Tværfaglig efteruddannelse

DSKE 10-02-2010

Energi

Faktoriel metode: BMR x AF x SF x VF

Basal Metabolic Rate$_{\text{Harris-Benedict}}$ x Aktivitetsfaktor x Stressfaktor x Vægtændringsfaktor

Aktivitetsfaktorer

Durnin JVGA, Passmore R Energy, Work and Leisure Heinemann, London, 1967		
Aktivitet	kcal/min	x REE
REE, mand, 65 kg	1,1	1
Siddende (læsning, radiolytten)	1,4	1,2
Skrivebordsarbejde	1,6	1,4
Stående	1,8	1,5
Gang, 3 km/t	2,9	2,5
Gang, 4 km/t	3,5	3,1
Gang, 5 km/t	4,2	3,7
Gang, 6 km/t	4,9	4,3
Radiomekaniker	2,7	2,4
Sprøjtemaler	3,4	3,0
Bilmekaniker	4,1	3,6
Cykling, 16 km/t	7,5	6,6

Aktivitetsfaktor

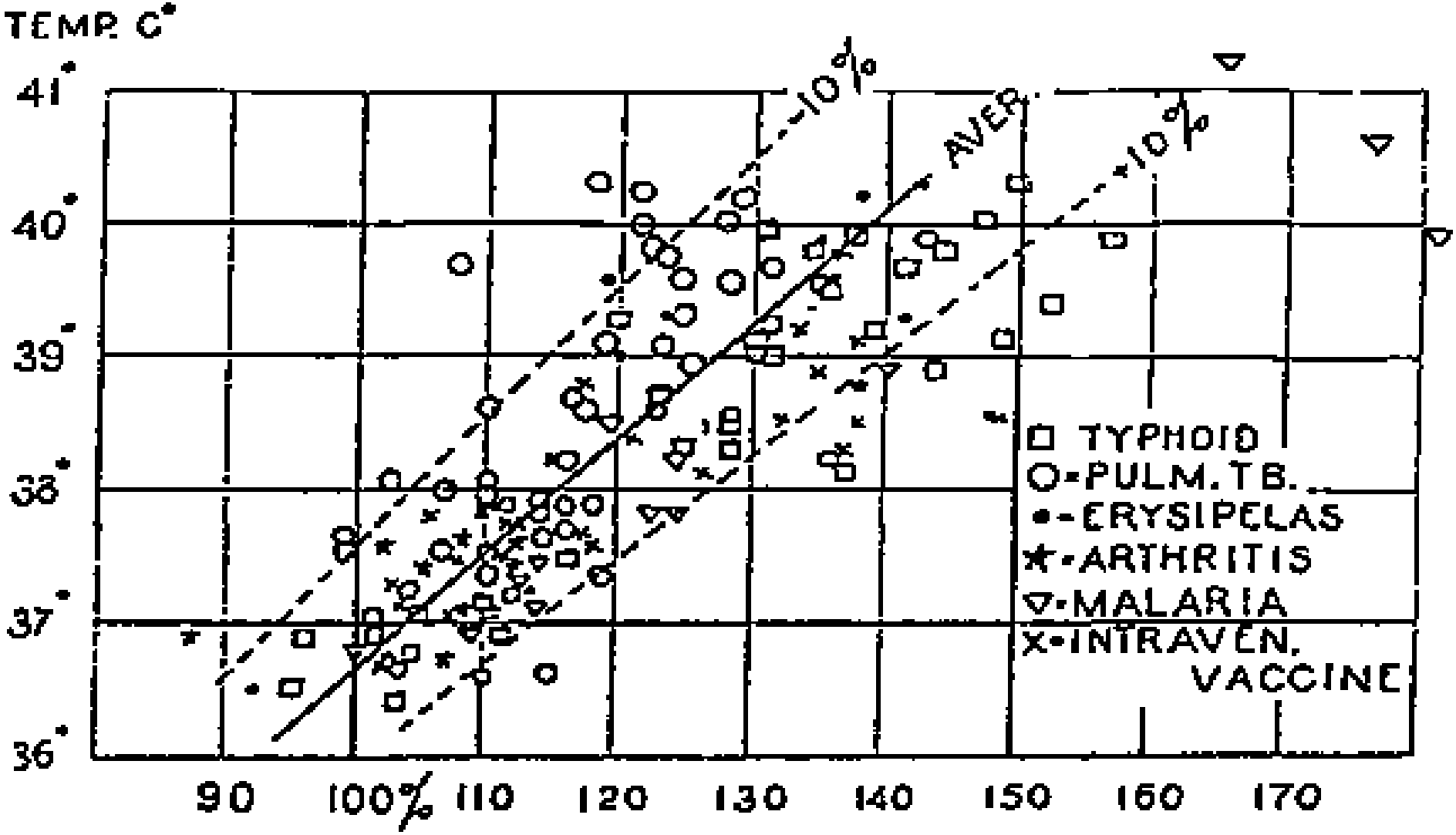
Aktivitet	Aktivitetsfaktor	Timer	AF x timer/24
søvn	0.9	8	0.30
Vågen i seng	1.2	7	0.35
Stol	1.3	6.5	0.35
Gang 3 km/t	2.5	2	0.21
Træning	6.6	0.5	0.14
Total		24	1.35

Sengeliggende: 1.1
Oppegående: 1.3

Stress factors

STRESS-FACTORS Fold increase in REE Chioléro et al. Nutrition 1997; 13: 45S-51S	
Major abdominal, thoracic or vascular surgery	
ICU + mechanical ventilation	1.1
Cardiac surgery	
ICU + mechanical ventilation	1.2
Multiple injury	
Spontaneous ventilation	1.2
ICU + mechanical ventilation	1.4
+ head trauma, ICU + mechanical ventilation	1.5
Head injury	
ICU and spontaneous ventilation	1.3
ICU + mechanical ventilation	1.1
Infection	
Sepsis + spontaneous ventilation	1.2
Sepsis + mechanical ventilation	1.6
Septic shock + ICU + mechanical ventilation	1.4

Feber: 13% per °C



du Bois 1937

Energi

Vejledende energibehov hos voksne patienter (Sundhedsstyrelsens vejledning)					
	Vedligeholdelse		Opbygning		
Vægt	Sengeliggende	Oppegående	Sengeliggende	Oppegående	Vægt
90	9.0	10.6	11.8	13.9	90
85	8.6	10.1	11.1	13.2	85
80	8.2	9.7	10.6	12.6	80
75	7.7	9.1	10.0	11.8	75
70	7.2	8.5	9.4	11.1	70
65	6.9	8.2	9.0	10.6	65
60	6.6	7.8	8.6	10.1	60
55	6.3	7.4	8.2	9.6	55
50	6.0	7.0	7.8	9.2	50
45	5.6	6.7	7.3	8.7	45
40	5.3	6.3	6.9	8.2	40

Beregnet for 50 årig mand med Harris-Benedict ligningen. Køn og alder ignoreret.
Ned til vægt = 70 kg er højden reduceret i takt med vægt, herefter konstant højde (176 cm). Undervægt ignoreret.
AF ved sengeliggende = 1.1; ved oppegående = 1.3. Opbygning = vægtøgningsfaktor = 1.3

Energi

Vejledende energibehov hos voksne patienter (Sundhedsstyrelsens vejledning)					
	Vedligeholdelse		Opbygning		
Vægt	Sengeliggende	Oppegående	Sengeliggende	Oppegående	Vægt
90	9	10	11	13	90
85	8				85
80		9	10		80
75	7			11	75
70		8	9		70
65				10	65
60	6	7	8		60
55				9	55
50			7		50
45		6		8	45
40	5				40

Inddelt i hele MJ ± 10%

Faktoriel eller additiv?

50 årig mand 176 cm høj vægt 70 kg, kJ

	Faktoriel x AF 1,3 x SF 1,3	Additiv + AF 0,3 + SF 0,3
HB	6.567	6.567
AF 1,3	8.537	1.970
SF 1,3	8.537	1.970
Total	11.098	10.507

Harris Benedict *versus* Schoefield

40 årig sengeliggende mand

Vægt	Højde	H-B	Schoefield
85	195	8,9	9,0
80	189	8,5	8,2
75	182	8,0	8,0
70	176	7,5	7,7
65	176	7,2	7,4
60	176	6,9	7,2
55	176	6,6	6,9
50	176	6,3	6,4
45	176	6,0	6,4
40	176	5,6	5,7

Harris Benedict *versus* Schoefield

70 årig sengeliggende mand

Vægt	Højde	H-B	Schoefield
85	195	7,9	8,5
80	189	7,5	8,0
75	182	7,0	7,4
70	176	6,5	7,0
65	176	6,2	6,8
60	176	5,9	6,5
55	176	5,6	6,3
50	176	5,3	6,1
45	176	5,0	5,9
40	176	4,6	5,7

Adipøse patienter: overensstemmelse mellem målt REE og forskellige formler hos (Bland-Altman analyse)

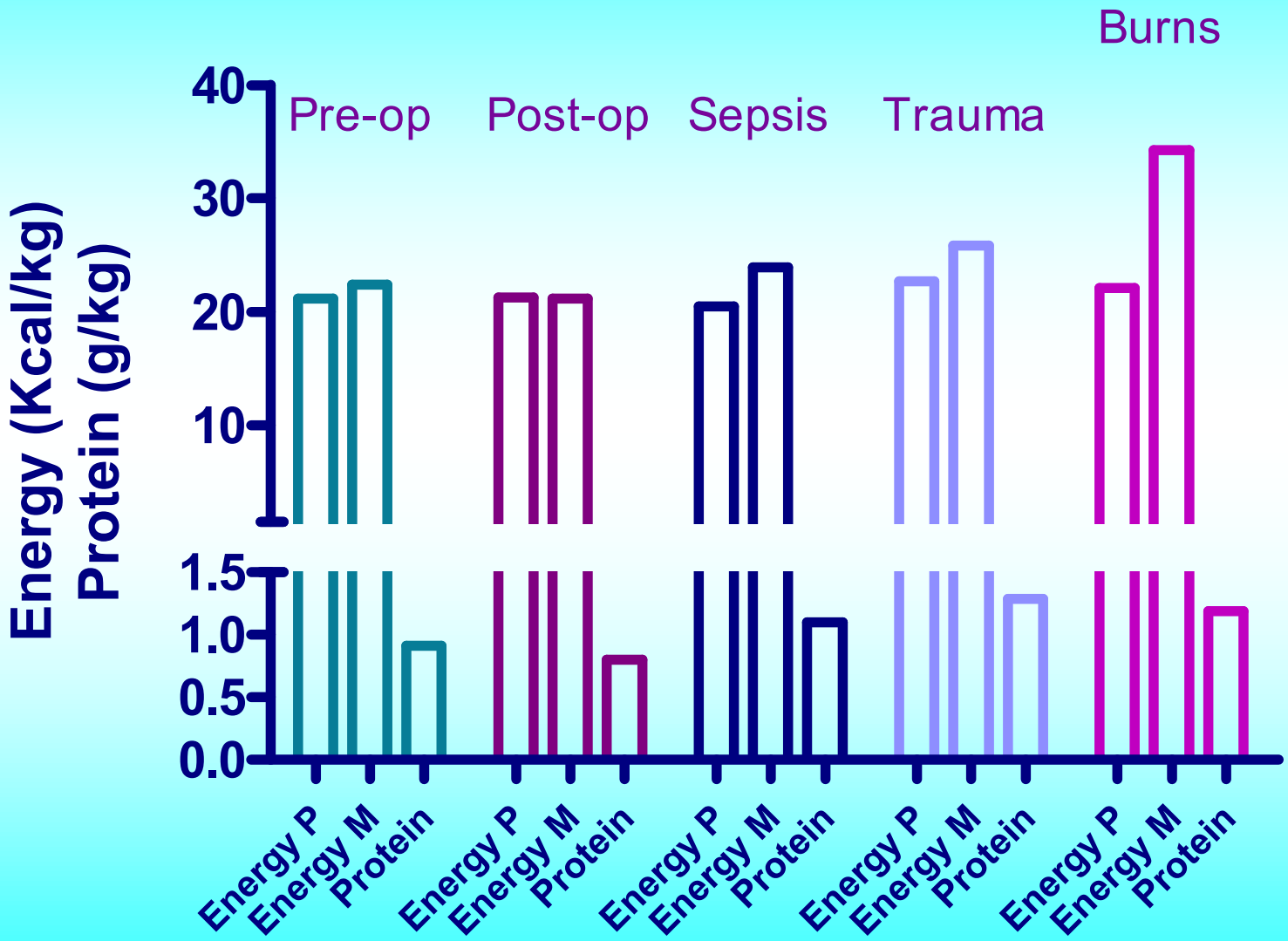
(N= 57; gns. BMI = 35; BMI<50)
Glynn et al. J Par Ent Nutr 1999;23:147-154

	$H\text{-}B_{adj}$ [1)]	IJ [2)]	21 Kcal/kg [3)]
Bias, Kcal [4)]	182	233	267
Precision, Kcal [5)]	123	177	203
± 10% mREE [6)]	67%	49%	24%

1) Harris-Benedict (med vægt = ½ aktuel vægt + ½ idealvægt) x 1.3 (SF)
2) Ireton-Jones for obesity: 606 x G (m=1) + 9 x BW – 12 x age + 400 x V (ventilator = 1) + 1444
3) Gns mREE/kg i tidligere studie (mREE = målt REE)
4) Gns afvigelse i forhold til mREE
5) 1 SD af Bias
6) Andel af patienter, der er inden for ± 10% af målt REE

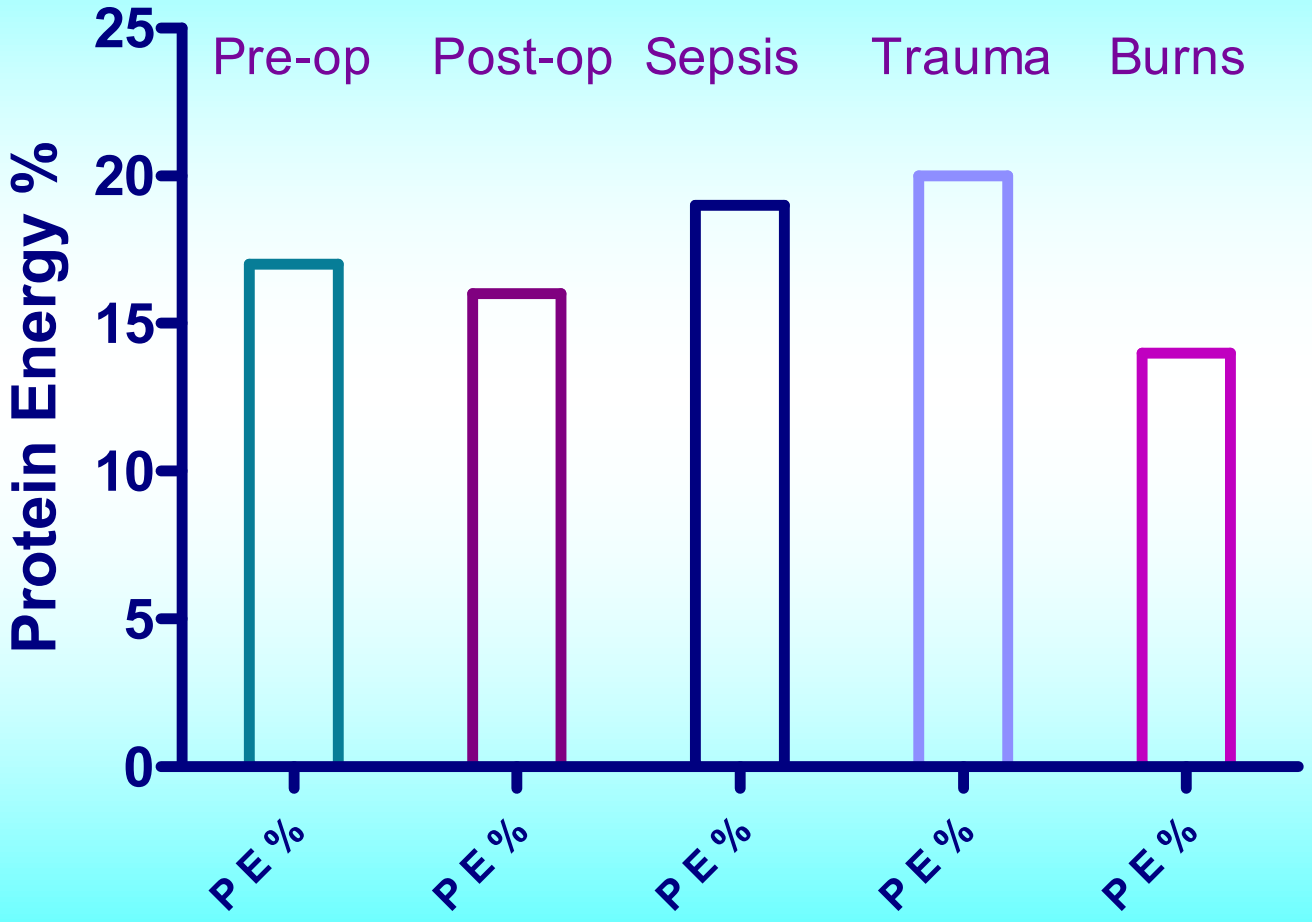
Protein

Duke et al. Surgery 1970; 68: 168-174



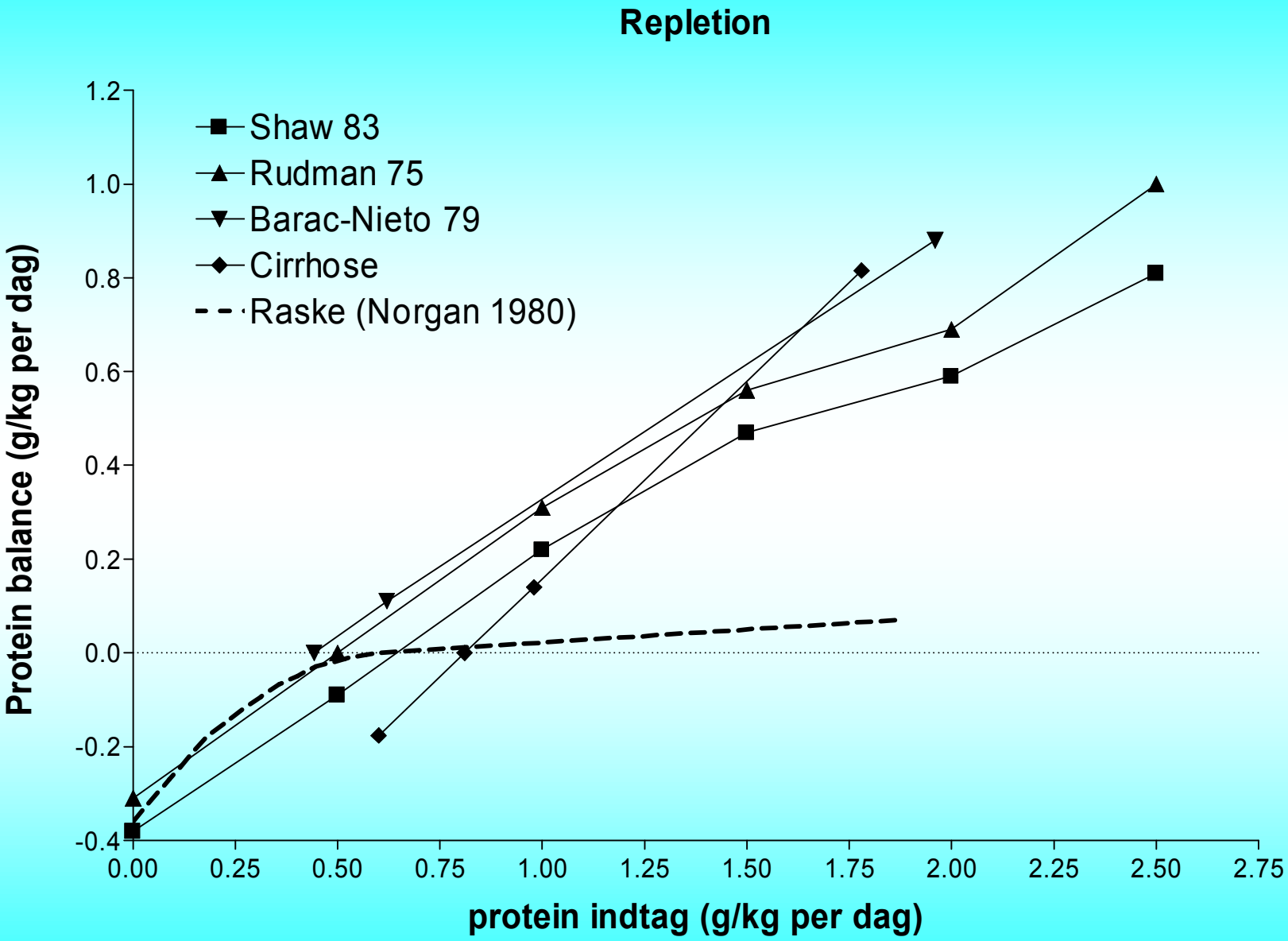
Energy P = predicted; Energy M = measured

Duke et al. Surgery 1970; 68: 168-174



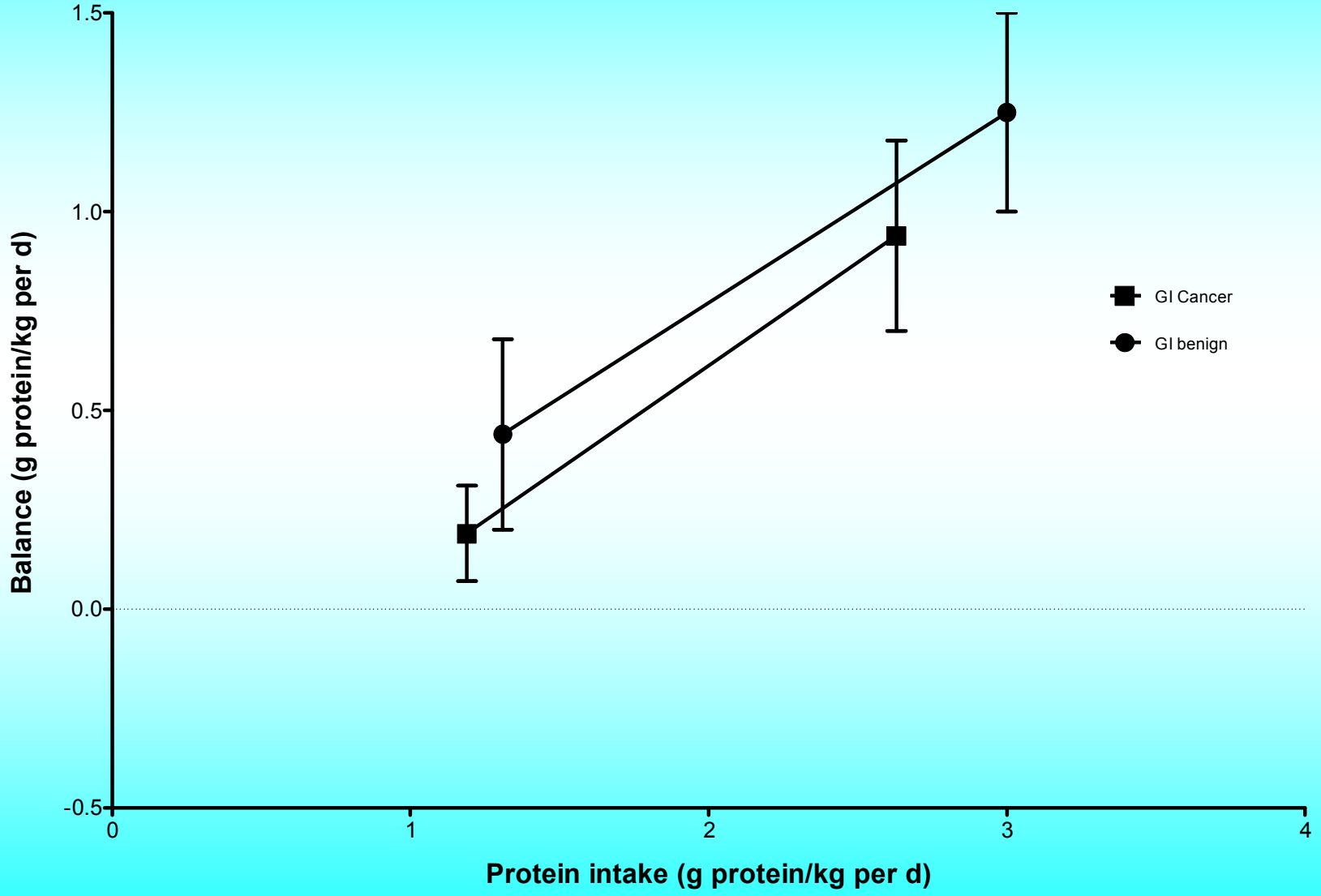
Hvis 25-30 kcal/kg → 18 E% = 1.1-1.3 g/kg per dag

Prot Repl

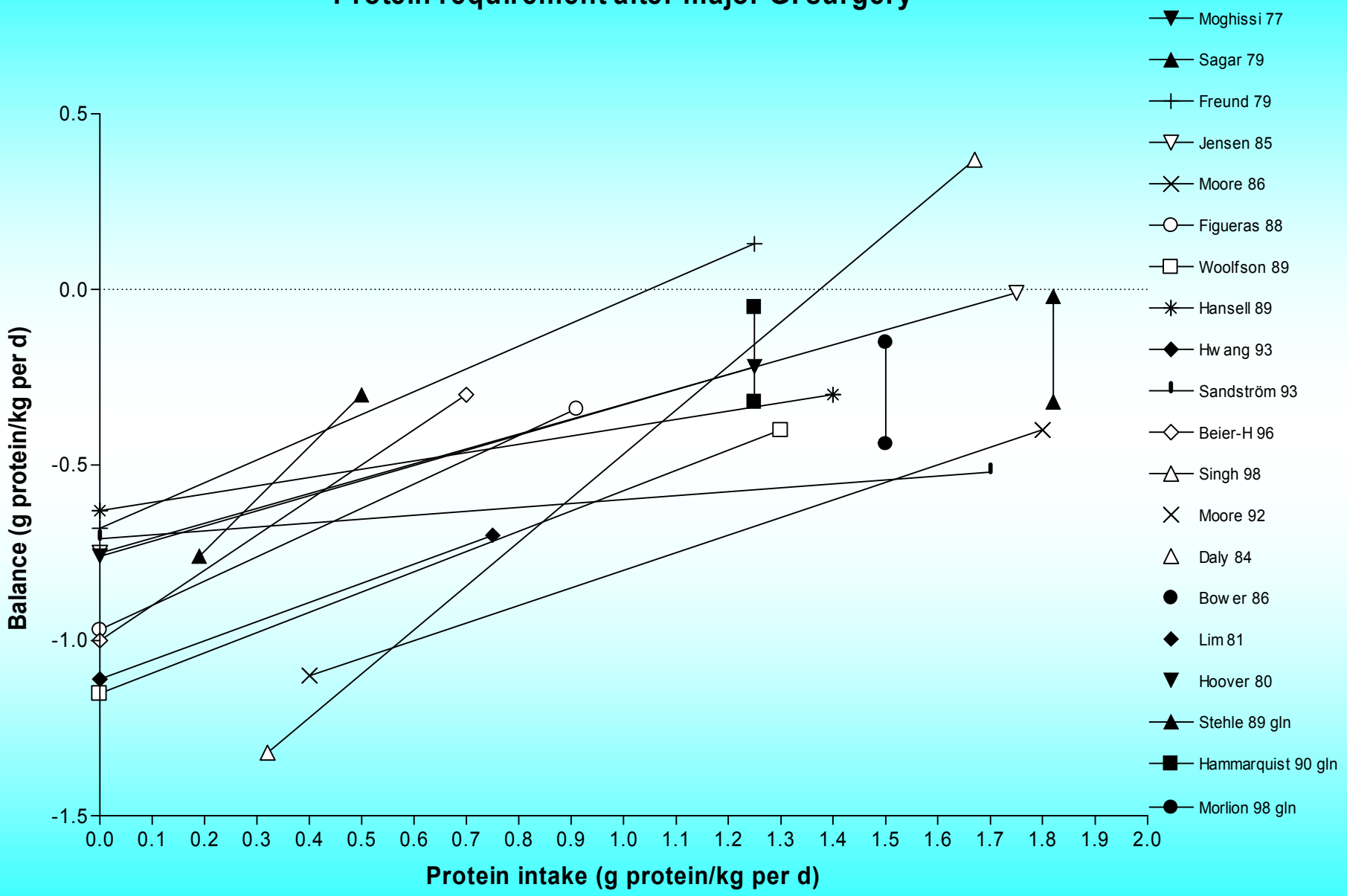

Repletion
Shaw 83
Rudman 75
Barac-Nieto 79
Cirrhose
Raske (Norgan 1980)
Protein balance (g/kg per dag)
protein indtag (g/kg per dag)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75

Protein utilization in cancer patients

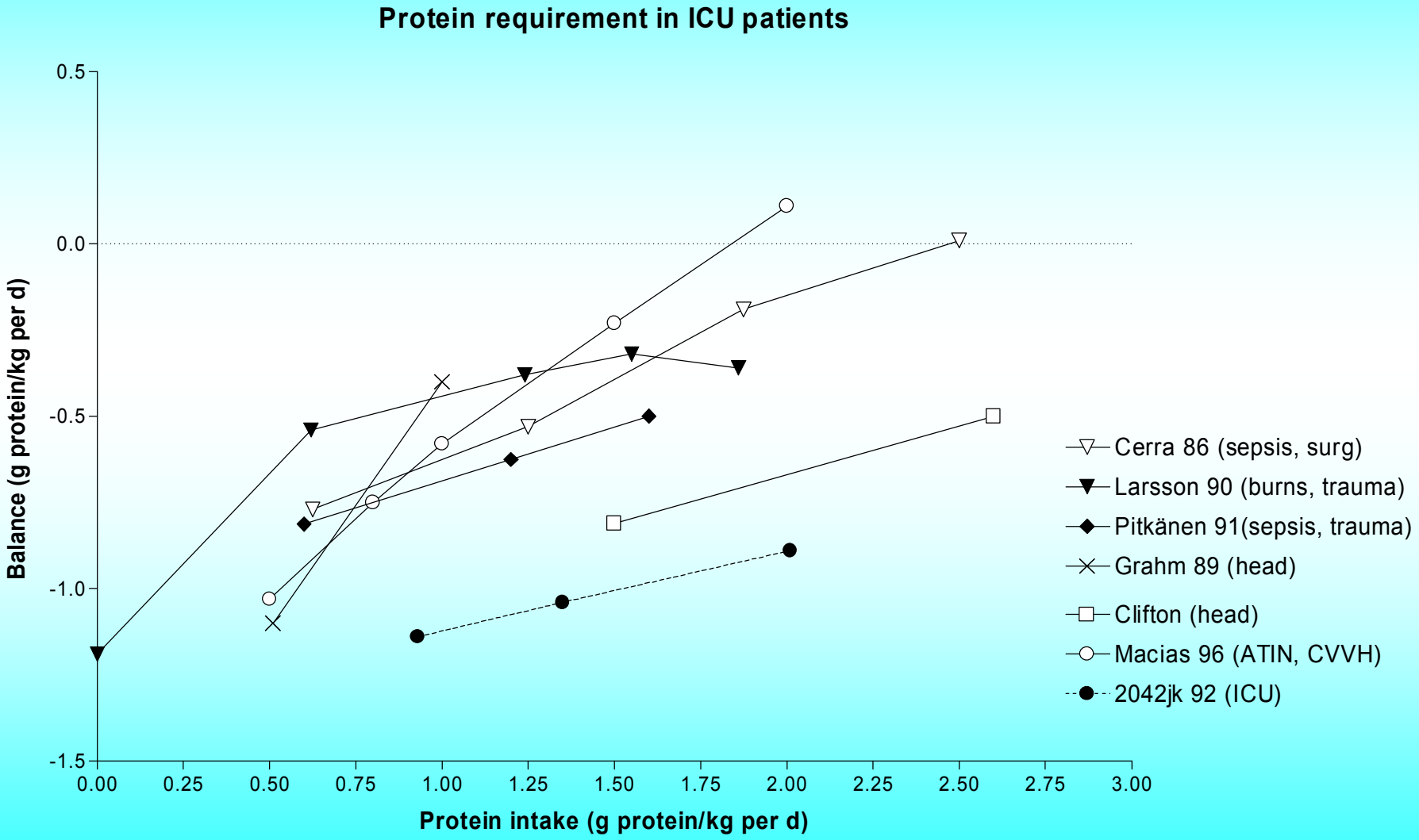
Bennegard et al 1983. Gastroenterology 85: 92-9.



Protein requirement after major GI surgery



Prot ICU


Protein requirement in ICU patients
Balance (g protein/kg per d)
0.5
0.0
-0.5
-1.0
-1.5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
Protein intake (g protein/kg per d)
Cerra 86 (sepsis, surg)
Larsson 90 (burns, trauma)
Pitkänen 91(sepsis, trauma)
Grahm 89 (head)
Clifton (head)
Macias 96 (ATIN, CVVH)
2042jk 92 (ICU)

Protein ≈ 18 E%

<table>
<tr><td colspan="6">Vejledende energibehov, MJ (proteinbehov, g) hos voksne patienter
(Sundhedsstyrelsens vejledning)</td></tr>
<tr><td></td><td colspan="2">Vedligeholdelse</td><td colspan="2">Opbygning</td><td></td></tr>
<tr><td>Vægt</td><td>Sengeliggende</td><td>Oppegående</td><td>Sengeliggende</td><td>Oppegående</td><td>Vægt</td></tr>
<tr><td>90</td><td rowspan="2">9 (95)</td><td rowspan="3">10 (105)</td><td rowspan="3">11 (115)</td><td rowspan="4">13 (135)</td><td>90</td></tr>
<tr><td>85</td><td rowspan="3">8 (85)</td><td>85</td></tr>
<tr><td>80</td><td rowspan="3">9 (95)</td><td rowspan="3">10 (105)</td><td>80</td></tr>
<tr><td>75</td><td rowspan="4">7 (75)</td><td rowspan="2">11 (115)</td><td>75</td></tr>
<tr><td>70</td><td rowspan="3">8 (85)</td><td rowspan="3">9 (95)</td><td>70</td></tr>
<tr><td>65</td><td rowspan="3">10 (105)</td><td>65</td></tr>
<tr><td>60</td><td rowspan="5">6 (65)</td><td rowspan="4">7 (75)</td><td rowspan="2">8 (85)</td><td>60</td></tr>
<tr><td>55</td><td rowspan="2">9 (95)</td><td>55</td></tr>
<tr><td>50</td><td rowspan="3">7 (75)</td><td>50</td></tr>
<tr><td>45</td><td rowspan="2">6 (65)</td><td rowspan="2">8 (85)</td><td>45</td></tr>
<tr><td>40</td><td>5 (55)</td><td>40</td></tr>
</table>

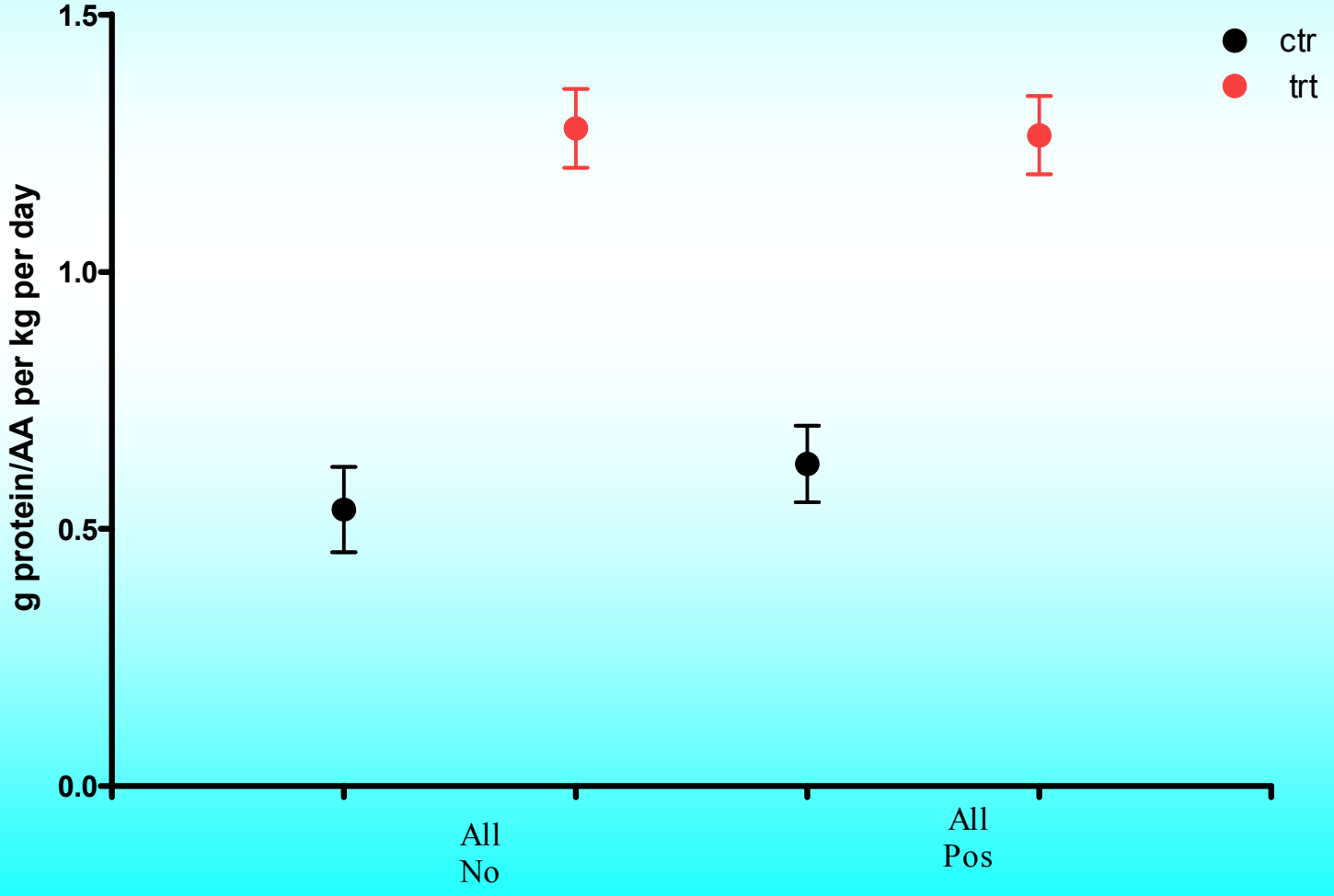
18 energi % protein

Protein/AA dosage in RCTs

Unpublished data from Kondrup et al. Clin Nutr 2003; 22: 321-336

ATIN BMT Cancer Cirrh COPD Fem&Ger GI surg Trauma

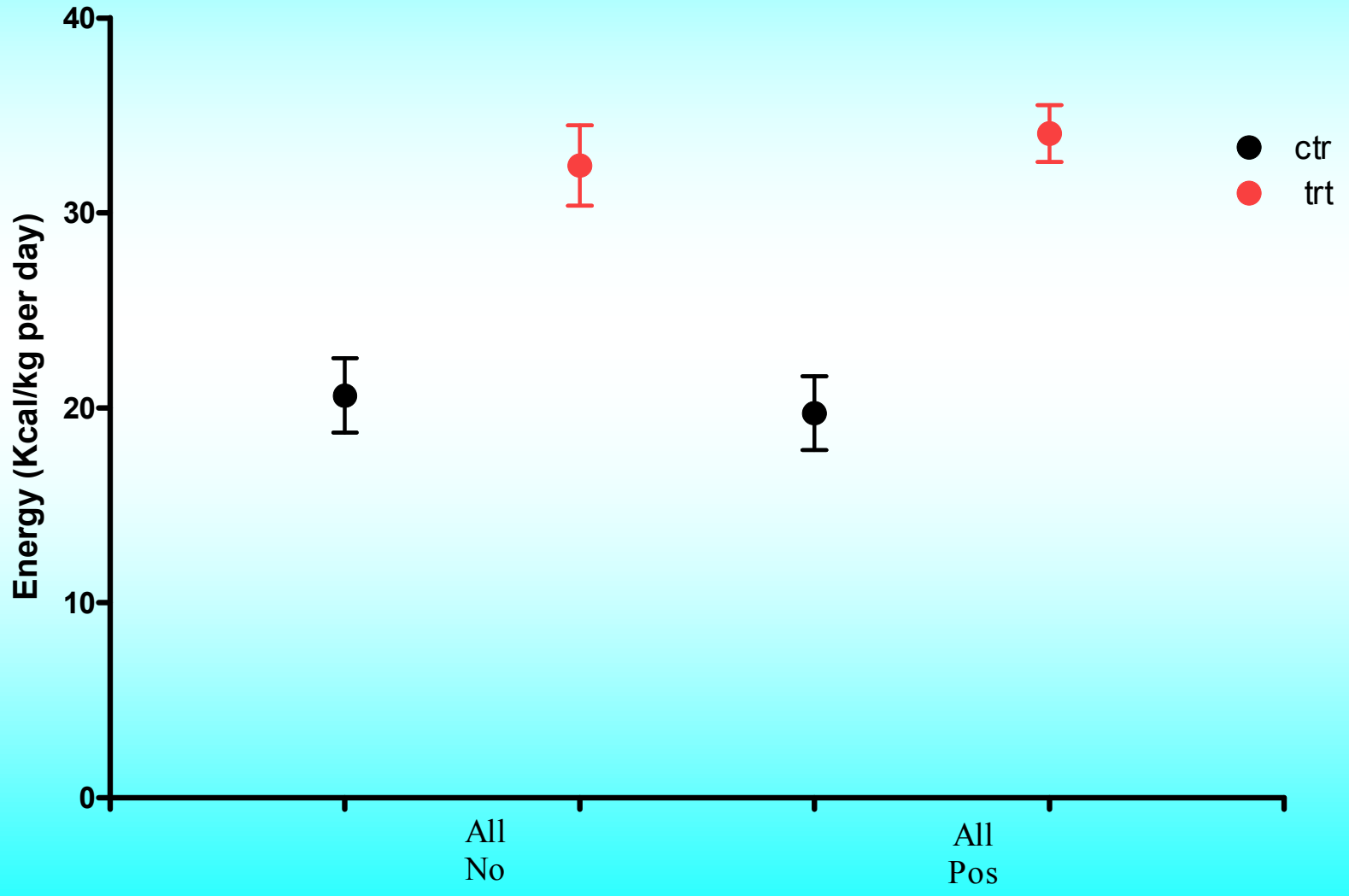
Mean ± SEM No: RCTs with no clinical effect; Pos: RCTs with positive clinical effect



Energy dosage in RCTs

Unpublished data from Kondrup et al. Clin Nutr 2003; 22: 321-336

Mean ± SEM No: RCTs with no clinical effect; Pos: RCTs with positive clinical effect



Protein/AA Energy% in RCTs

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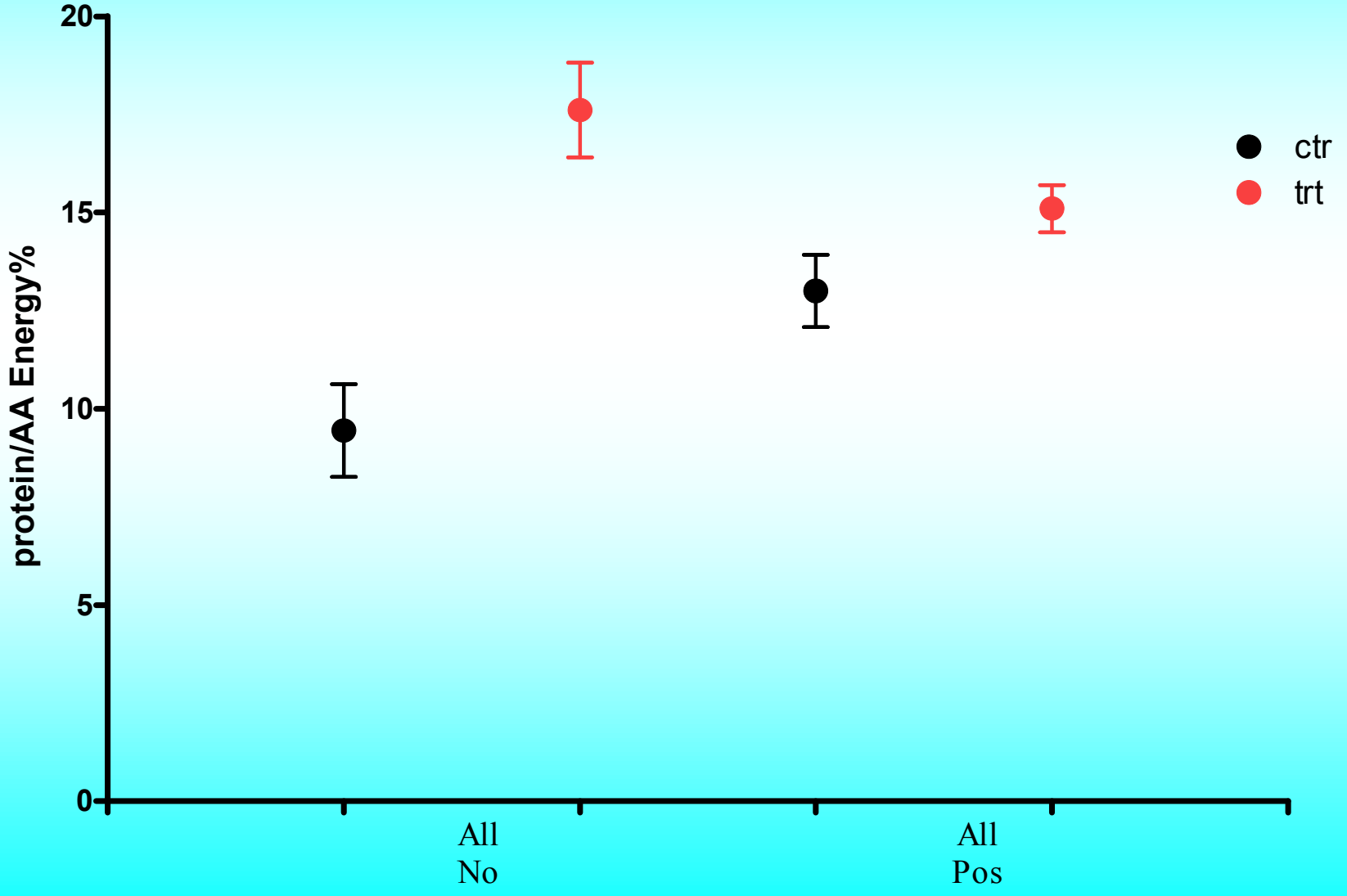
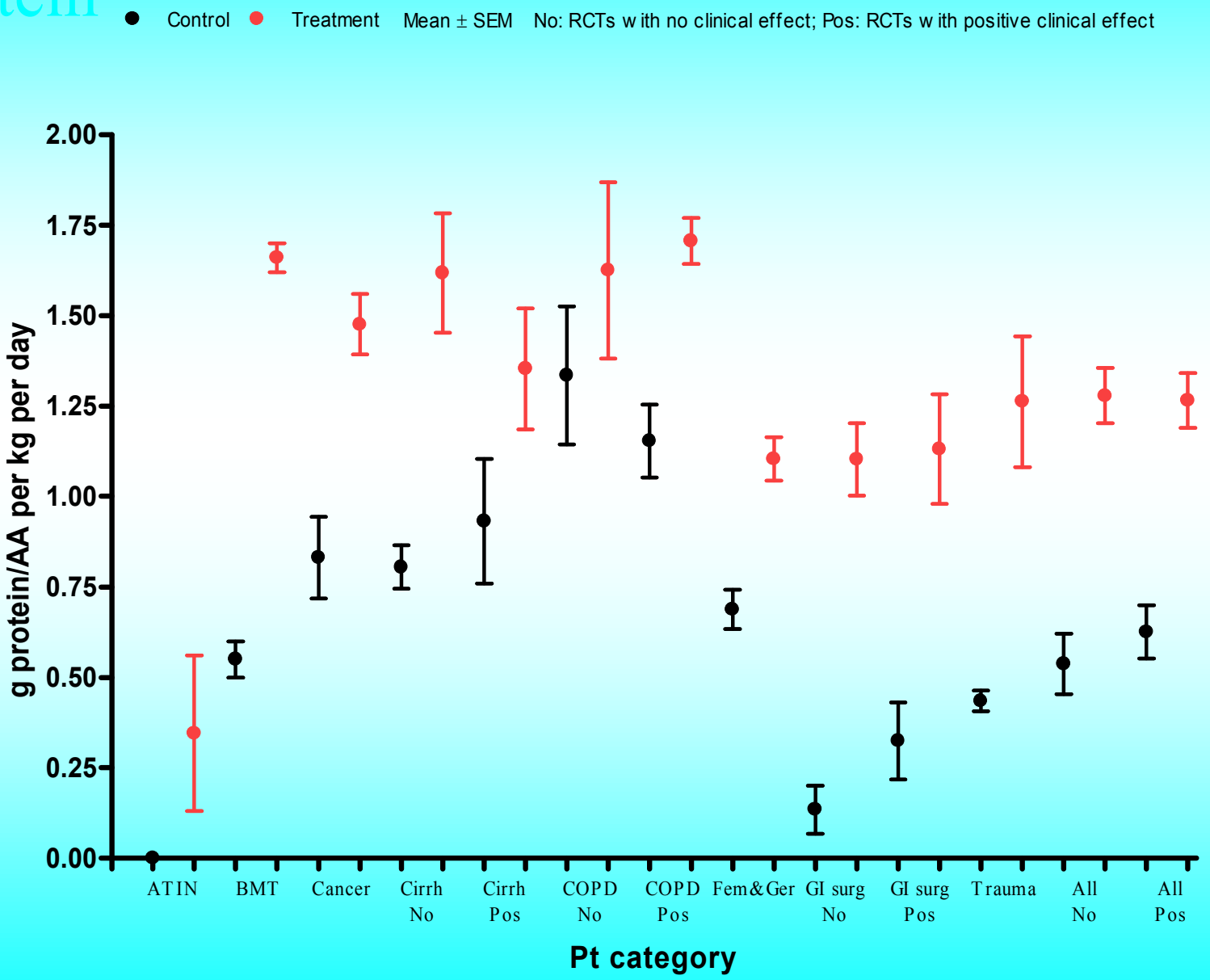
Mean ± SEM No: RCTs with no clinical effect; Pos: RCTs with positive clinical effect



RCT protein

Protein/AA dosage in RCTs

Unpublished data from Kondrup et al. Clin Nutr 2003; 22: 321-336

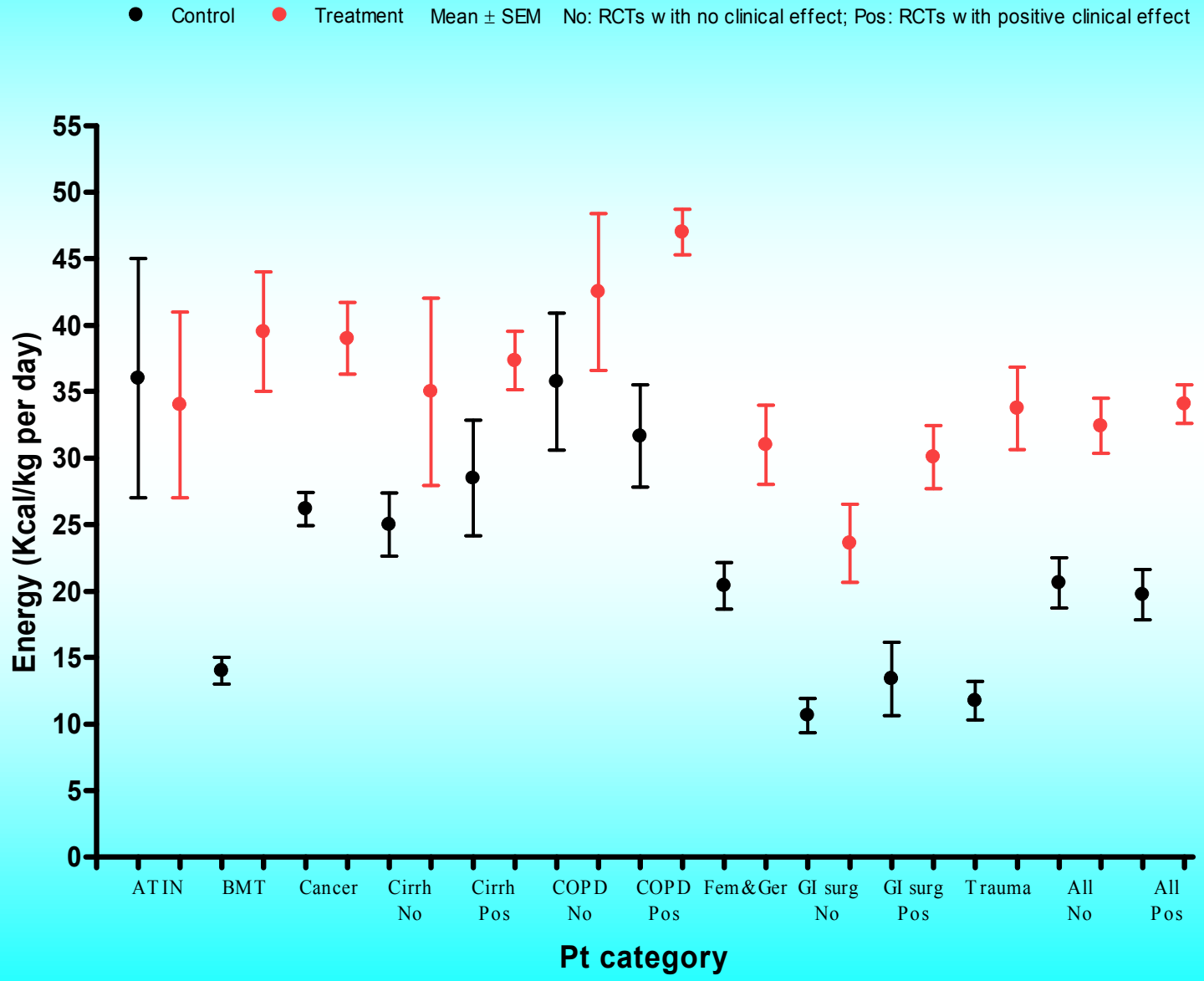


RCT

energy

Energy dosage in RCTs

Unpublished data from Kondrup et al. Clin Nutr 2003; 22: 321-336

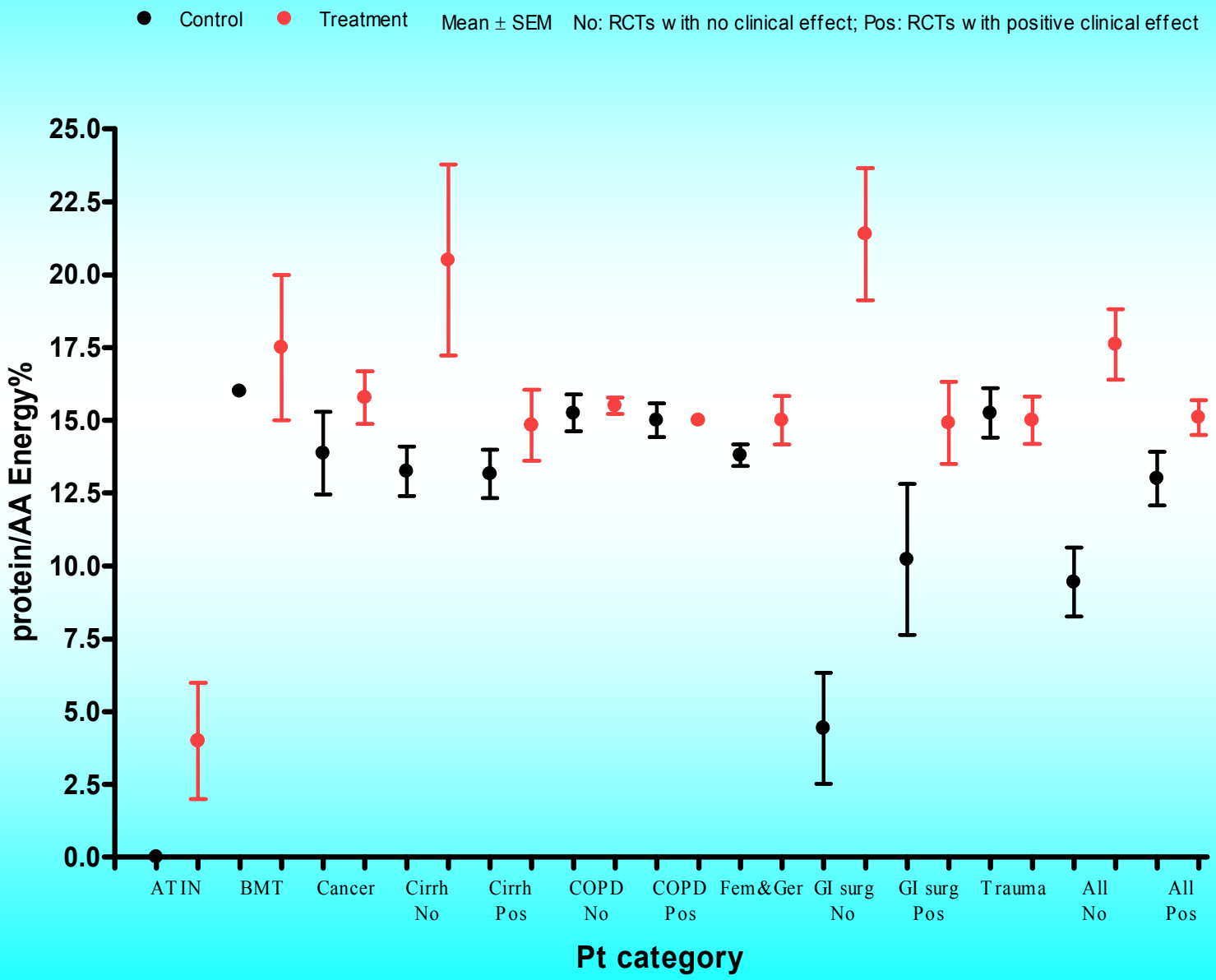


proteinE

%

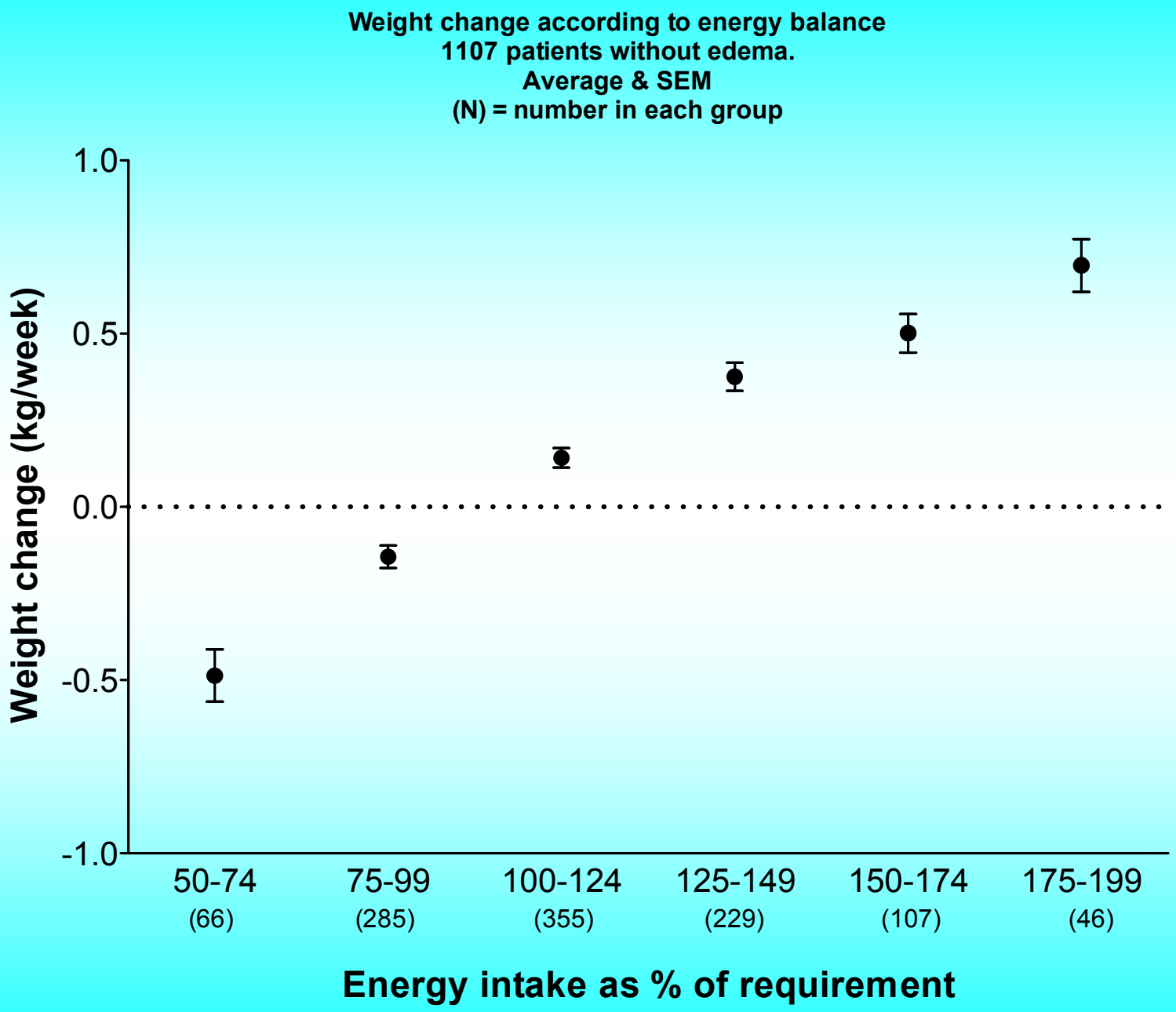
Protein/AA Energy% in RCTs

Unpublished data from Kondrup et al. Clin Nutr 2003; 22: 321-336



Vitaminer - mineraler

- husk vitaminpille


Weight change according to energy balance
1107 patients without edema.
Average & SEM
(N) = number in each group
Weight change (kg/week)
1.0
0.5
0.0
-0.5
-1.0
50-74
(66)
75-99
(285)
100-124
(355)
125-149
(229)
150-174
(107)
175-199
(46)
Energy intake as % of requirement

Empiric disease factor

EDF = (Energy intake-Energy equivalent of weight change)/(BMR x AF x SF)
Mean ± SEM (N)

Benign, no stress	1.07 ± 0.03 (229)
Benign, stress	1.09 ± 0.03 (161)
Malignant hematology, chemo	1.00 ± 0.03 (135)
Malignant solid, chemo/radio	0.94 ± 0.03 (220)
Allogenic Bone Marrow Transplantation	1.02 ± 0.02 (126)
Organ Transplantation	1.32 ± 0.05 (86)
Ileo-/jejunostomy	1.43 ± 0.06 (52)
Aim weight gain; 0.4 kg/week obtained	1.11 ± 0.01 (706)

How much energy?

Energy should be given according to measurements – not recommendations

ESPEN Guidelines on parenteral nutrition:ICU Clin Nutr 2009; 28: 387-400

Energy equations

Continuous (24 h/day for ≥ 5 days) indirect calorimetry in general ICU patients requiring mechanical ventilation for ≥ 5 days.

Mean admission APACHE II: 20.

192 days of measurements in 27 patients. Mean TEE was 27.4 kcal/kg or 2053 kcal/day.

Reid. Clin Nutr 2007; 26: 649–657

Table 3 Number (%) of energy expenditure estimates (calculated using the different equations) within 80% and 110% of TEE values and the number (%) of estimates that would result in under (<80% TEE) and overfeeding (>110% TEE).

Equation	Percentage of estimates within 80–110% of TEE	Percentage of estimates <80% of TEE	Percentage of estimates >110% of TEE
HB (acBW)+30% SF	65.7	16.1	18.2
HB (adBW)+30% SF	60.4	21.9	17.7
Ireton-Jones (acBW)	52.1	25.5	22.4
Ireton-Jones (adBW)	49.5	28.1	22.4
Schofield (acBW)+30% SF	65.6	15.1	19.3
Schofield (adBW)+30% SF	61.5	20.3	18.2
ACCP (acBW) 25 kcal/kg per day	64.6	22.9	12.5
ACCP (adBW)	63.5	27.1	9.4

TEE = total energy expenditure; HB = Harris-Benedict; acBW = actual body weight; SF = stress factors; adBW = adjusted body weight; ACCP = American College of Chest Physicians.

Tight calorie control decreases hospital mortality.

RCT; 2 N = 130. Critically ill patients (APACHE II score ≈ 23) with expected LOS ≥ 3 days randomized to

1) 25 Kcal/kg per day or

2) energy = REE measured every 48 hours by indirect calorimetry

Anbar et al. Clin Nutr Supplements 2009; 4(2):7 (abstract)

	25 kcal/kg/day	REE study
Energy, kcal per day	1480	2096
Protein/AA, g per day	53	76
Cumulative energy balance, kcal	- 3486	2008[1)]
Length of Ventilation	12	17[2)]
Length of Stay ICU	13	19[2)]
Hospital survival, %	28	48[3)]

[1)] $P<0.001$ [2)] $P<0.015$ [3)] $P=0.03$

N.S.: age, weight, REE, APACHE II score, SOFA scores, mean glucose level hospital LOS

How much protein?

When PN is indicated, a balanced amino acid mixture should be infused at approximately 1.3 – 1.5 g/kg ideal body weight per day in conjunction with an adequate energy supply.
(Grade B)

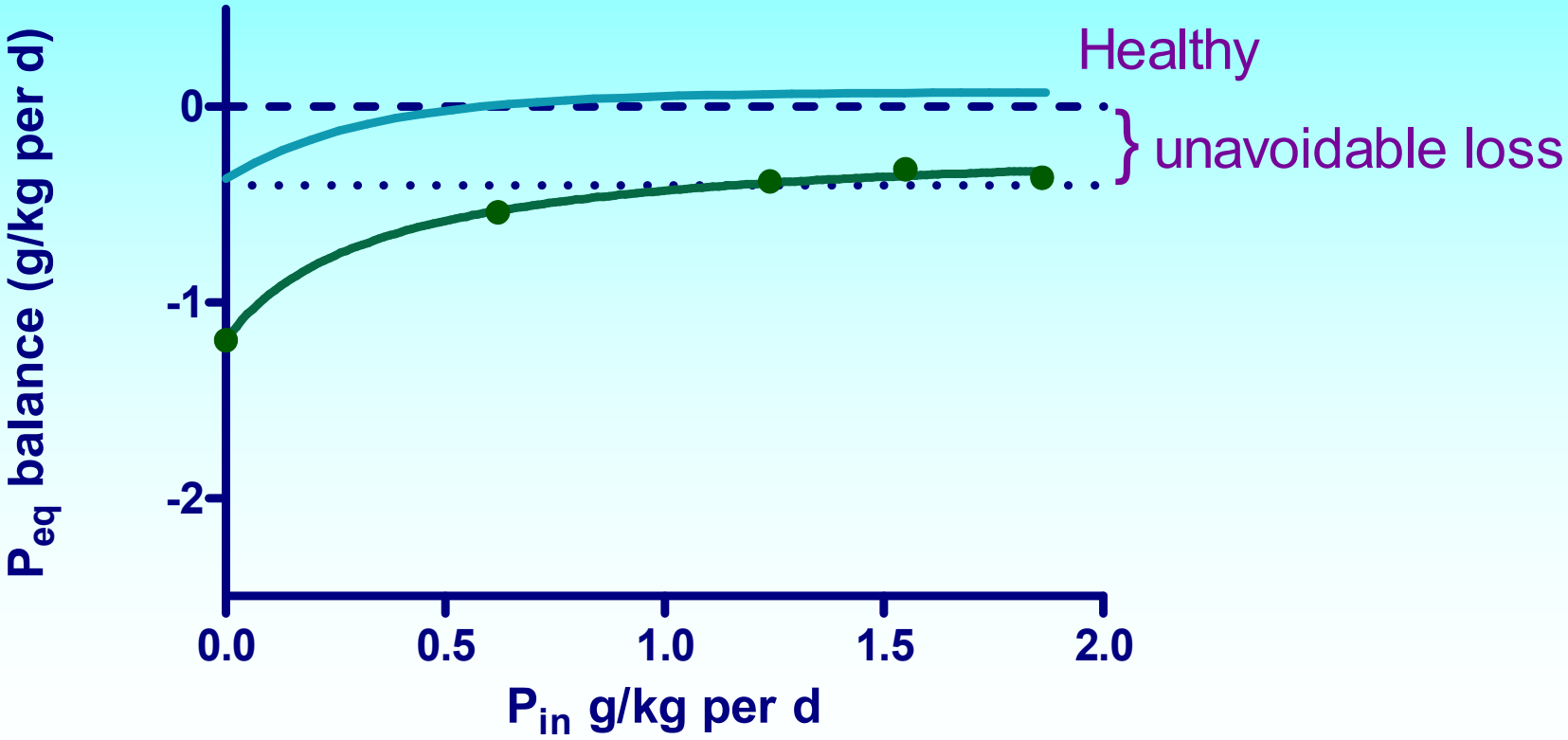
- Balanced amino acids mixture is similar to essential amino acid requirements in healthy subjects
- Lean tissue loss is unavoidable in patients with severe trauma or sepsis
- The loss is minimized with 1.3 – 1.5 g/kg per day

ESPEN Guidelines on parenteral nutrition Clin Nutr 2009; 28: 387-400

Protein recommendation and unavoidable loss

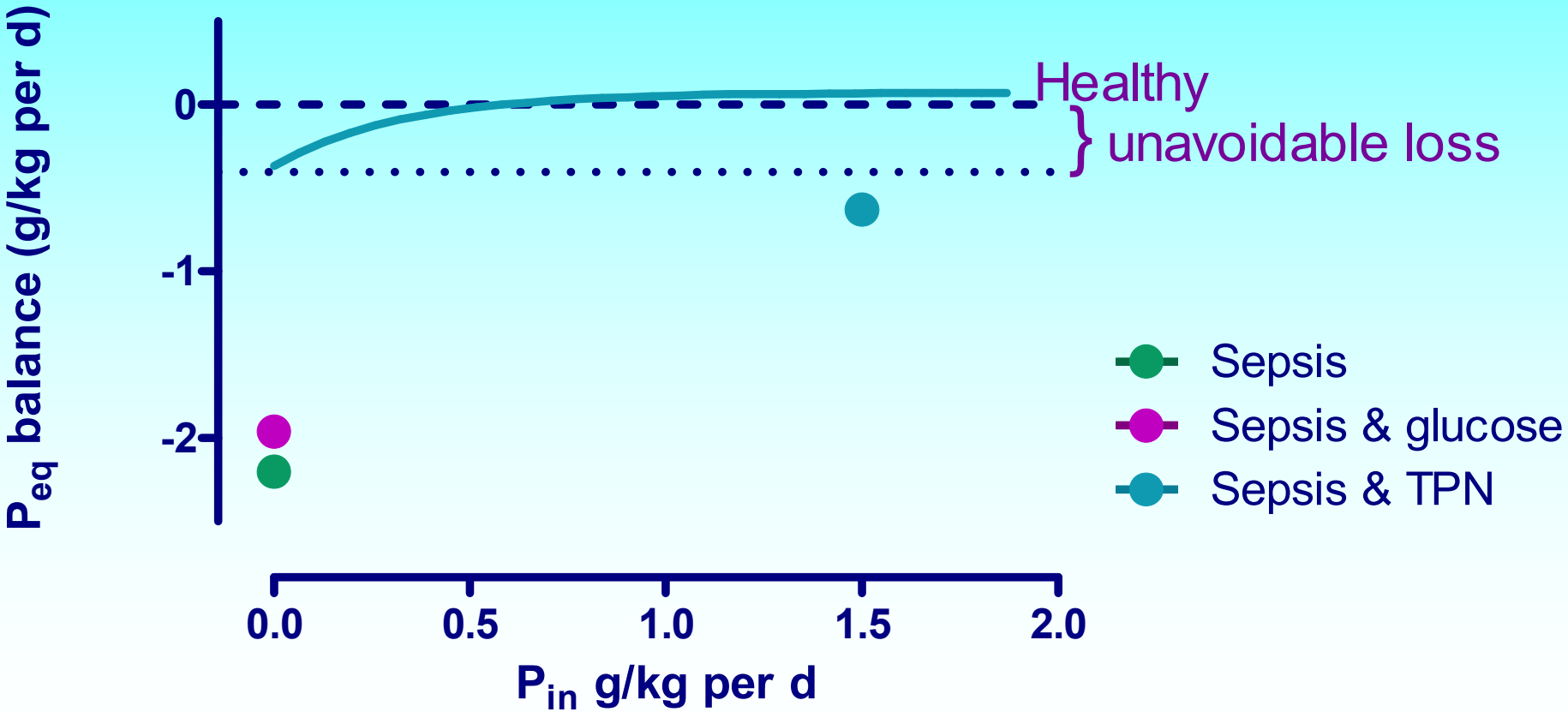
Larsson et al. Br J Surg 1990; 77: 413-16.

Severely injured patients with a burn or fractures of more than two long bones

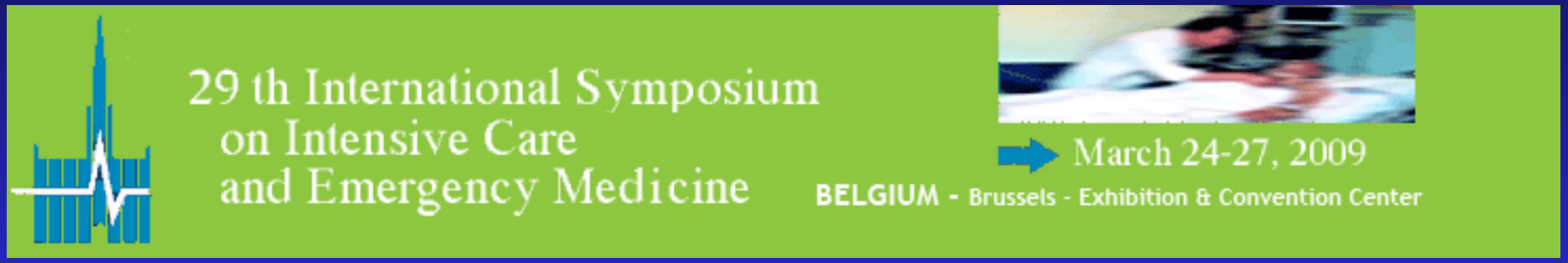


Protein recommendation and unavoidable loss

Shaw et al. Ann Surg 1987;205:288-94.
Severe sepsis



A few slides from…



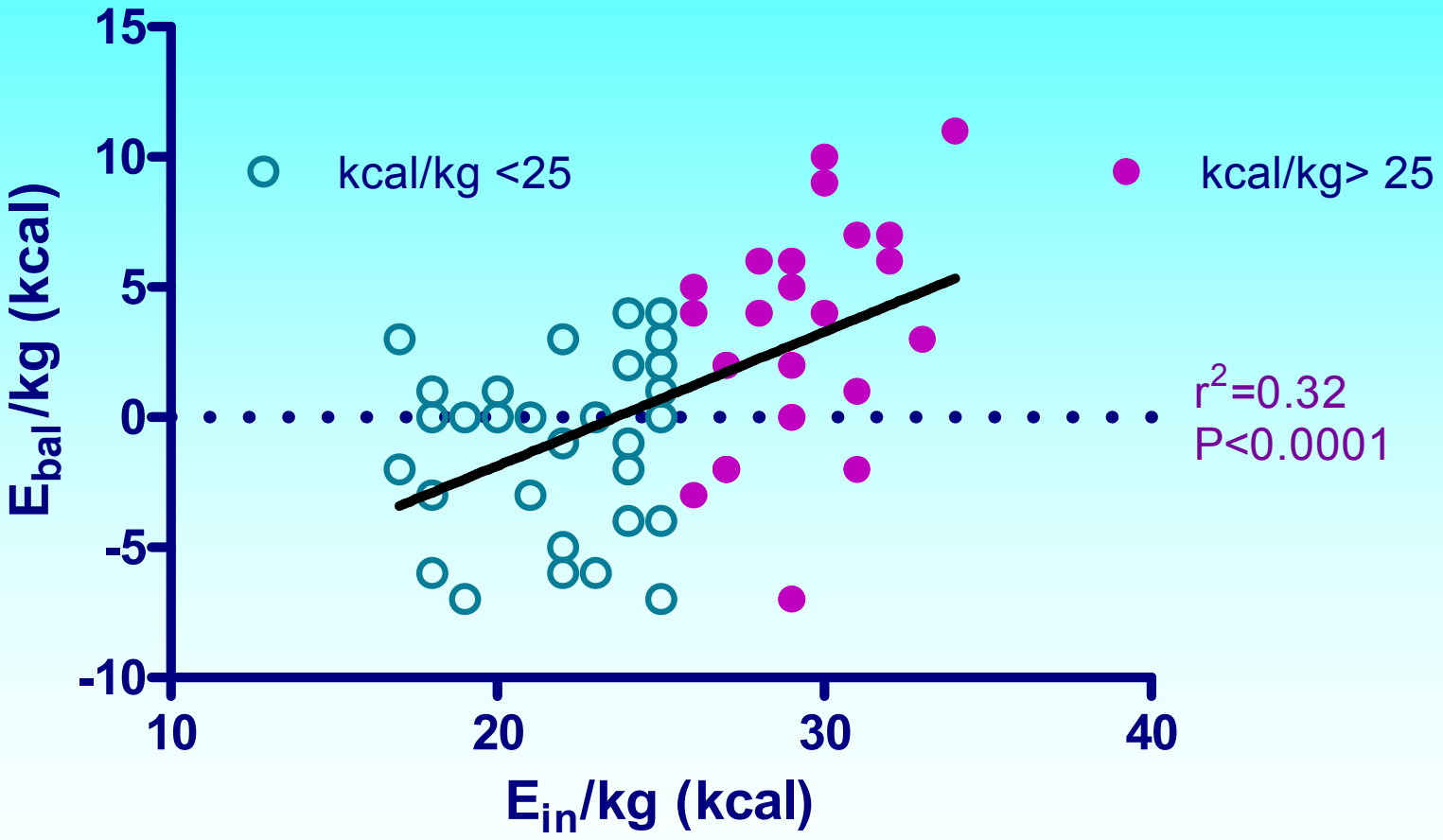
Measured vs predicted energy and protein requirements

A Wilkens
K Espersen
J Kondrup

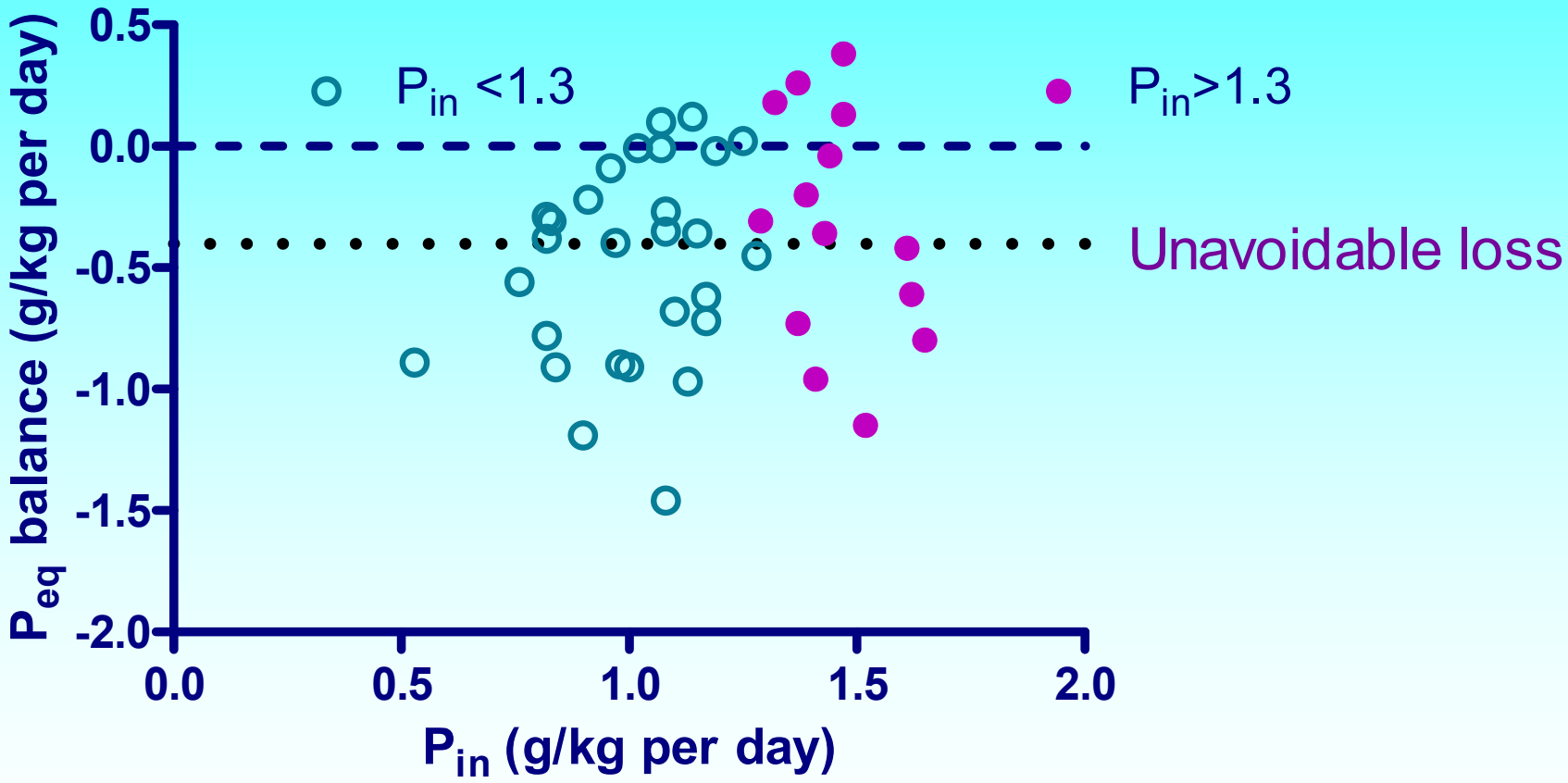
55 consecutive patients included in January-May 2006 (mean ± SEM)

Age, yrs	60 ± 2
BMI	25.7 ± 0.6
APACHE II	22.1 ± 0.9
SIRS score	1.8 ± 0.1
SOFA score	6.5 ± 0.4
P-glucose, mmol/l	9.1 ± 0.3
LOS, d	10 ± 1
N days with measurements	6 ± 1

Energy balance according to < or >25 Kcal/kg given



$Protein_{eq}$ balance according to < or >1.3g/kg given



Many patients with unacceptable loss
Balance not related to P_{in}

Conclusions from ISICEM:

Energy and protein balances do not change in parallel:

- Avg. measured REE = 1.2 x H-B (this study ≈ others)
- Avg. measured $protein_{eq}$ loss = 1.6 g/kg per day – at an avg. dose of 1.2 g/kg per day (1.5 x recommendation for healthy)

- Protein balance is more severely affected and less predictable than energy balance
- Protein balance should be measured and treated (as REE)
- This should be tested in a clinical outcome RCT

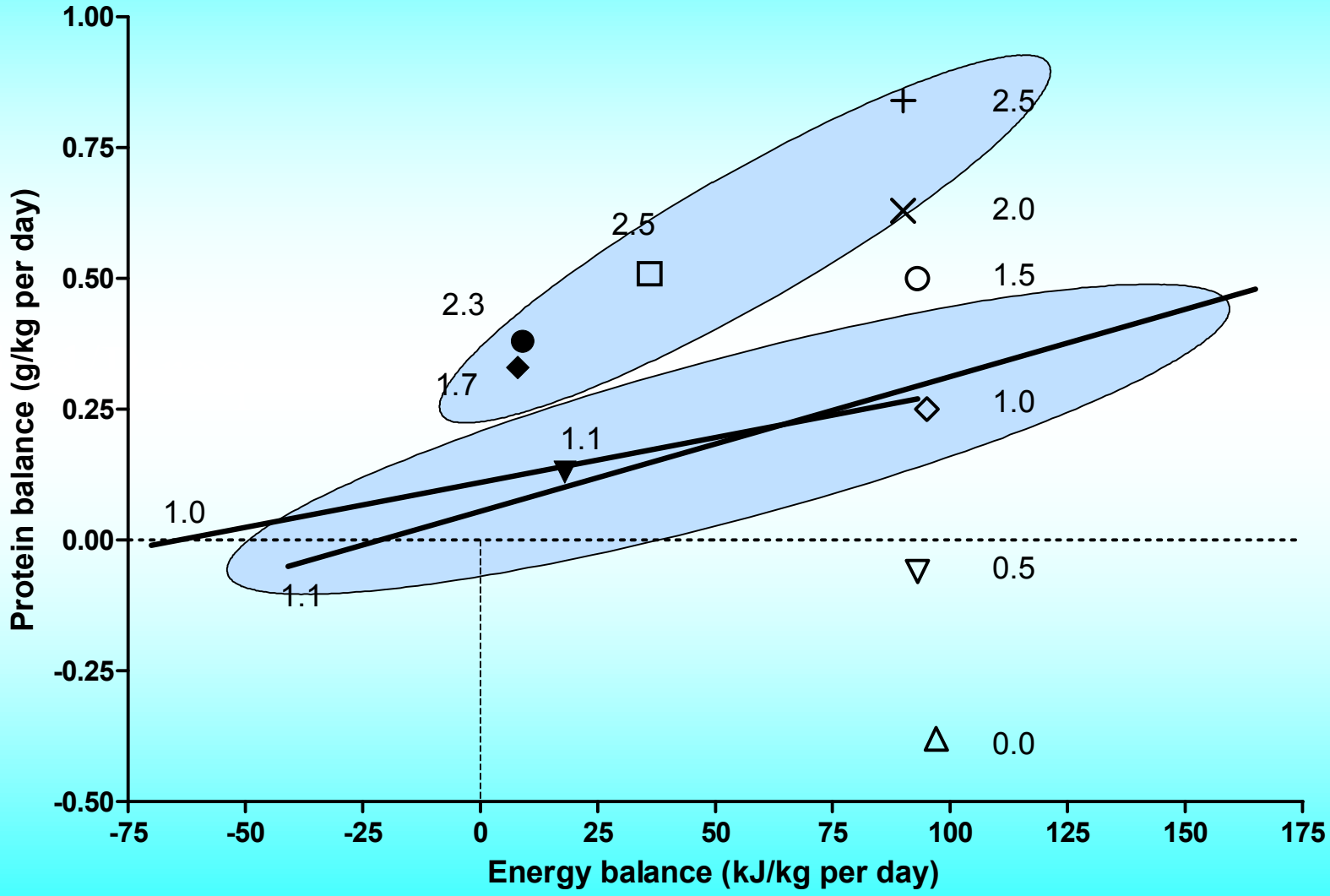
Conclusions from today:

- Still too little evidence for the clinical benefit of PN in ICU patients – all Grade C recommendations.
- By inference, it seems appropriate to give PN when EN is impossible at admission, or insufficient.
- Energy balance should be measured – it improves survival (single centre study).
- Protein requirements are recommendations today – and perhaps measured values in the future

Protein balance & Energy balance

Chikenji et al. Clin Sci 1987; 72: 489-501

Numbers: protein intake (g/kg per day)



FIN

Beregning af N balance→

N balance

Nitrogen balance = $N_{ind} - N_{ud}$

N_{ind} = Protein ind/6.25 ≈ 100/6,25 = 16 g N

N_{ud} = dU-N + dF-N + øvrige (hud, sekreter)

Souba: ikke stress-metabole

Souba et al. *in* Shils et al. Modern Nutrition in Health & Disease 8th edition 1994; 1207-1240

dU-N = dU carbamid-N x 1.25 Souba

Bistrian: stress-metabole

Blackburn et al. J Par Ent Nutr 1977; 1:11-22

dU-N = dU carbamid-N + 2 Bistrian

Metabolisk proteinbehov

Faeces + hud + sekret: (0.125 + 0.03) g prot/kg per dag
≈ 2g N/70 kg per dag

Metabolisk proteinbehov

Faeces + hud + sekret: (0.125 + 0.03) g prot/kg per dag
≈ 2g N/70 kg per dag

N_{ud} = dU carbamid-N x 1.25 + 2 Souba
N_{ud} = dU carbamid-N + 2 + 2 Bistrian

Metabolisk proteinbehov

dU carbamid (mmol/dag) → g ”prot”/dag:

(dU-carbamid (mmol) x 60 mg/mmol x 28/60 (N/M) x 6.25)/1000 mg/g

g ”prot”/dag = 0.175 x dU carbamid (mmol/dag)

Metabolisk proteinbehov

Metabolisk proteinbehov:

dU-carbamid (mmol/dag) x 0.175 x 1.25 + 2 x 6.25 Souba

dU-carbamid (mmol/dag) x 0.175 + (2 + 2) x 6.25 Bistrian

→

dU-carbamid (mmol/dag) x 0.22 + 12.5 Souba (dU-carbamid < 200)

dU-carbamid (mmol/dag) x 0.18 + 25 Bistrian (dU-carbamid > 400)

Protein-indhold i sekreter m.v.

Pitkänen et al. Clin Nutr 1991; 10: 258-265

Plasma	70 g/l
Lymfe	35 g/l
Ventrikel aspirat	10 g/l
Blodholdigt abdominalt sekret	39 g/l
Blodholdig pleuravæske	31 g/l
Serøs pleuravæske	12 g/l