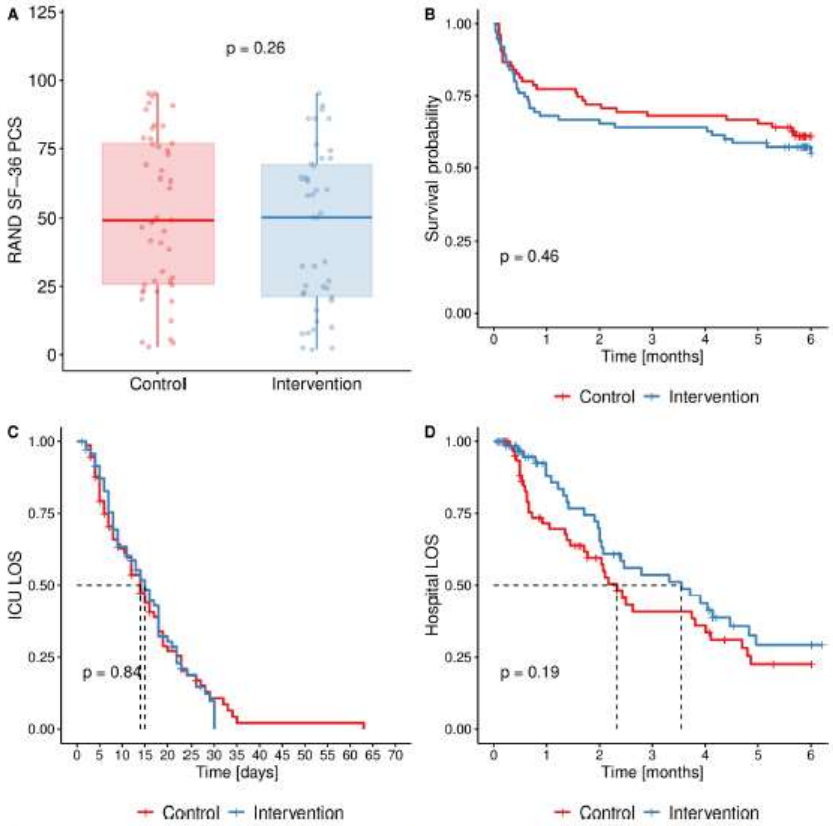

Figure 3 (A) Physical component summary of SF-36 score (primary outcome); (B) Kaplan-Meier curve of survival in the study; (C) Kaplan-Meier curve of patients in the ICU (censored for non-survivors); (D) Kaplan-Meier curve of patients at hospital (censored for non-survivors). P values are from Wilcoxon in (A) and log-rank test in (B), (C) and (D). ICU, intensive care unit; LOS, length of stay; PCS, Physical Component Summary.

Thorax May 2021

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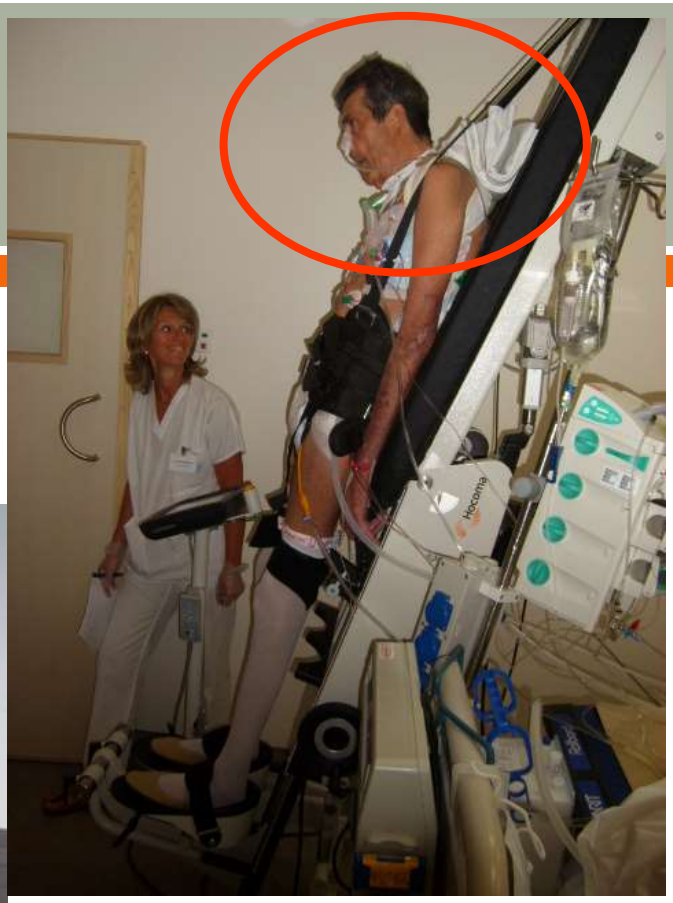
Table 2 Secondary outcomes

Secondary outcomes	Intervention	Standard of care	P value
PFIT-s at ICU discharge	9.4 (8.0 to 10.8) n=37	9.6 (8.3 to 10.9) n=42	0.77*
Rectus muscle diameter at ICU discharge (mean difference from baseline (cm))	−11 (−17 to −6) % n=57	−13 (−19 to −7) % n=54	0.64
MRC score at ICU discharge	42.4 (39.2 to 45.6)	39.4 (36.5 to 42.4)	0.13
Nitrogen balance (gN/m^2/day)	−2.7 (−3.1 to −2.4) n=852 days of 75 patients	−3.4 (−3.7 to −3.0) n (days)=759 days of 75 patients	**0.004**
Ventilator-free days at D28	9.3 (6.5 to 12.0) n=75	11.0 (8.2 to 13.8) n=75	0.33
Number of untoward dialysis interruptions/days of rehabilitation during dialysis	0/17	0/41	N/A
Numbers of ICP elevations/days with ICP measured	1.5 (0.2 to 2.9) (n=4 patients, 15 ICP days)	0 (n=3 patients, 15 ICP days)	**0.018***

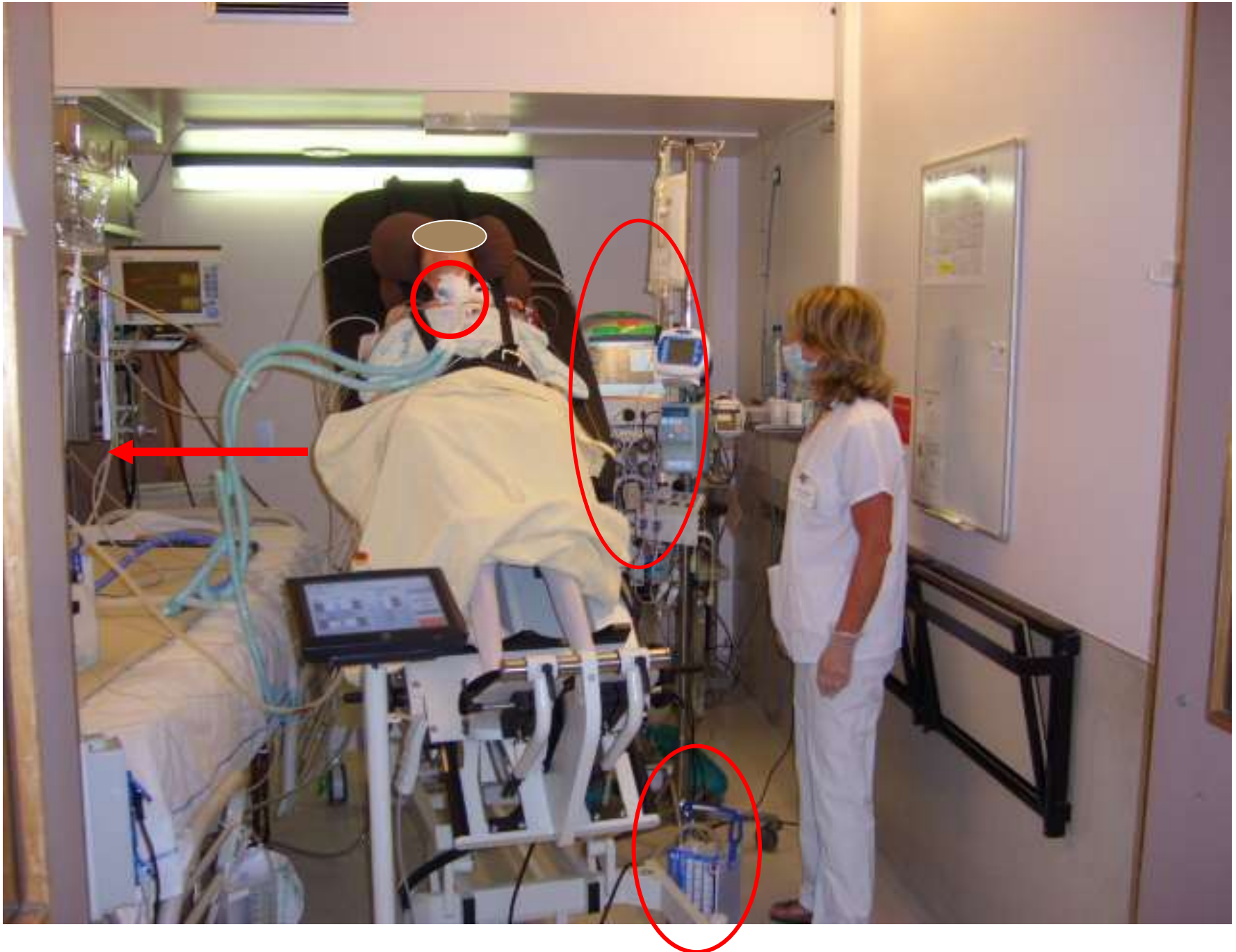
Thorax May 2021

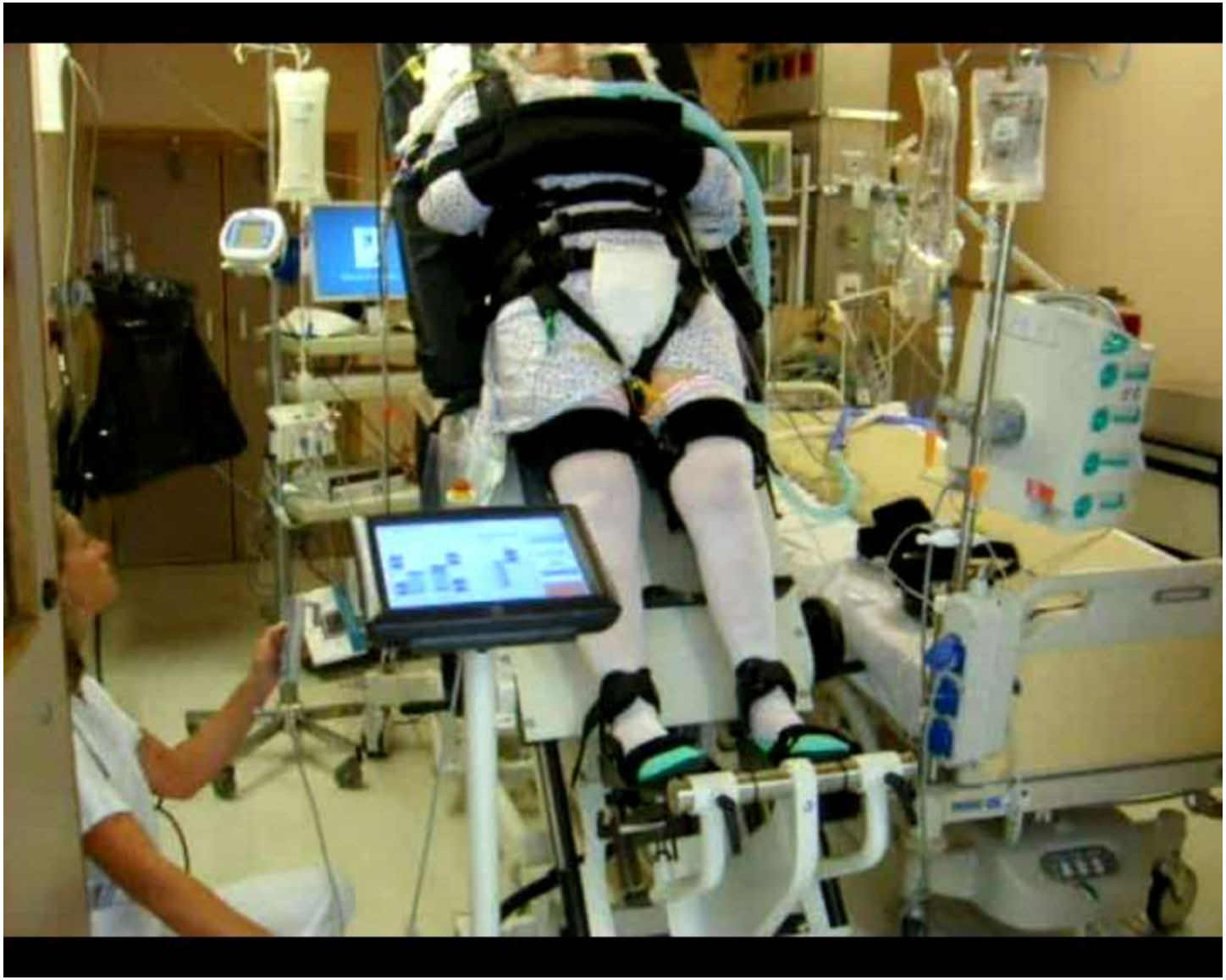
Tilting-up table




Hocoma

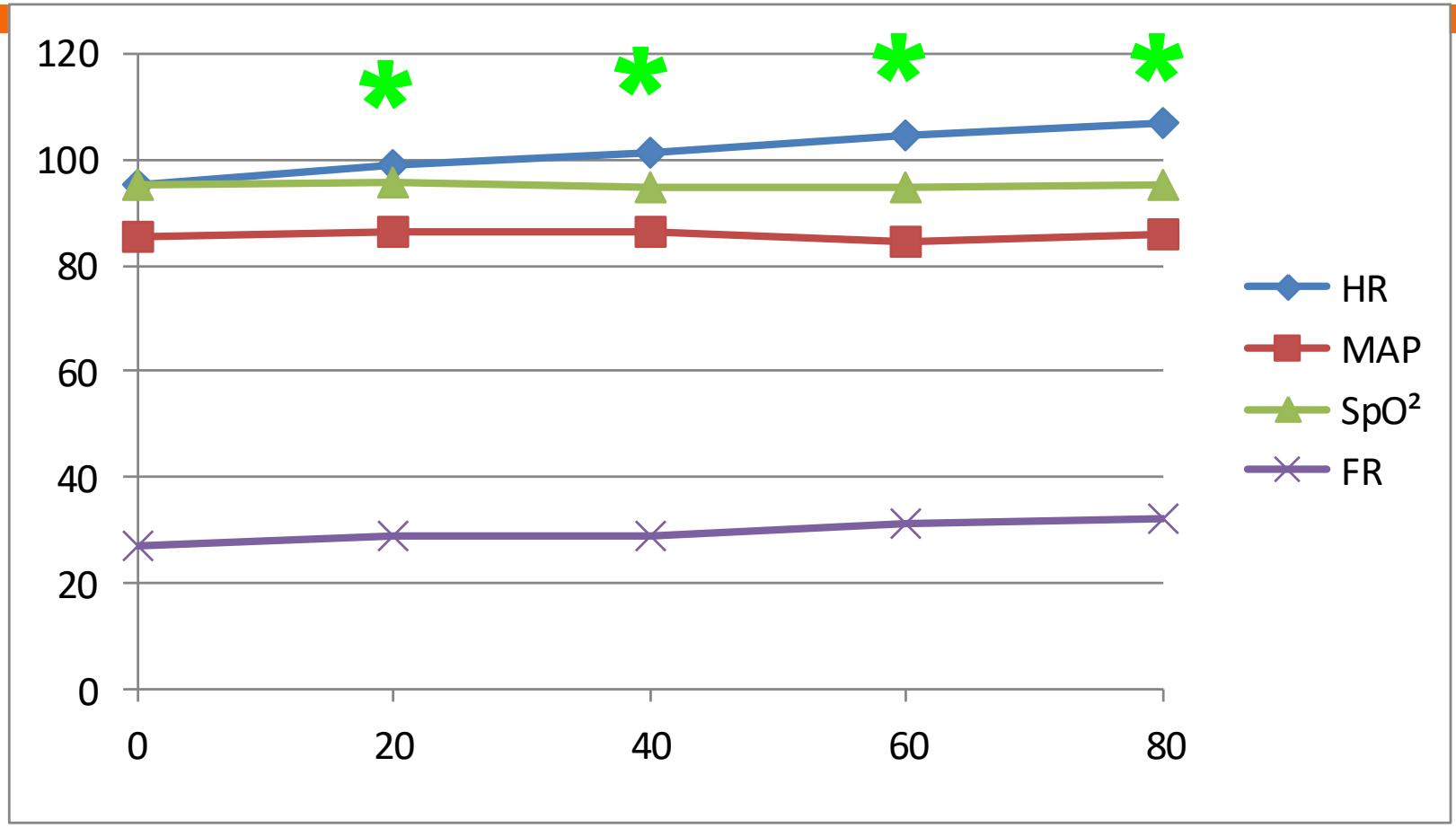

Erigo





	0°	20°	40°	60°	80°
HR	96 ± 3	99± 3*	101 ± 3*	105 ± 3*	107 ± 3*
MAP	96 ± 3	90 ± 2	89 ± 2	87 ± 2	88 ± 2
CO	5.9 ± 0,5	6.1 ± 0.5	5.5 ± 0.5	5.6 ± 0.5	5.2 ± 0.5
SpO2	95 ± 1	96± 1	95 ± 1	95 ± 1	95 ± 1
Vt	513 ± 50	501 ± 43	516 ± 44	515 ± 38	504 ± 40
RR	27 ± 1	29 ± 1	29 ± 1	31 ± 1	32 ± 1

* statistically significant at 5%, Level vs Angle 0
Anova Variance analysis for repeated mesurements.


120
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HR
MAP
SpO²
FR

Effect of verticalization with Erigo® in the acute rehabilitation of severe acquired brain injury

Emilio Ancona[1] · Annamaria Quarenghi[1] · Marcello Simonini[1] · Raoul Saggini[2] · Stefano Mazzoleni[3] · Antonio De Tanti[4] · Donatella Saviola[4] · Giovanni Pietro Salvi[1]

Neurological Sciences 2019
https://doi.org/10.1007/s10072-019-03917-0

- 44 patients CG 45 min neurorehabilitation (with Tilt up table)
- TG 45 min ERIGO

Table 2 Trend of NIHSS in subsets of patients

	Intervention group ($N = 22$)			Control group ($N = 22$)		
	T0	T1	T2	T0	T1	T2
Sex						
Males	12.93 ± 4.32	11.93 ± 3.95*	10.64 ± 3.10*	14.33 ± 9.98	13.80 ± 9.56*	11.93 ± 9.91**
Females	14.38 ± 3.42	13.50 ± 4.11	12.38 ± 4.03*	11.00 ± 9.76	10.86 ± 9.84	10.43 ± 10.11
Etiology						
Ischemic stroke	14.09 ± 5.11	13.09 ± 5.22*	12.00 ± 4.31**	10.69 ± 8.98	10.54 ± 8.97	9.62 ± 9.08*
Hemorrhagic stroke	13.67 ± 1.86	13.17 ± 1.94*	11.83 ± 1.33	20.50 ± 11.10	19.33 ± 10.80	17.67 ± 11.41
Traumatic brain injury	11.80 ± 3.11	10.40 ± 1.82	9.00 ± 2.55*	10.00 ± 1.73	10.00 ± 1.73	7.00 ± 3.46

Values are expressed as mean ± standard deviation

$P < 0.05$; ** $P < 0.001$

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Table 3 Trend of Tinetti scale in subsets of patients

	Intervention group ($N = 22$)			Control group ($N = 22$)		
	T0	T1	T2	T0	T1	T2
Sex						
Males	2.86 ± 4.02	5.86 ± 3.46**	7.64 ± 3.46**	3.80 ± 3.69	5.80 ± 4.43*	7.80 ± 5.19**
Females	2.50 ± 3.42	6.63 ± 5.18*	10.00 ± 6.39*	4.43 ± 5.00	5.43 ± 4.65	7.71 ± 5.12*
Etiology						
Ischemic stroke	3.45 ± 3.96	6.27 ± 4.41*	8.18 ± 4.53**	4.23 ± 4.00	5.92 ± 4.27	8.15 ± 4.65**
Hemorrhagic stroke	1.67 ± 3.61	6.17 ± 4.26	10.00 ± 5.93*	3.17 ± 3.97	4.17 ± 4.62	5.17 ± 5.08*
Traumatic brain injury	2.40 ± 3.78	5.80 ± 3.90*	7.40 ± 4.62	4.67 ± 5.69	7.67 ± 5.13	11.33 ± 5.69*

Values are expressed as mean ± standard deviation

*$P < 0.05$; **$P < 0.001$)

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Table 4 Trend of FIM in subsets of patients

	Intervention group ($N = 22$)			Control group ($N = 22$)		
	T0	T1	T2	T0	T1	T2
Sex						
Males	53.00 ± 13.99	59.29 ± 16.10**	64.14 ± 20.15**	49.80 ± 22.68	53.27 ± 23.72*	59.33 ± 26.60**
Females	52.50 ± 21.52	57.25 ± 23.77*	59.88 ± 25.00*	58.43 ± 27.24	60.71 ± 28.22	65.29 ± 29.31*
Etiology						
Ischemic stroke	55.91 ± 15.34	62.36 ± 17.11*	67.27 ± 19.95*	56.62 ± 23.97	59.85 ± 24.79*	65.31 ± 26.56*
Hemorrhagic stroke	47.50 ± 15.86	52.17 ± 18.63	55.00 ± 20.36	40.33 ± 25.81	40.83 ± 24.89	46.17 ± 29.94
Traumatic brain injury	52.40 ± 21.80	57.80 ± 23.87	61.40 ±27.84	59.33 ± 16.44	67.00 ± 16.09	73.67 ± 10.97**

Values are expressed as mean ± standard deviation

*P < 0.05; **P < 0.001

Comparison between Erigo tilt-table exercise and conventional physiotherapy exercises in acute stroke patients: a randomized trial

Table 3 Outcome measure score (Mean ± SD) of two groups over the periods

Outcome measure	Day 0	Day 30	Day 90
QOL:			
Group A	75.45 ± 6.59	83.20 ± 9.41[a]	89.84 ± 11.74[ab]
Group B	77.71 ± 8.69	87.58 ± 9.93[a]	100.47 ± 11.97[ab]
P value[#]	1.000	0.321	< 0.001
MMT (UE):			
Group A	0.82 ± 0.90	2.16 ± 0.96[a]	2.93 ± 0.88[ab]
Group B	1.17 ± 0.86	2.42 ± 0.93[a]	3.31 ± 0.90[ab]
P value[#]	0.658	1.000	0.463
MMT (LE):			
Group A	1.25 ± 1.04	2.47 ± 1.01[a]	3.36 ± 0.89[ab]
Group B	1.42 ± 0.98	2.88 ± 0.83[a]	3.90 ± 0.54[ab]
P value[#]	1.000	0.241	0.030
NIHSS:			
Group A	12.53 ± 1.59	6.78 ± 2.11[a]	4.07 ± 2.07[ab]
Group B	11.95 ± 1.45	6.20 ± 2.00[a]	2.96 ± 1.99[ab]
P value[#]	1.000	1.000	0.035
MMSE:			
Group A	15.22 ± 4.45	22.00 ± 3.59[a]	24.33 ± 2.93[ab]
Group B	15.80 ± 4.10	22.15 ± 3.46[a]	24.42 ± 2.81[ab]
P value[#]	1.000	1.000	1.000
Ashworth:			
Group A	0.09 ± 0.29	0.56 ± 0.54[a]	0.64 ± 0.62[ab]
Group B	0.11 ± 0.31	0.33 ± 0.51[a]	0.45 ± 0.57[b]
P value[#]	1.000	0.181	0.793

Group A Conventional physiotherapy, *Group B* Erigo tilt-table, *QOL* Quality of life, *MMT (UE)* Manual muscle testing (upper extremity) or overall upper limb strength, *MMT (LE)* Manual muscle testing (lower extremity) or overall lower limb strength, *NIHSS* National institute of health stroke scale, *MMSE* Mini-mental state examination, *Ashworth* Ashworth scale-6
[a]$p < 0.001$- as compared to day 0 and [b]$p < 0.001$- as compared to day 30 (intragroup comparison), [#](intergroup comparison)

133 patients 7-28 of onset
Gr A conventional PT
Gr B Erigo 40 min, 6/week 4 weeks
(30° st week, 50° 2-3 weeks, 75°, 4th week)

Kumar *et al. Archives of Physiotherapy* (2020) 10:3
https://doi.org/10.1186/s40945-020-0075-2

Whole-body vibration to prevent intensive care unit-acquired weakness: safety, feasibility, and metabolic response

Wollersheim et al. Critical Care (2017) 21:9
DOI 10.1186/s13054-016-1576-y

Tobias Wollersheim[1,2†], Kurt Haas[1†], Stefan Wolf[3], Knut Mai[2,4], Claudia Spies[1], Klaus-D. Wernecke[1,5], Joachim Spranger[2,4,7] and Steffen Weber-Carstens[1,2*]

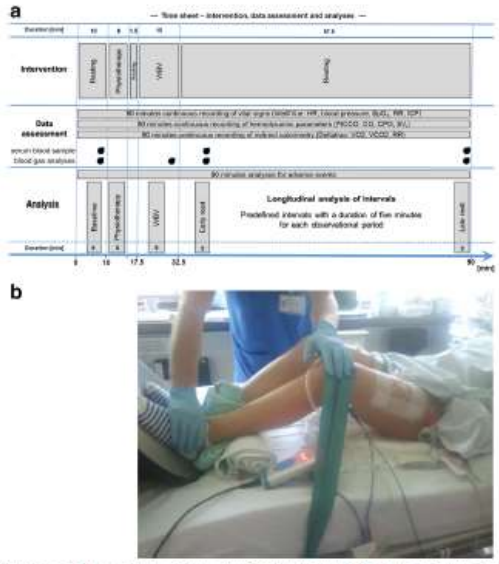

Fig. 1 Study protocol and visual presentation of study execution **a** Visualization of study protocol. Intervention started with 10 minutes of resting, followed by 6 minutes of physiotherapy (passive range of motion of upper and lower extremity). After physiotherapy there was a short resting time, followed by WBV. After WBV, a long resting period took place. Serum blood samples and blood gas analyses were performed at different time points, as shown. Longitudinal analysis of intervals was performed at five different time segments. Analysis was performed at baseline, at physiotherapy, during WBV, and at early and late rest periods. **b** Female patient in a supine position. Vibration device positioned at the end of the bed, with the patient's feet placed on the middle of the device. An elastic strap is placed around the knee joint to generate pressure on the vibration device. The aim was to flex the knee joint about 20°. The physiotherapist assisted in the stabilization of the lower extremities if necessary. *WBV* whole-body vibration

19 patients mechanical ventilation
PRM before body vibration (15 min)
Vital signs, haemodynamic parameters

Conclusions: In our study the application of whole-body vibration was safe and feasible. The technique leads to increased energy expenditure. This may offer the chance to treat patients in the ICU with whole-body vibration. Further investigations should focus on the efficacy of whole-body vibration in the prevention of ICU-acquired weakness.


Progressa

MOBILIZATION

- ✓Transferring


Transplantation
cardiaque
Juin 2019
Merci !


XL
M
L

Feasibility and observed safety of interactive video games for physical rehabilitation in the intensive care unit: a case series.

- use of major muscle groups
- performance of fine movements
- mental effort
- motivation

Kho ME et al J Crit Care 2012

Steps to recovery: body weight-supported treadmill training for critically ill patients: a randomized controlled trial

Robin C. H. Kwakman[1,2,3], Juultje Sommers[1], Janneke Horn[4], Frans Nollet[1], Raoul H. H. Engelbert[1,2] and Marike van der Schaaf[1,2*]

- **88 patients Mech vent >48H, MRC>2, seated unsupported edge of bed**
- **Treadmill + usual care or usual care 40 min**
- **Number of days to functional ambulation, 6 min WT**

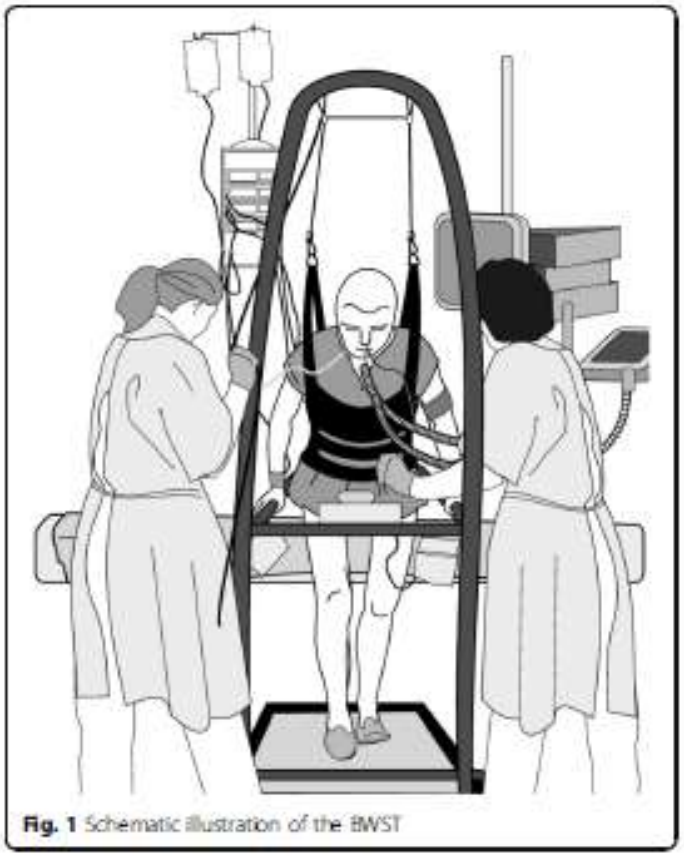

Fig. 1 Schematic illustration of the BWST

Protocol BMJ 2020


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