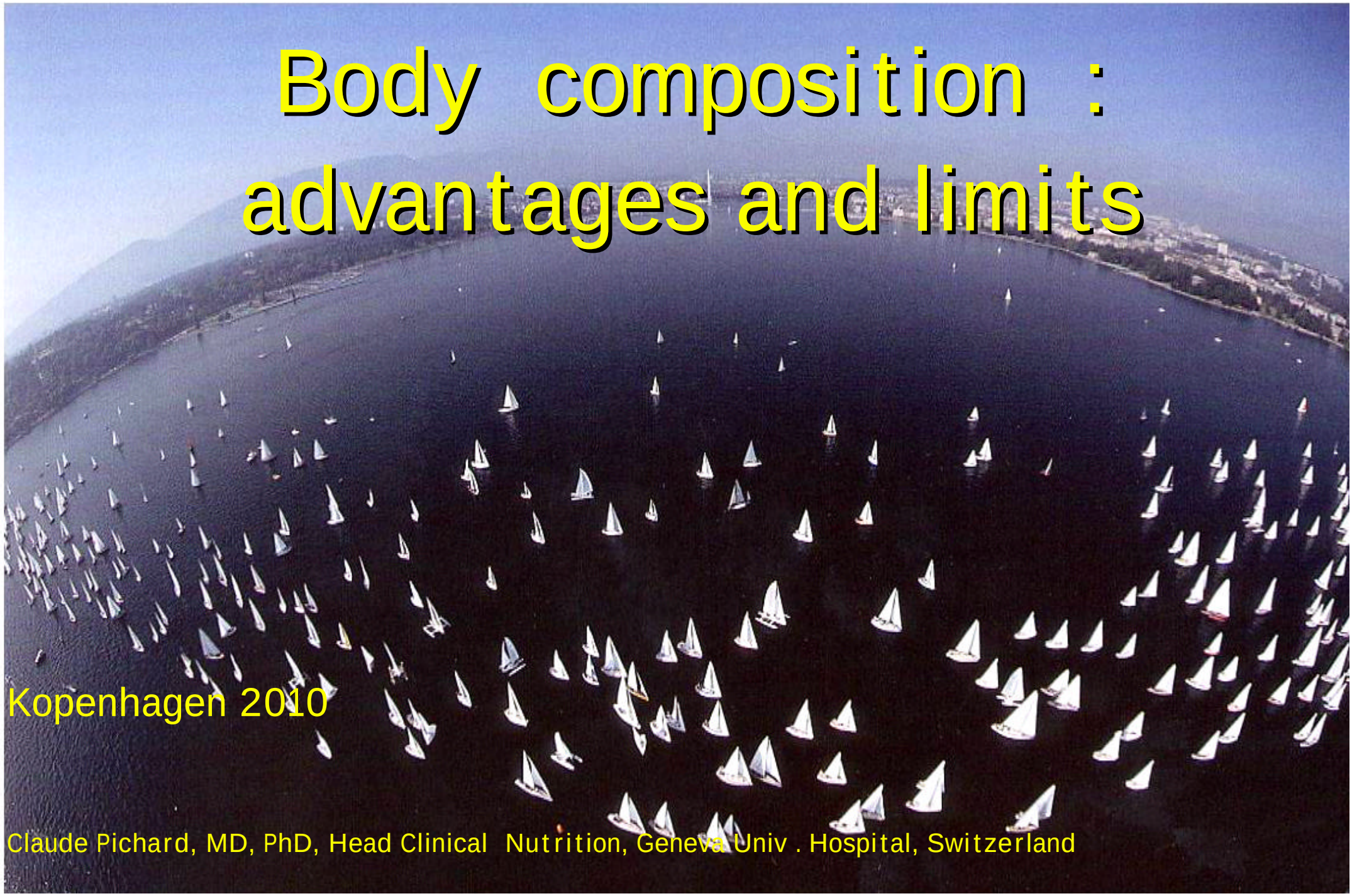
Body composition : advantages and limits



Kopenhagen 2010

Claude Pichard, MD, PhD, Head Clinical Nutrition, Geneva Univ . Hospital, Switzerland

MESSAGES

Body composition :

1. Integrates energy and protein " Intakes - Losses - Needs"
2. Is correlated with nutritional risks and clinical outcome
3. Is contributive to document the efficiency of nutrition support
4. Allows to tailor treatments to patient's characteristics

MESSAGES

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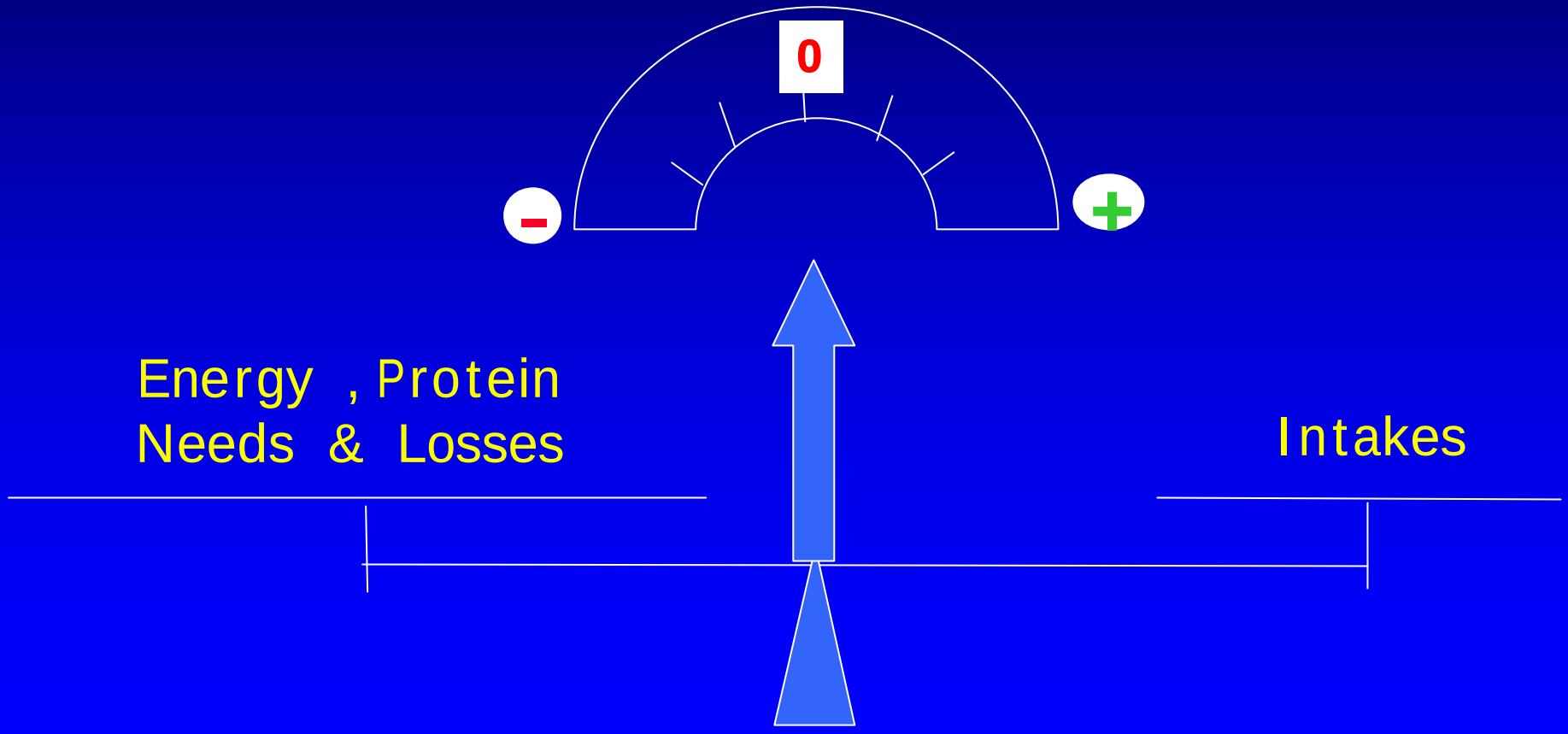
1. **Integrates energy and protein " Intakes - Losses - Needs "**
2. Is correlated with nutritional risks and clinical outcome
3. Is contributive to document the efficiency of nutrition support
4. Allows to tailor treatments to patient's characteristics

Body composition (BC) changes with

Deltas (Intakes – Losses - Expenses) over Time



Undernutrition

Women 30 yr, 60 kg / 173 cm, h

Temperature : J1 - 6 d

INTAKE

kcal

D 6 ’350 kcal

50 % g protein ~ 4.0 kg lean tissue

50 % : 7 = 460 g fat ~ 0.5 kg fat tissue

Water retention : 3.5 kg

Measured BW loss : 1 kg

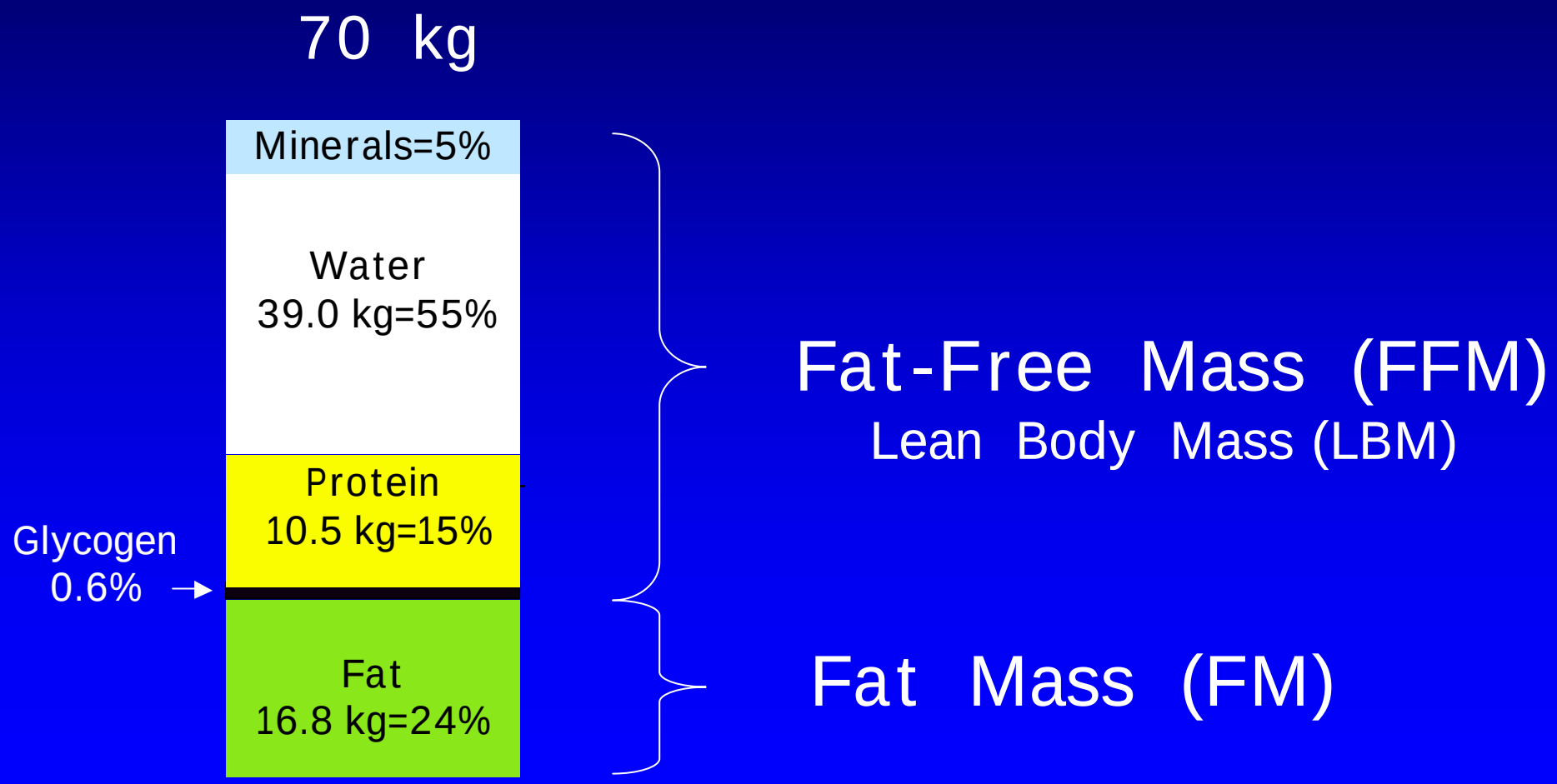
Tissue loss : 4.5 kg

Body Weight loss (%)	Protein loss * (%)
5	11.2 - 16.8
10	15.2 - 20.8
15	19.2 - 24.8
20	23.0 - 29.0
25	26.8 - 33.2

* in vivo neutron analysis. Hill G.L. J Parent Enteral Nutr 16, 197-218, 1992

Body composition measurements during wasting diseases

C. Pichard et al. Curr Op Clin Nutr 1998, 1: 357-61

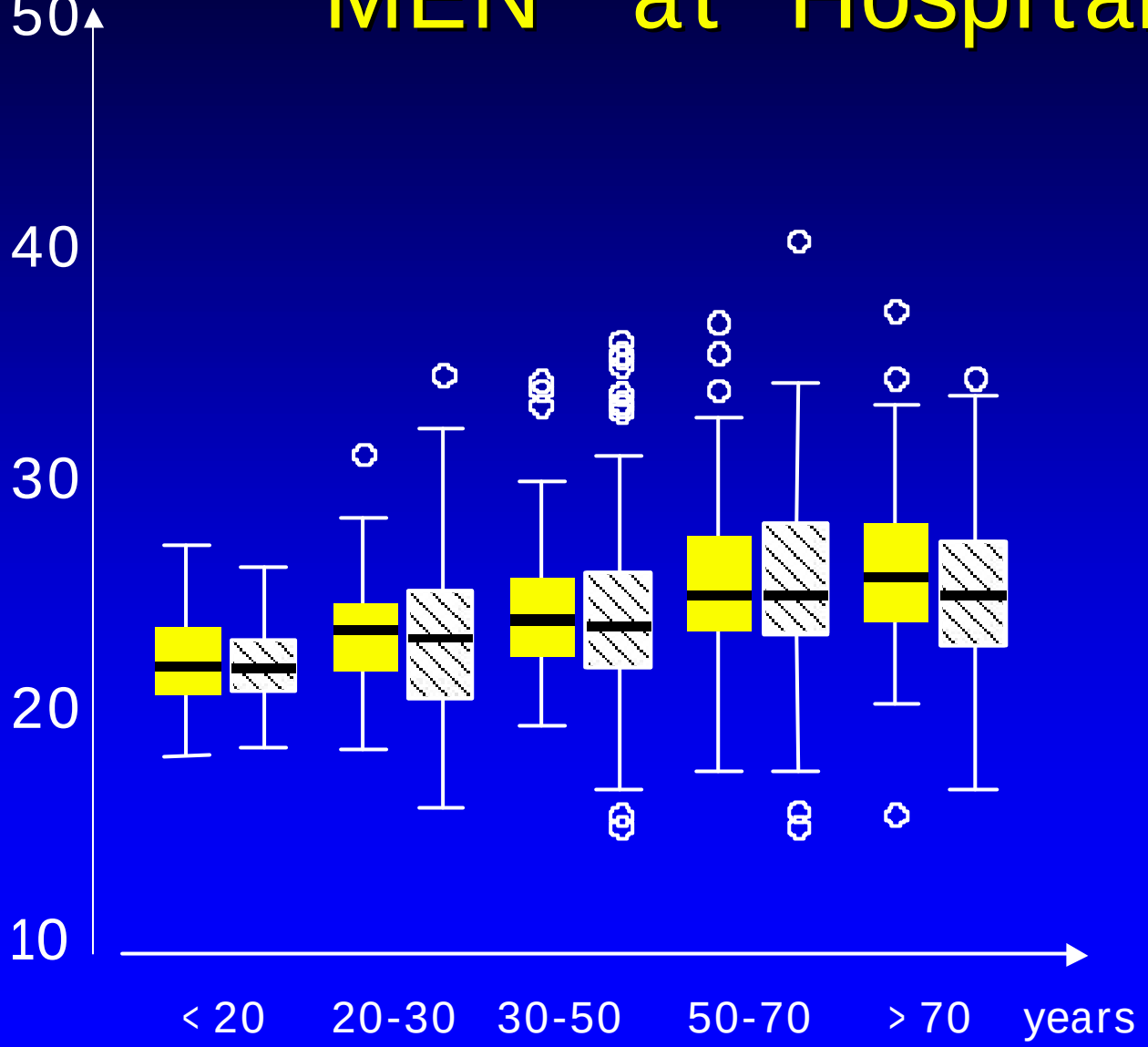


Contribution of body composition to nutritional assessment at hospital admission in 995 patients:

A controlled population study

Kyle UG et al. Brit J Nutr 2001, 86: 725-731

Body Mass Index (kg/m^2): MEN at Hospital Admission



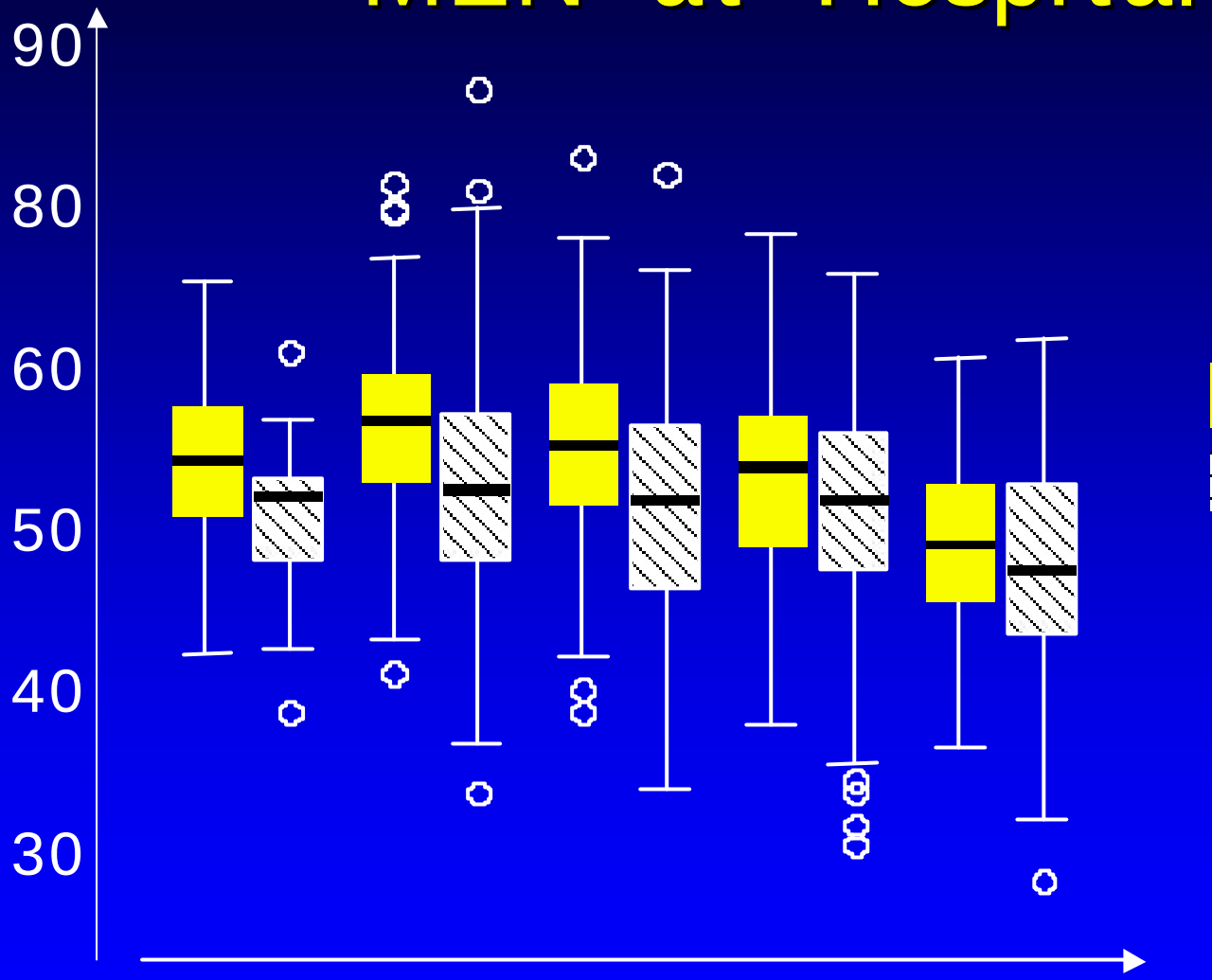
controls, n = 619

patients, n = 471

x ± SD

Kyle U. et al.
Brit J Nutr 2001
86: 725-731

Fat - Free Mass (kg) : MEN at Hospital Admission



controls, n = 619
patients, n = 471

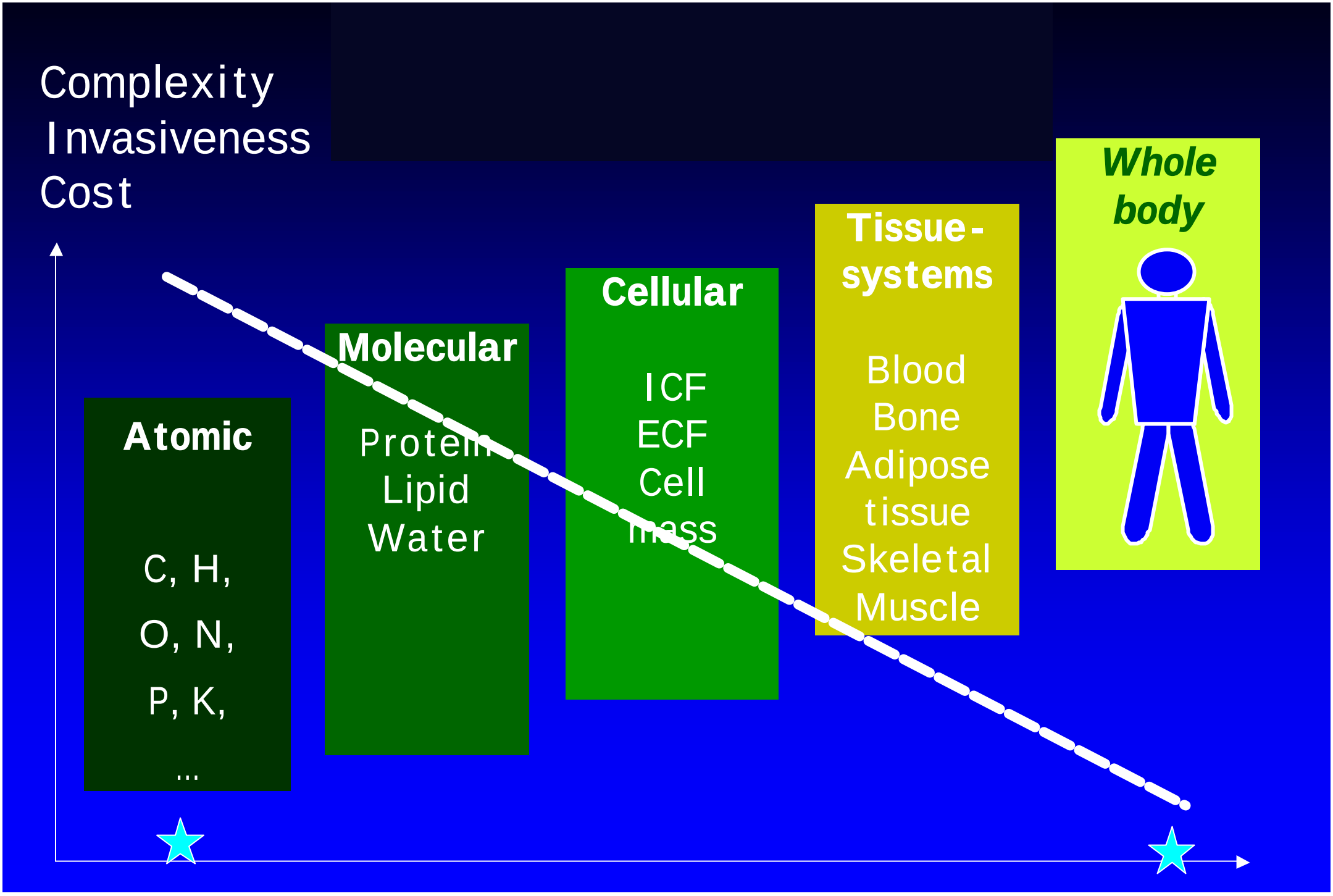
x ± SD

Kyle U. et al.
Brit J Nutr 2001
86: 725-731

Methods

to measure

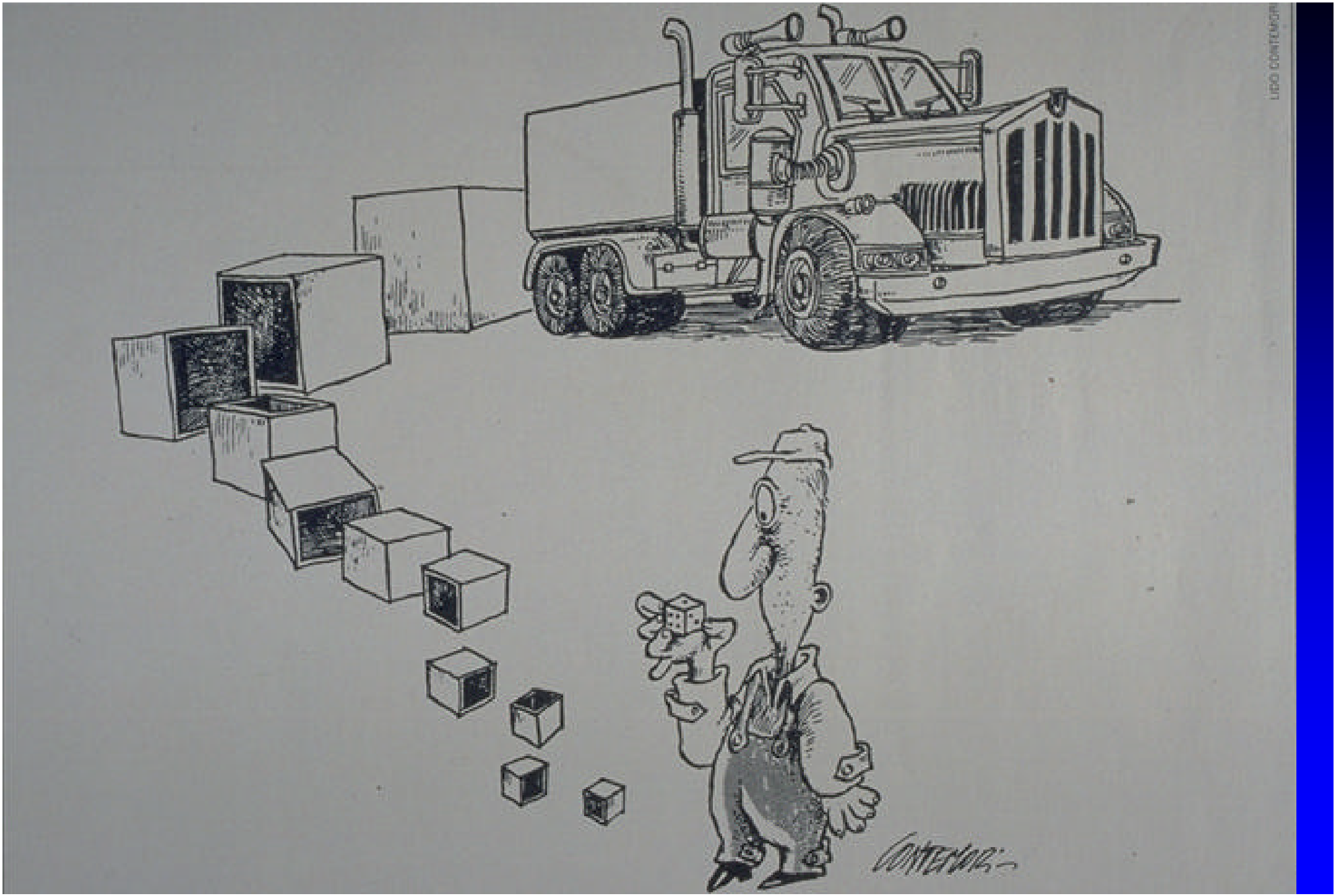
Body Composition


Complexity
Invasiveness
Cost
Atomic
C, H,
O, N,
P, K,
...
Molecular
Protein
Lipid
Water
Cellular
ICF
ECF
Cell
mass
Tissue-
systems
Blood
Bone
Adipose
tissue
Skeletal
Muscle
Whole
body

Anthropogammametry

Total Body ^{40}Potassium

Pierson RN et al.
Am J Physiol 1984, 246: F234-F239



Skinfolds

Sites

triceps, biceps, subscapular, supra-iliac, abdominal, thigh

✍ Fat Mass

Limitations

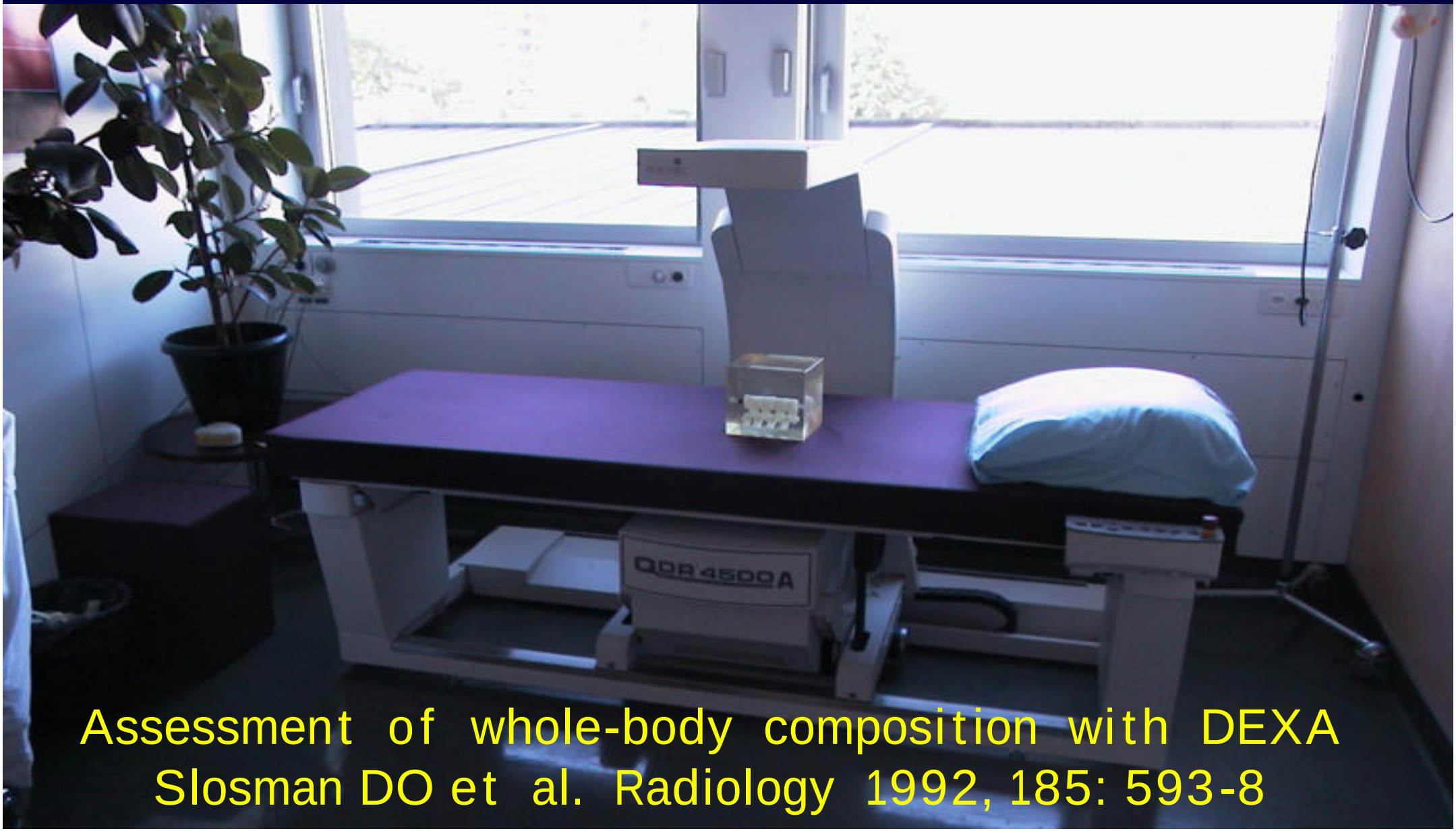
- Equations
- References
- Interobserver variability
- …

? Age

Obesity

} FM underestimation

Dual X-ray Absorptiometry (DEXA)



Assessment of whole-body composition with DEXA
Slosman DO et al. Radiology 1992, 185: 593-8

Dual X-ray Absorptiometry (DXA)

Fat Mass

Lean Body Mass

Total Mass

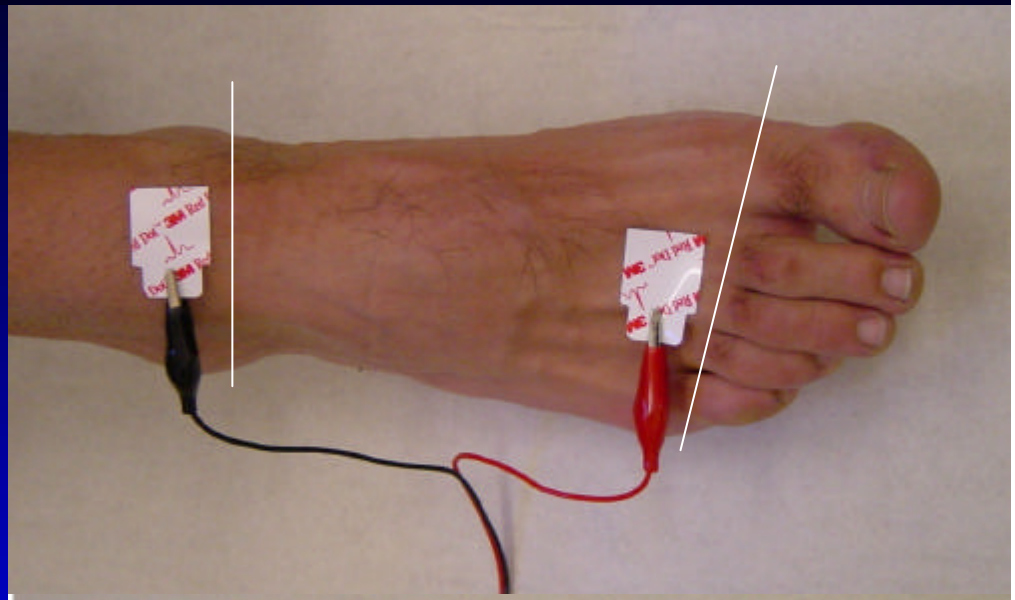
Dual X-ray Absorptiometry (DEXA)

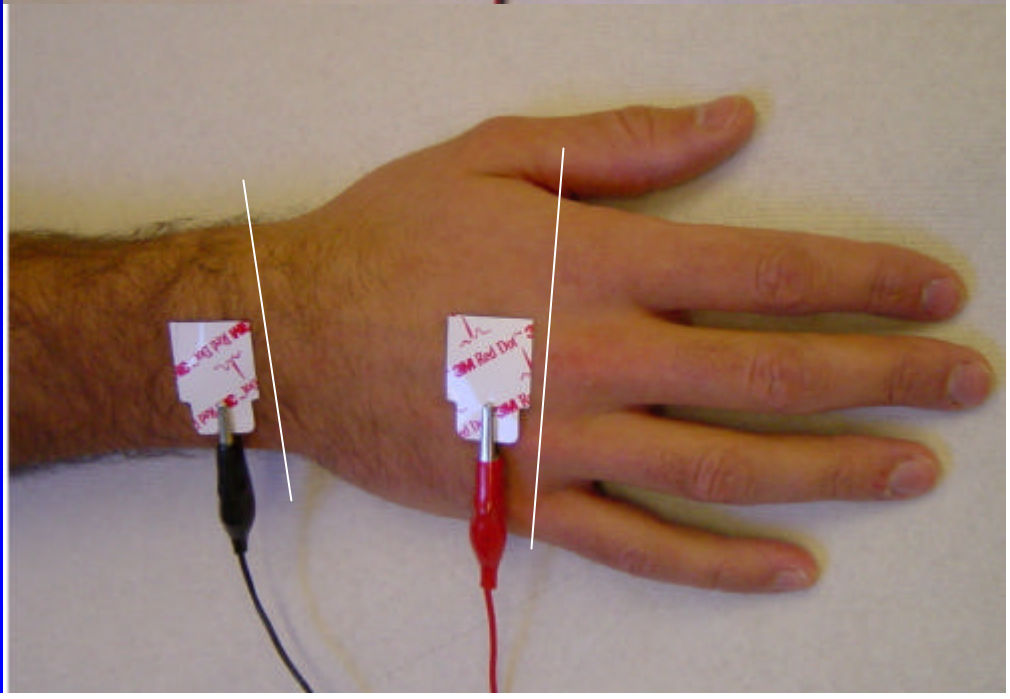
Limitations

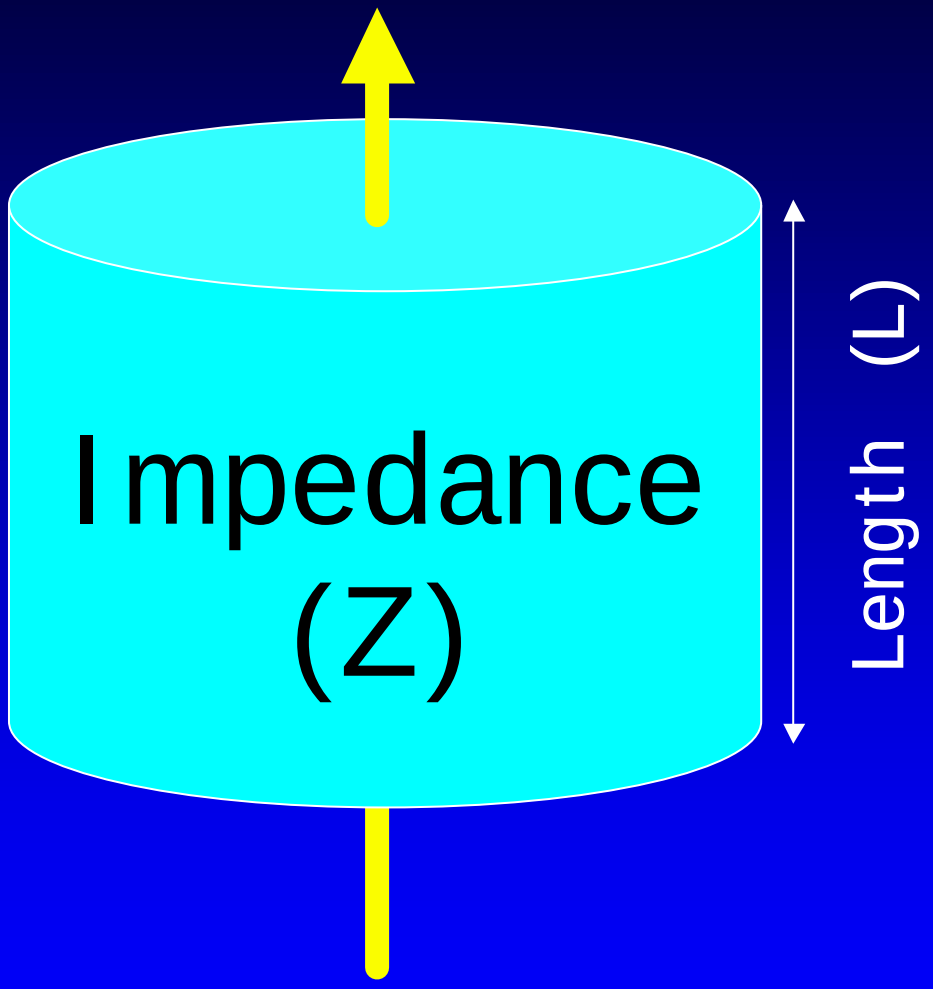
- Callibration
  - CV: FFM 0.7, FM 1.9 %
  - Precision: FFM 1.2, FFM 2.0 %
- Equations: hydration, extreme BMIs
- Cost
- X-rays exposure

Leonard CM et al. Pediatr Radiol 2009, 39: 148–154
Genton L et al. Clin Nutr 2006, 25: 428-437
Slosman DO et al. Radiology 1992, 185: 593-598

Bioelectrical Impedance Analysis (BIA)





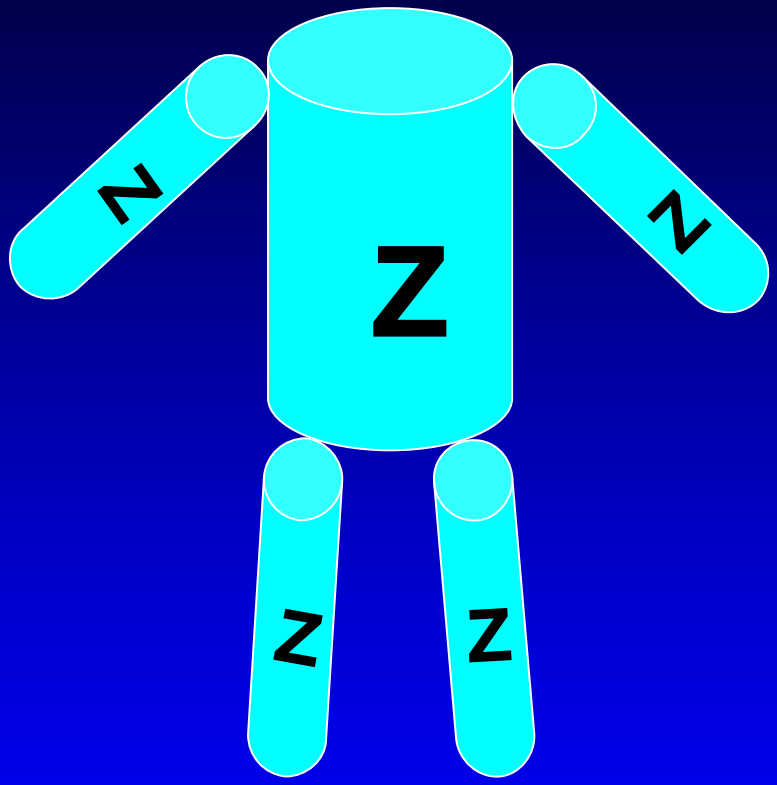


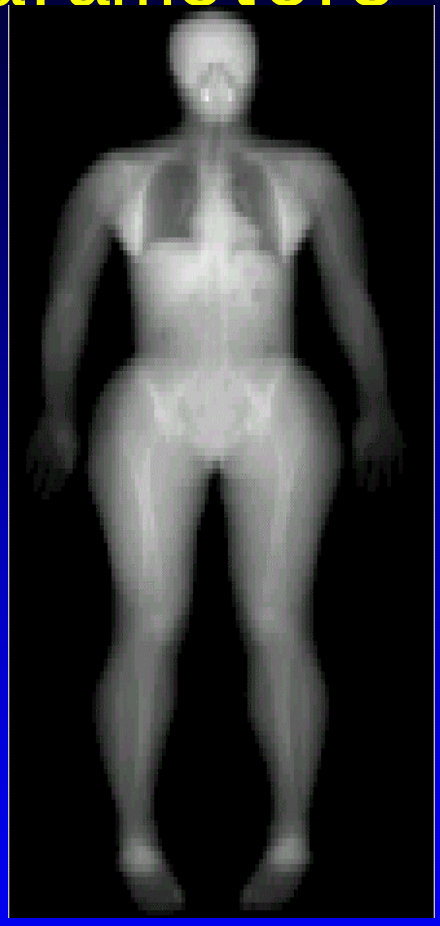
OHM ‘s Law :

Impedance (Z) =

(L^2) * Volume

From the modelisation of the whole body, we can derived body composition parameters





$$\text{Fat-free mass} = K^1 * K^2 * (W \times P) / Z * L^2$$

K^1, K^2 = constants; W = specific electrical conductivity; P = density

Resistance (R) = Opposition of a conductor to an alternating current

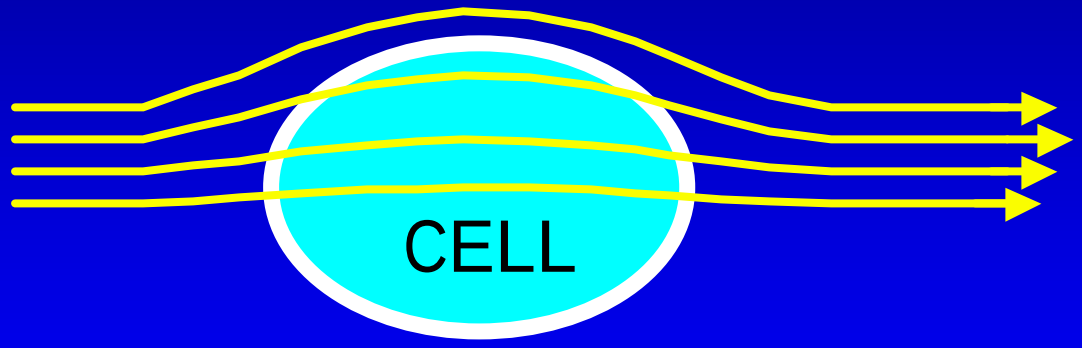
<-> total water & electrolytes
(e.g. Traffic speed limit)

Reactance (Xc) = Opposition which a condenser offers to an alternating current

<-> cell membranes are mini condensers
<-> cell mass
(e.g. Traffic lights)

Impedance (Z) = $\sqrt{R^2 + Xc^2}$

Signal frequencies



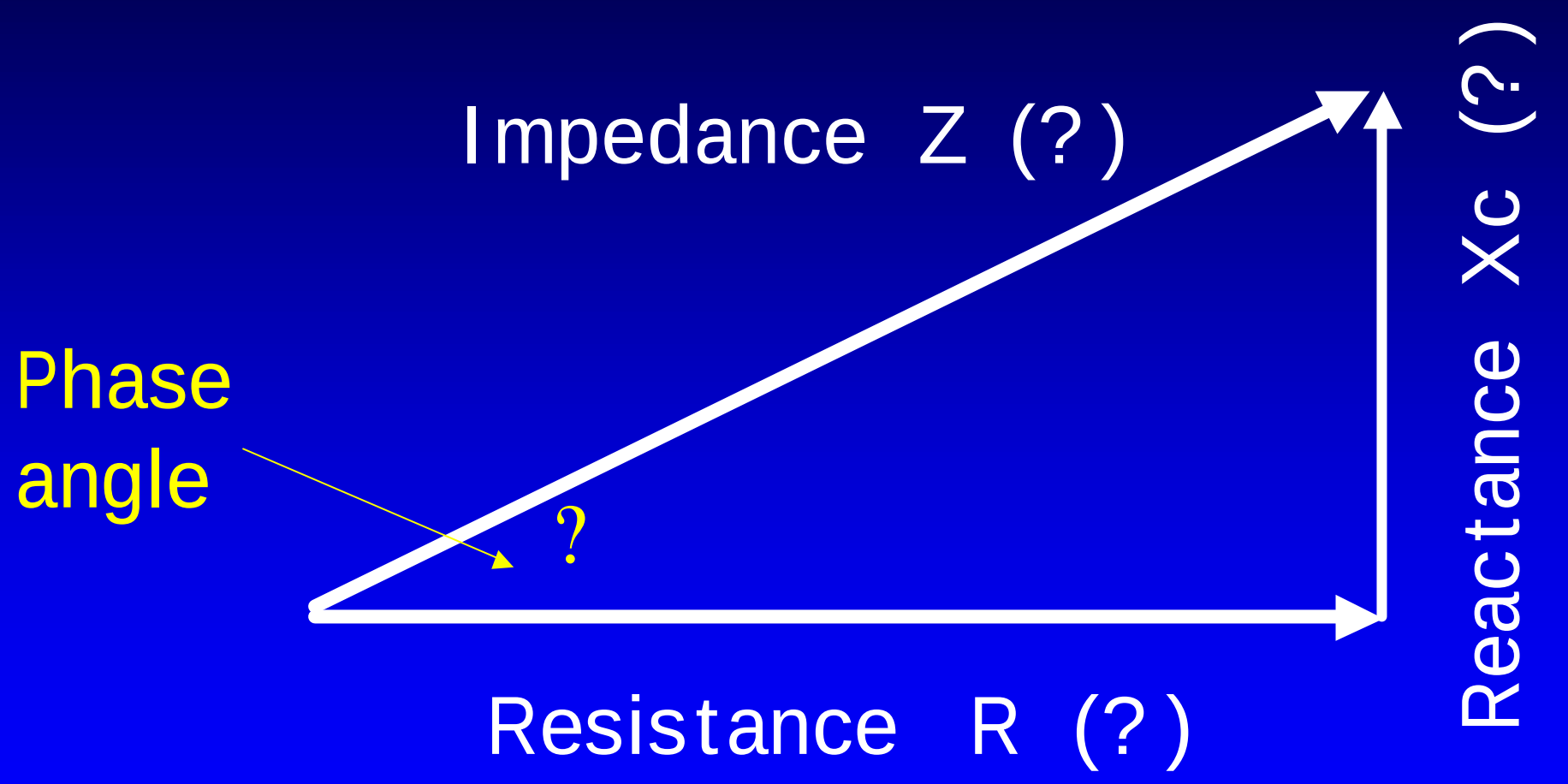
Frequency :

5 kHz

50 kHz

> 100 kHz

BIA - measured parameters



Single prediction equation for BIA in adults (20-94 yrs, 17.0 - 33.8 kg/m2)

Kyle U et al. Nutrition 2001, 17: 248-53

$$FFM = -4.104 + (0.518 * height^2 / resistance) + (0.231 * weight) + (0.130 * reactance) + (4.229 * sex\ (men = 1, women = 0))$$

Y= 1.423 + 0.973 * x, r=0.986

SEE = 1.72 kg, TE = 1.74 kg

Single prediction equation for BIA in adults (20-94 yrs, 17.0 - 33.8 kg/m2)

Kyle U et al. Nutrition 2001, 17: 248-53

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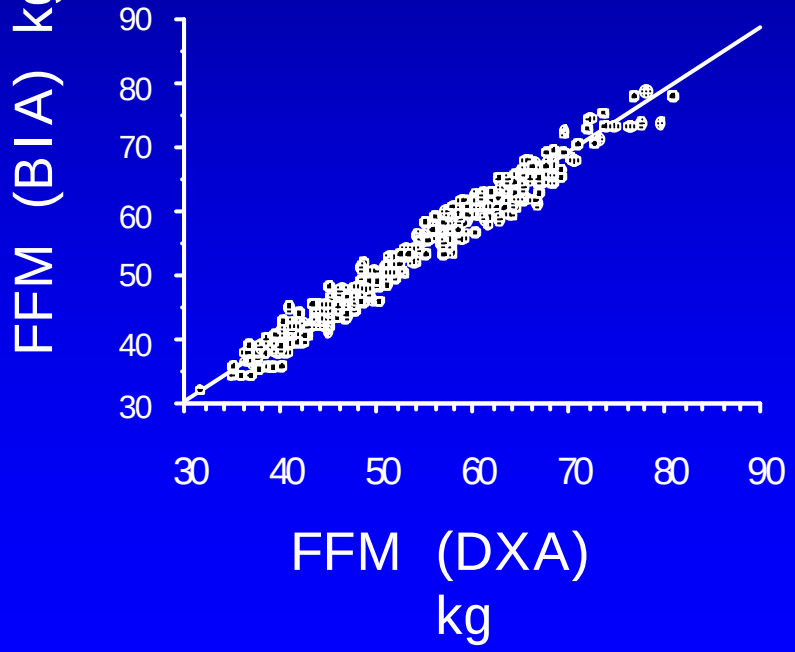

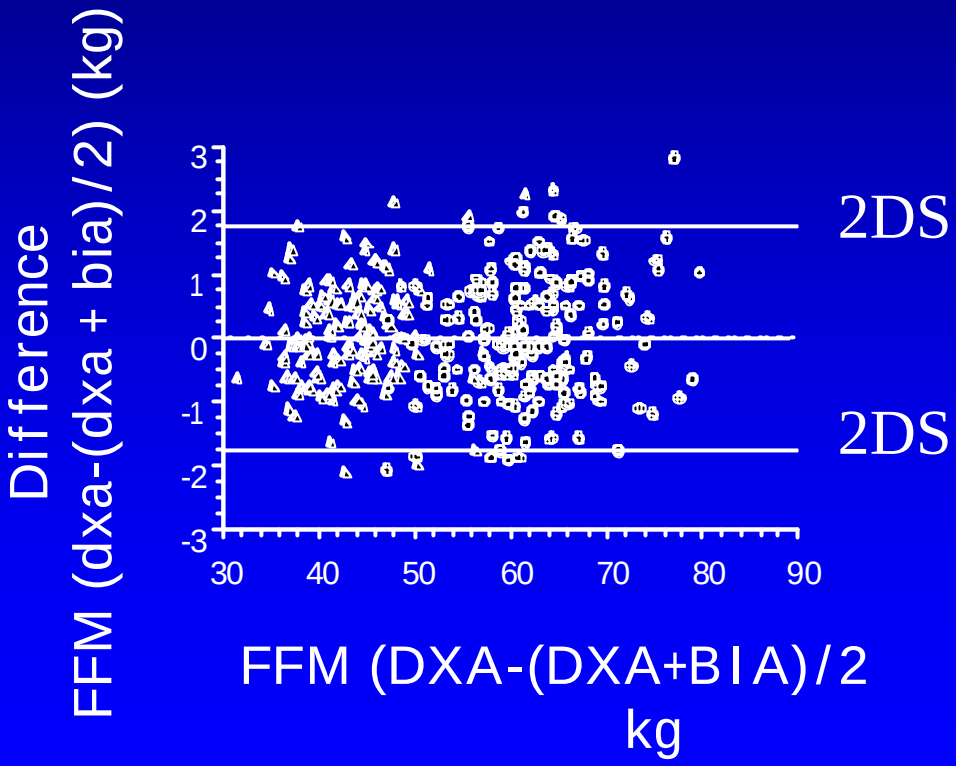

Body composition by BIA

Precision

Rep

Relevant for:

- Initial assessment
- Follow-up

, 245

within 1 week (n = 29)

1 month (n = 40)

r

cv

Relevance of BC measurements

MESSAGES

Body composition :

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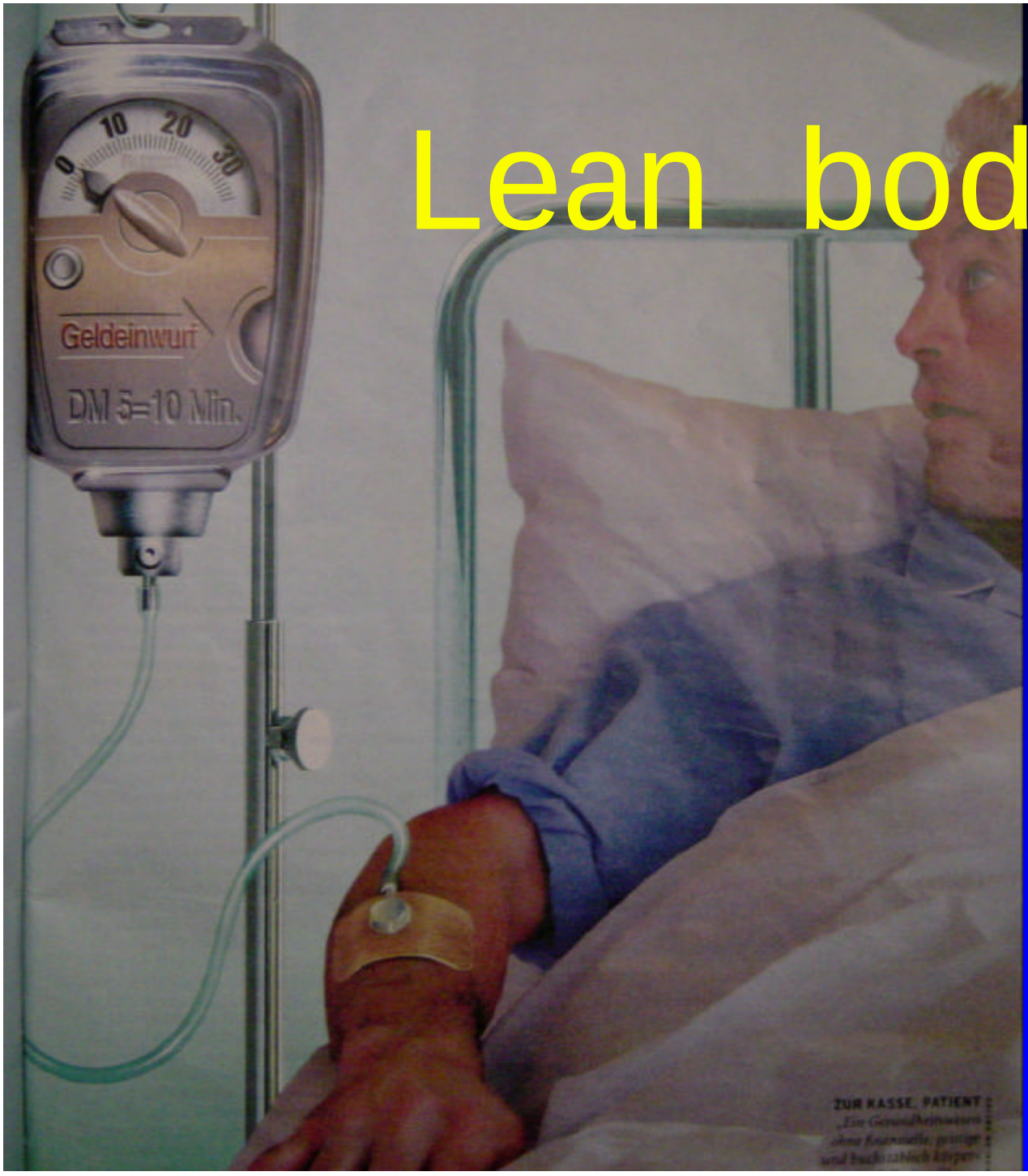
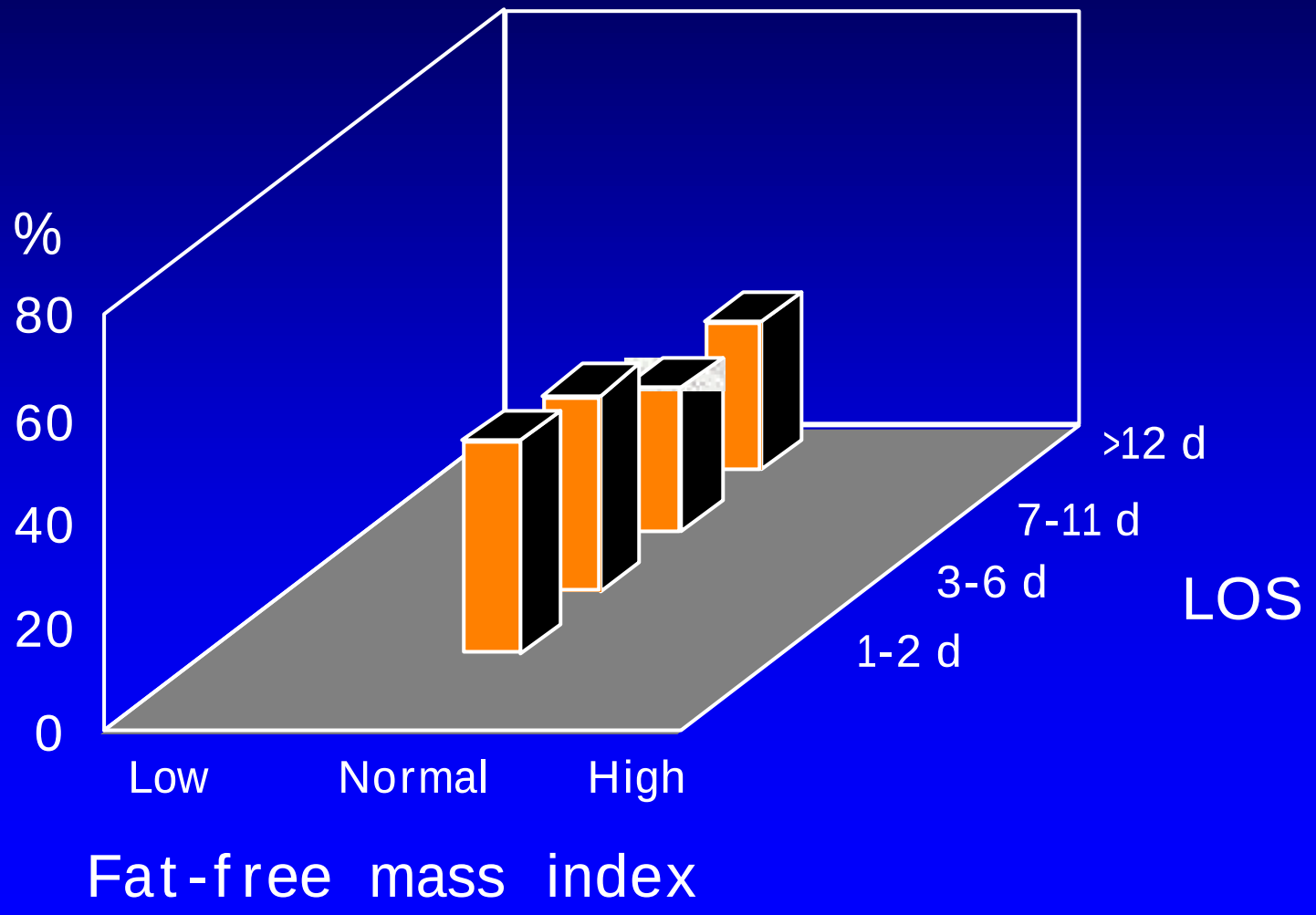


Lean body reserves & Length of Stay

Fat-Free Mass Index at hospital admission is associated with increased LOS : a prospective controlled population study (N = 996)

Pichard C et al. Am J Clin Nutr 79, 2004: 613-8



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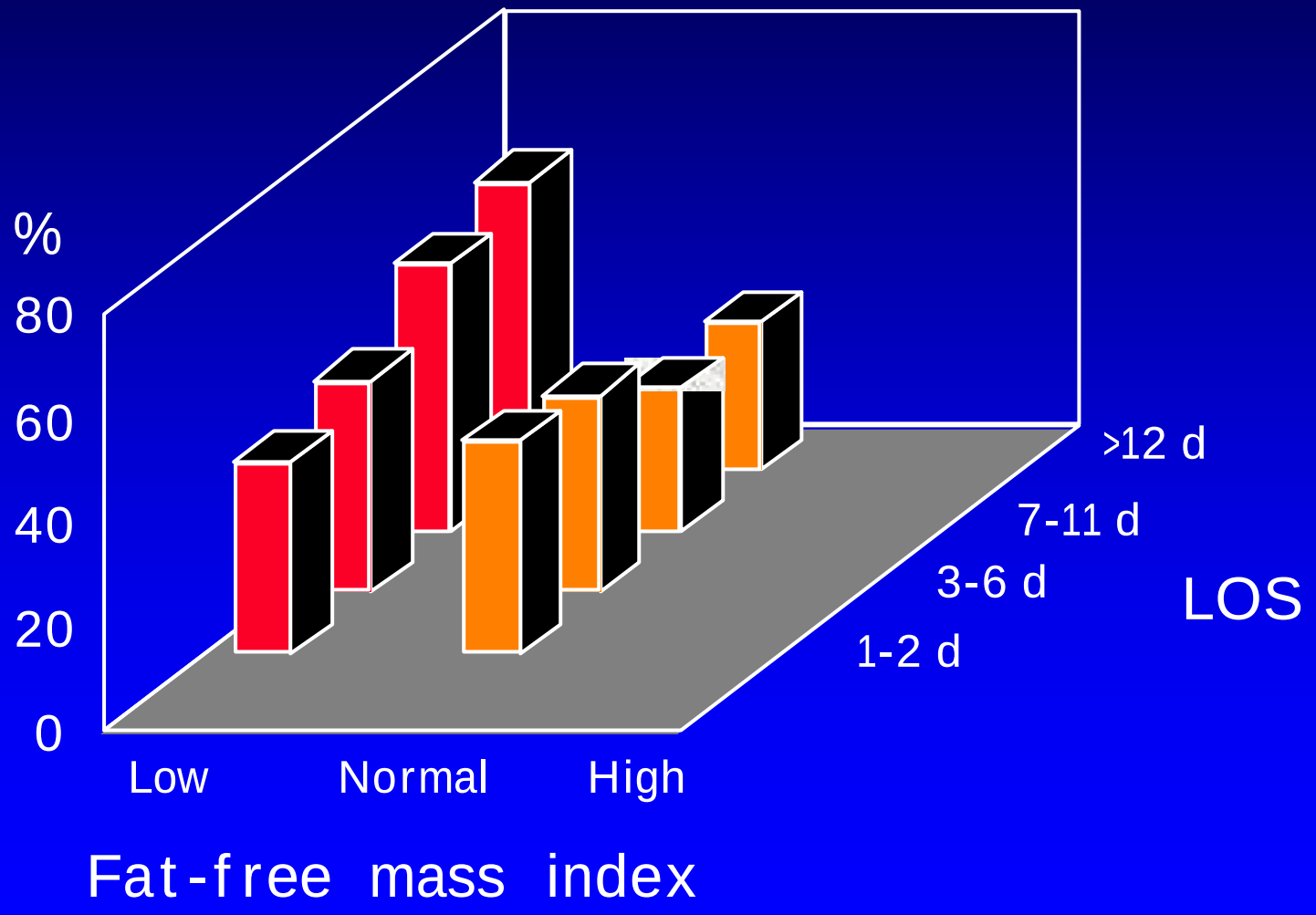

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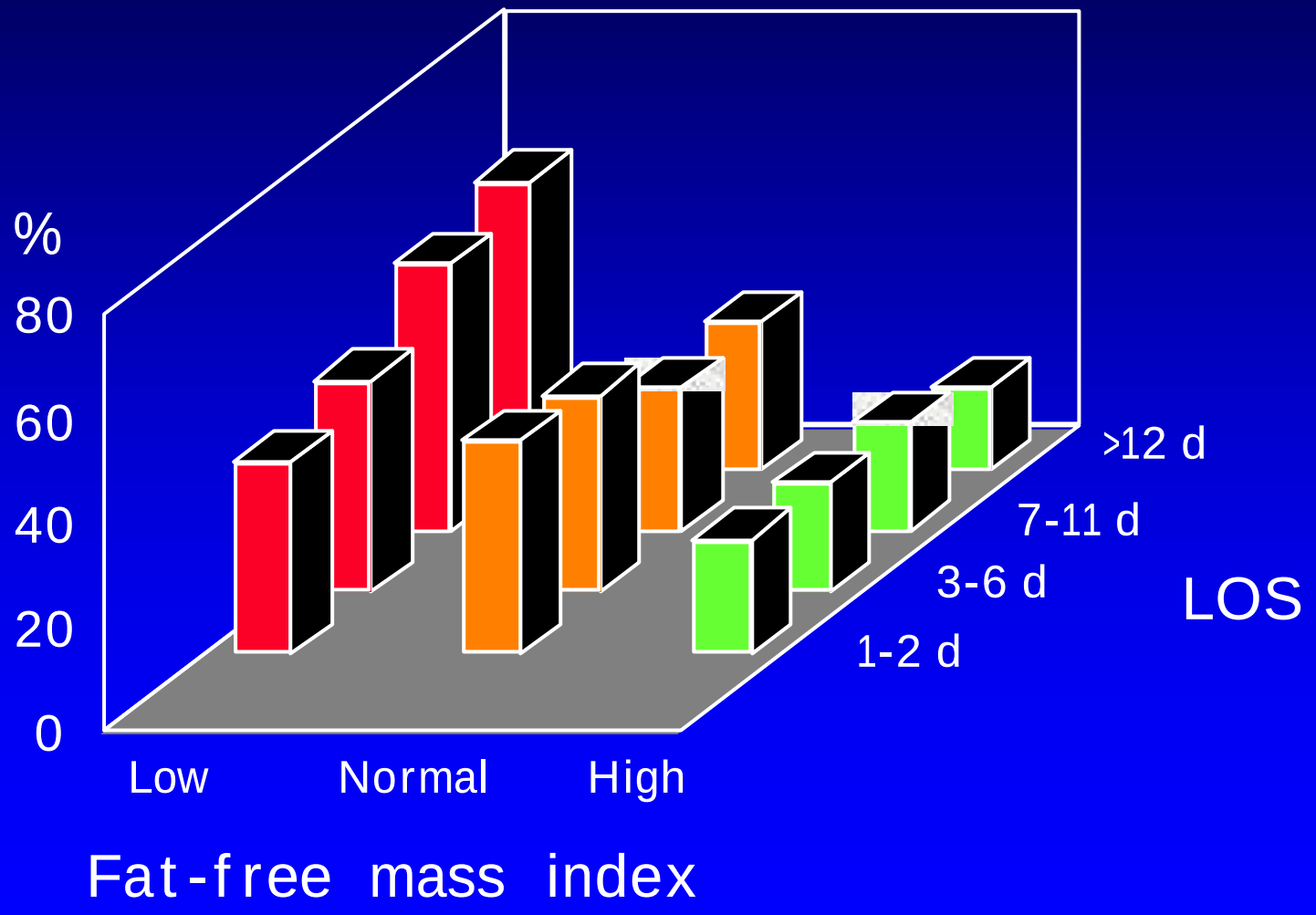

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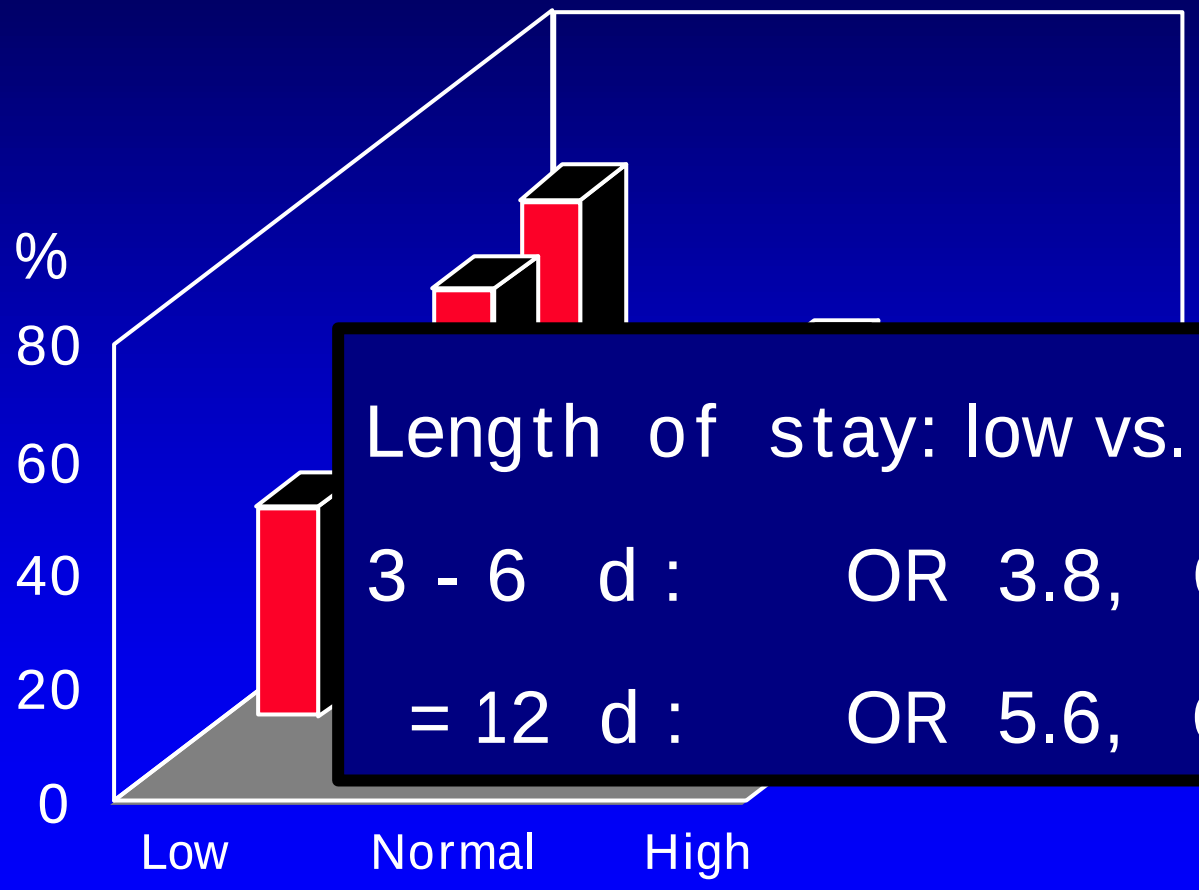


Length of stay: low vs. normal FFMI

3 - 6 d : OR 3.8, CI 1.6 - 8.9

= 12 d : OR 5.6, CI 3.1-10.4

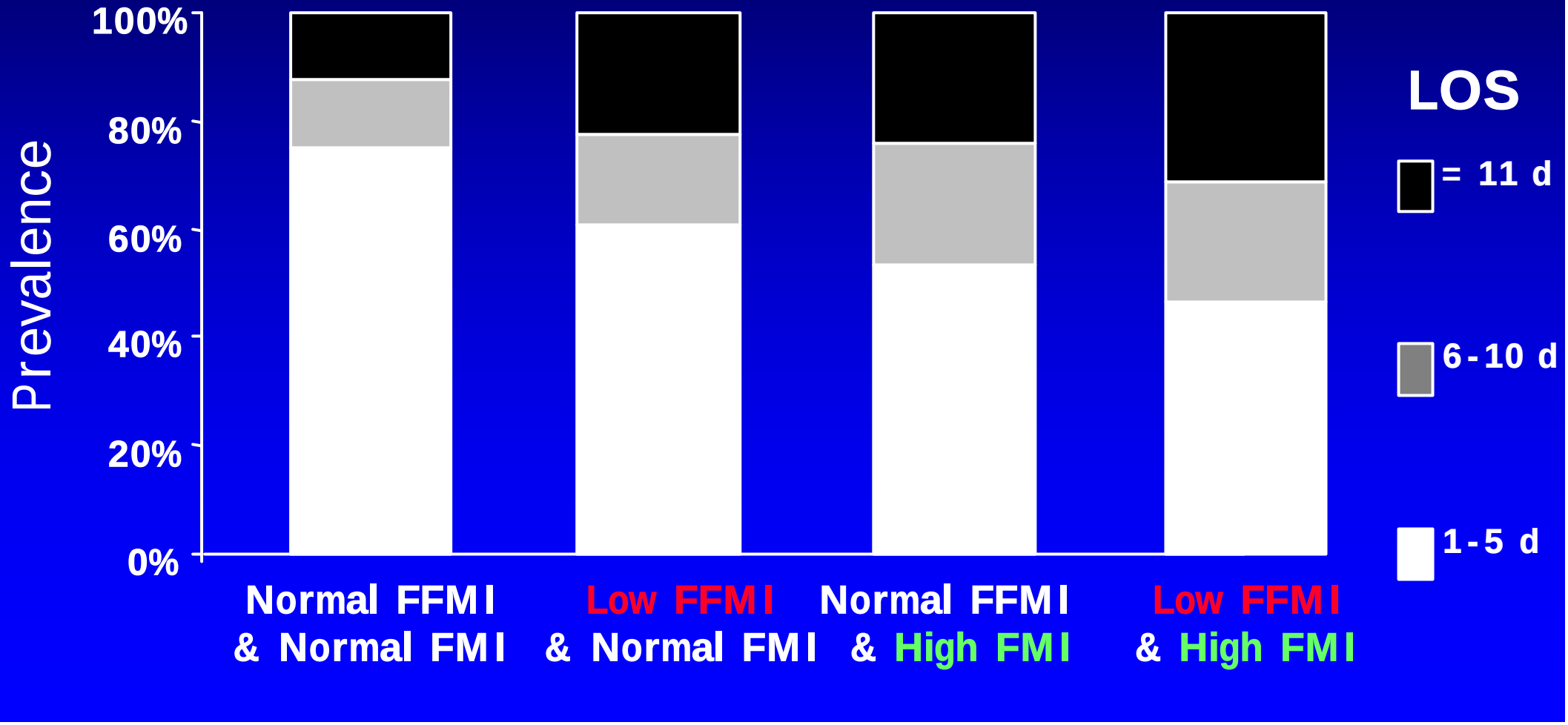
LOS is increased if body protein reserves are decreased

Respective contribution of FFM & FM in the LOS

Increased length of hospital stay in underweight and overweight patients at hospital admission:

A controlled population study (1707 patients/1707 volunteers)

Kyle UG et al. Clin Nutr. 2005; 24: 133-142



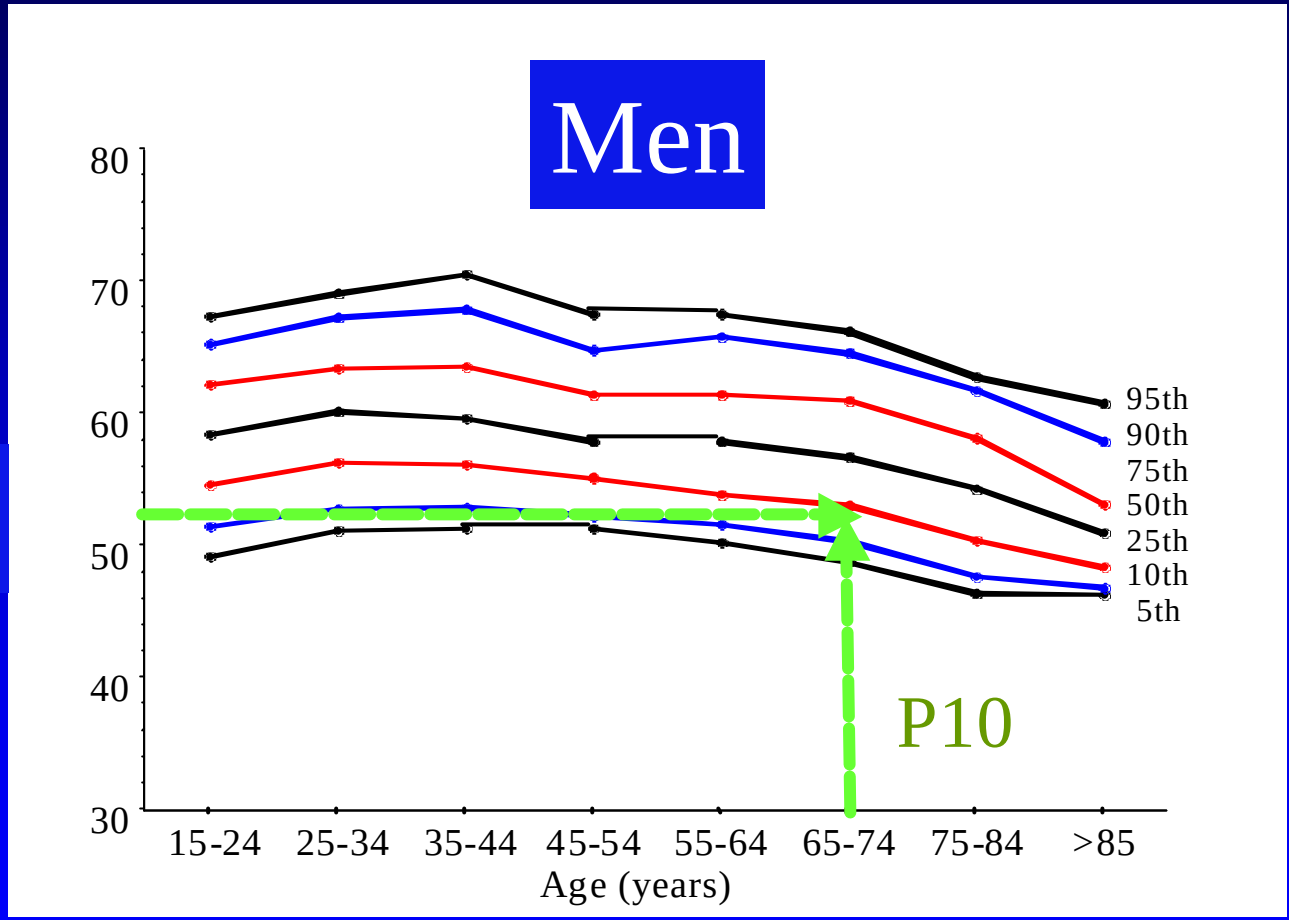
BIA Reference Values

- Caucasian Population
- Age 15 - 98 yrs
- BMI 17.0 - 33.8 kg/m^2

Percentiles Fat - free Mass in 5225 Volunteers

Kyle U. et al. Nutrition 2001, 17:534-541

(15 - 98 years, 16.0 - 47.1 kg/m2)



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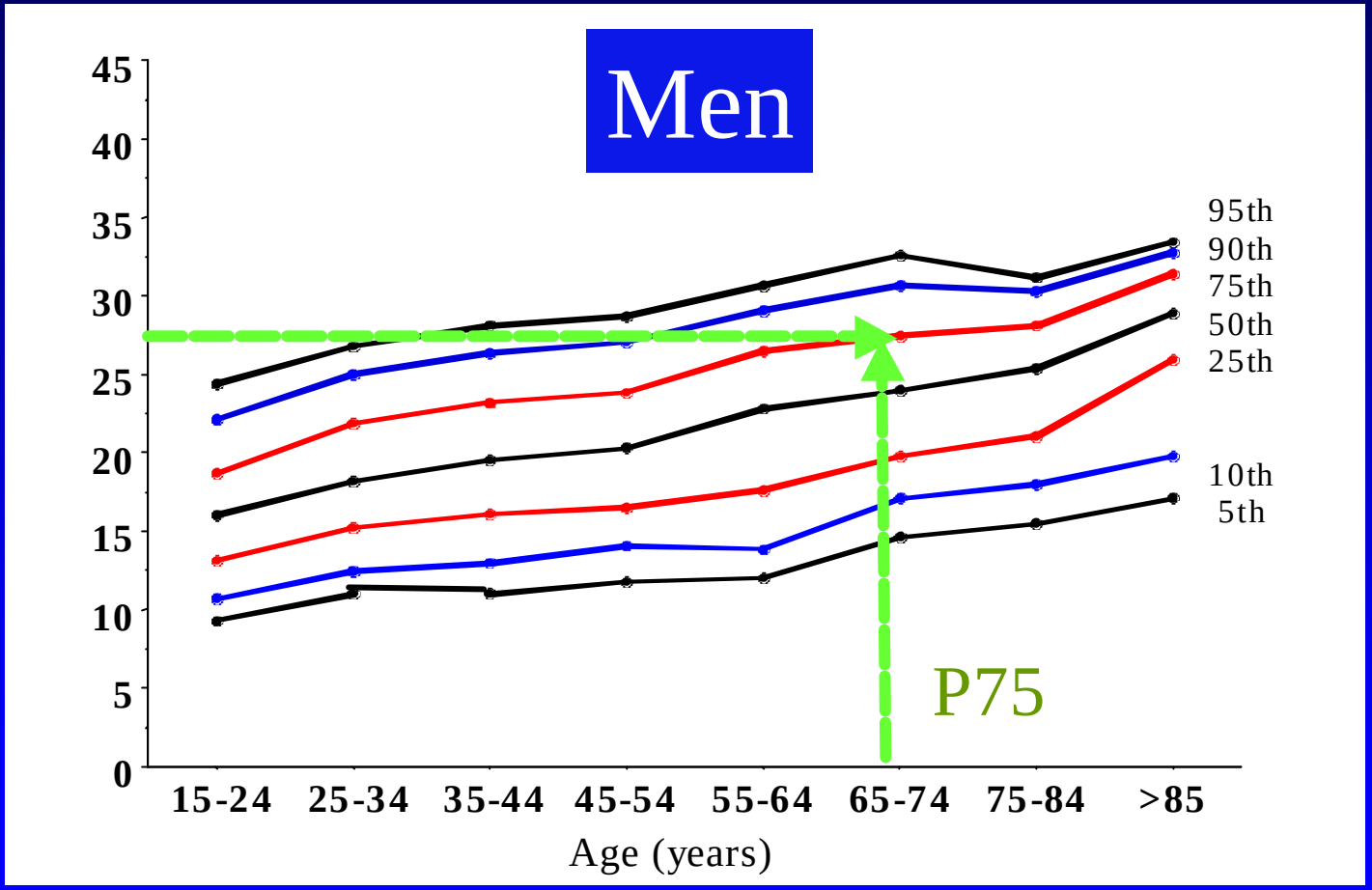
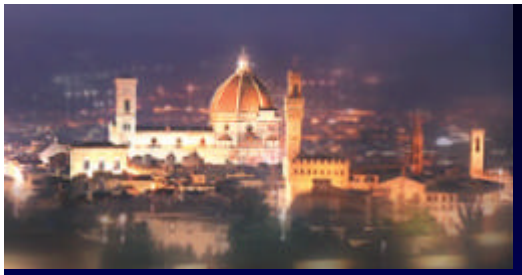
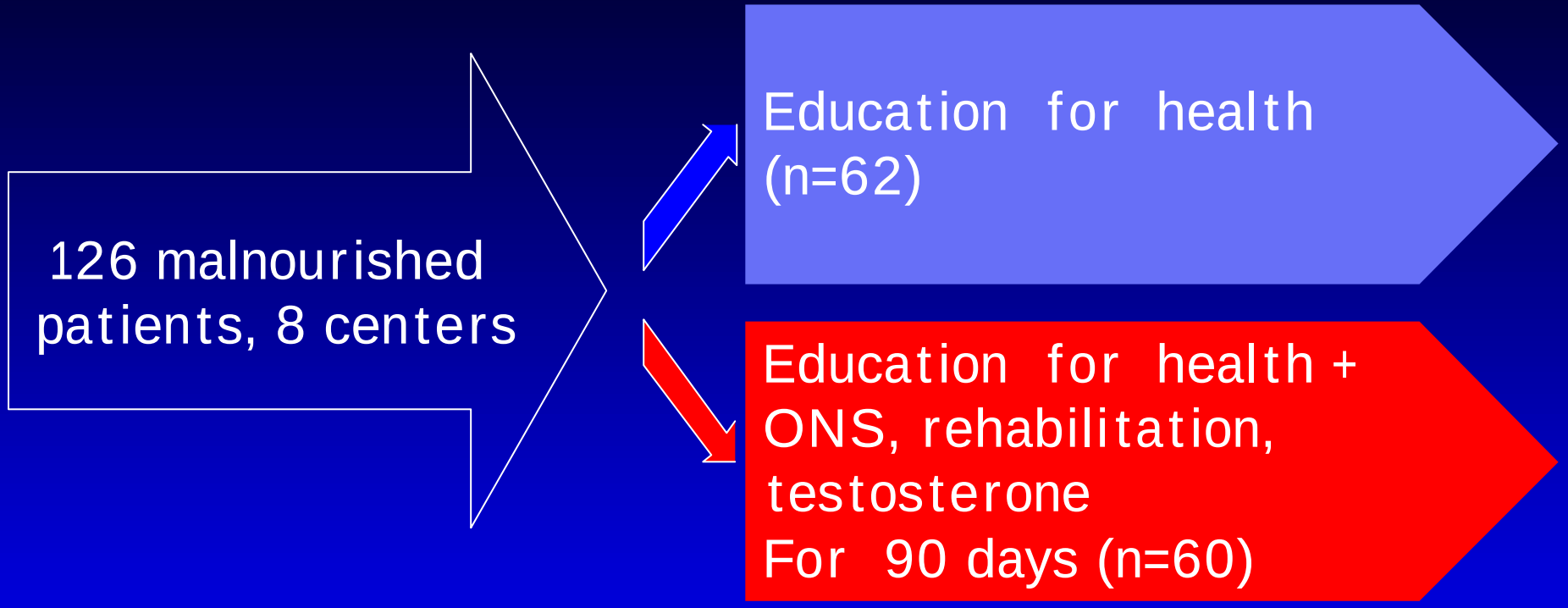




Home care combining oral nutritional supplement, exercise and androgen substitution in malnourished patients with chronic respiratory failure: a prospective controlled multicenter trial

N Cano, C. Pison, et al.

Study design



- Follow-up: 15 months (including 3- month treatment)
- days 0 , 90: nutritional status, respiratory function, exercise capacity & QoL
- months 9, 15: survival assessment

Patient selection

Stable patients PaO_2 < 8 kPa

BMI < 21 or BW loss > 10% within 6 months

or < 63% IBW (women), < 67% IBW (men) *(Schols 95)*

or FFM (BIA) < 25 percentile

Home care combining oral nutritional supplement, exercise and androgen substitution in malnourished patients with chronic respiratory failure: a prospective controlled multicenter trial

N Cano et al.

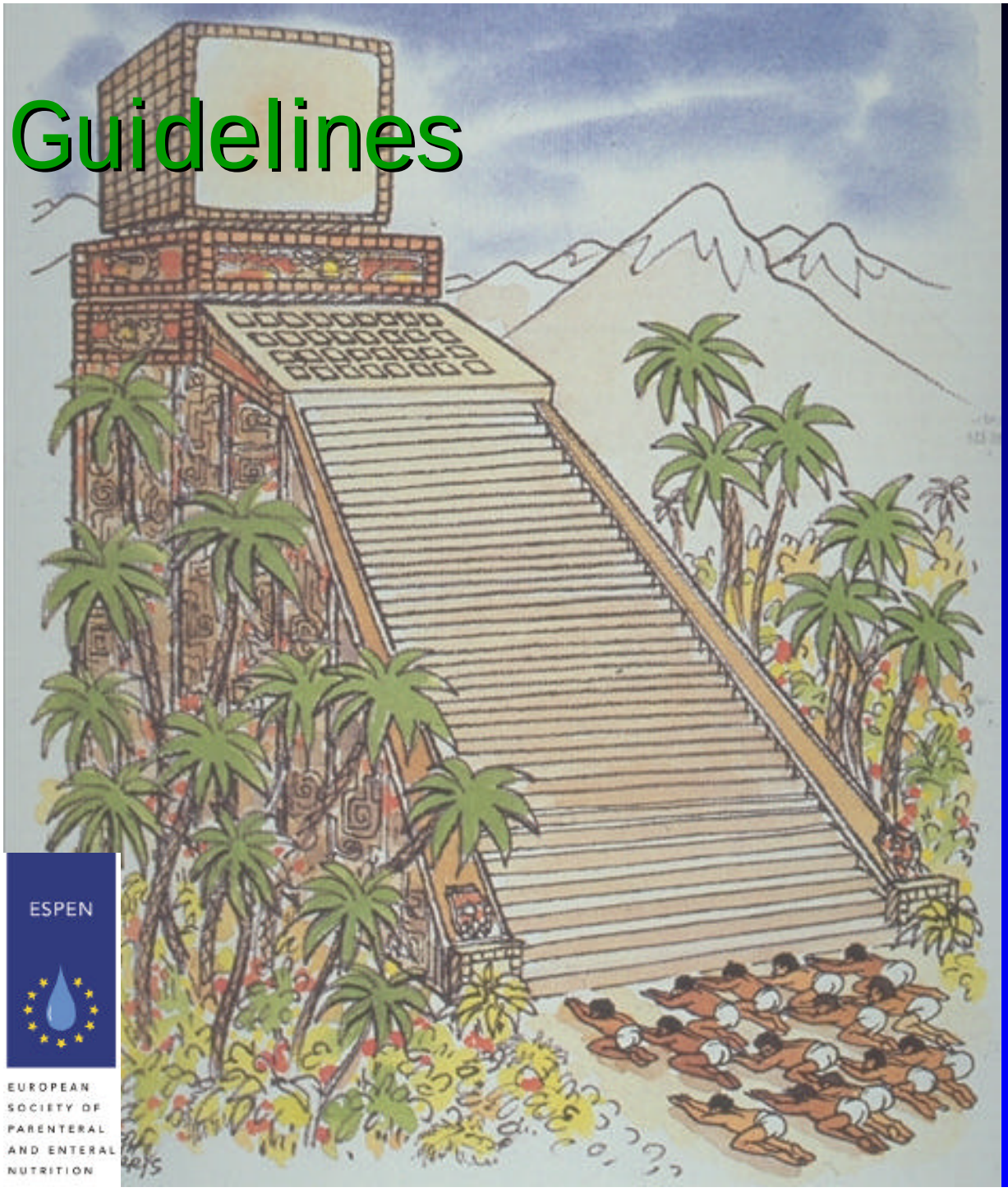
Multivariate Cox analysis for SURVIVAL

- Intervention group RR: 0.18 [0.04-0.79] 95% CI p< 0.02
- + 1 kg FFM / m^2 RR: 0.05 [0.002-0.07] 95% CI p< 0.05

Body Composition provides Health Care Givers with:

Objective data

Initial assessment & Follow-up



ESPEN Guidelines On

Bioelectrical Impedance Analysis

Free at: www.espen.org

ESPEN

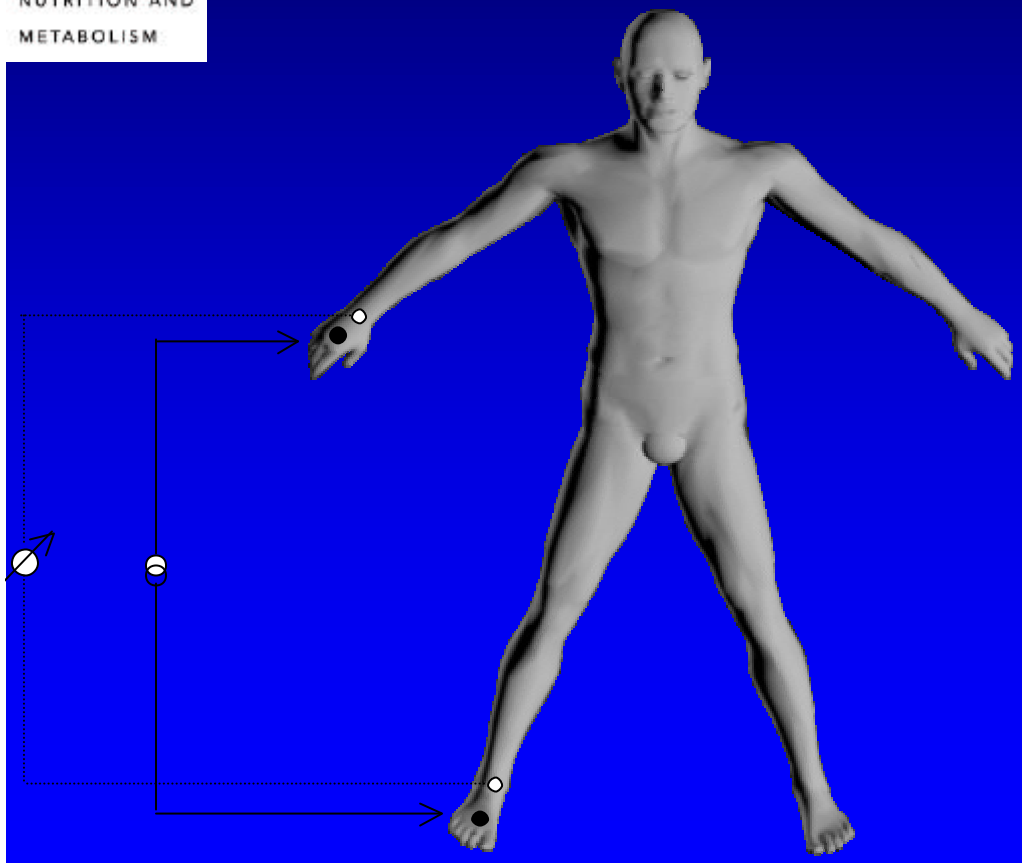
EUROPEAN SOCIETY OF PARENTERAL AND ENTERAL NUTRITION

ESPEN

THE EUROPEAN SOCIETY FOR CLINICAL NUTRITION AND METABOLISM

ESPEN GUIDELINES
Bioelectrical impedance analysis

www.espen.org/education



Review of principles & methods.
Clin Nutr 2004
23: 1226-1243

Utilisation in clinical practice.
Clin Nutr 2004
23: 1430-1453

ESPEN

THE EUROPEAN SOCIETY FOR CLINICAL NUTRITION AND METABOLISM

ESPEN GUIDELINES
Bioelectrical impedance analysis

SUMMARY

- Non-invasive, relatively inexpensive, no ionizing radiation, very limited inter-observer variations
- Works well : healthy subjects & chronic diseases (validated BIA equation for age, sex , race), if BMI 16 – 34 kg/m2

- Not recommended: abnormal hydration

MESSAGES

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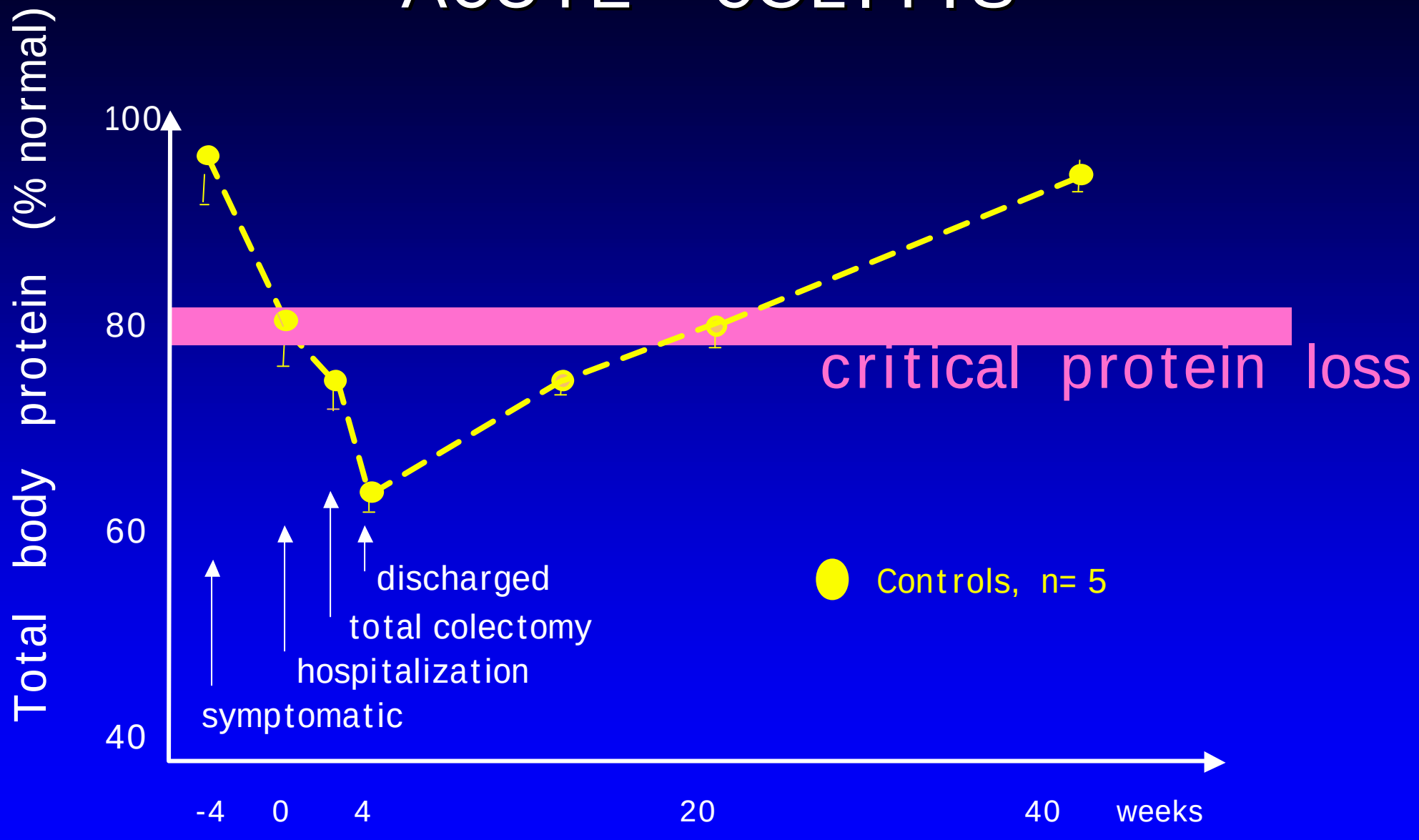
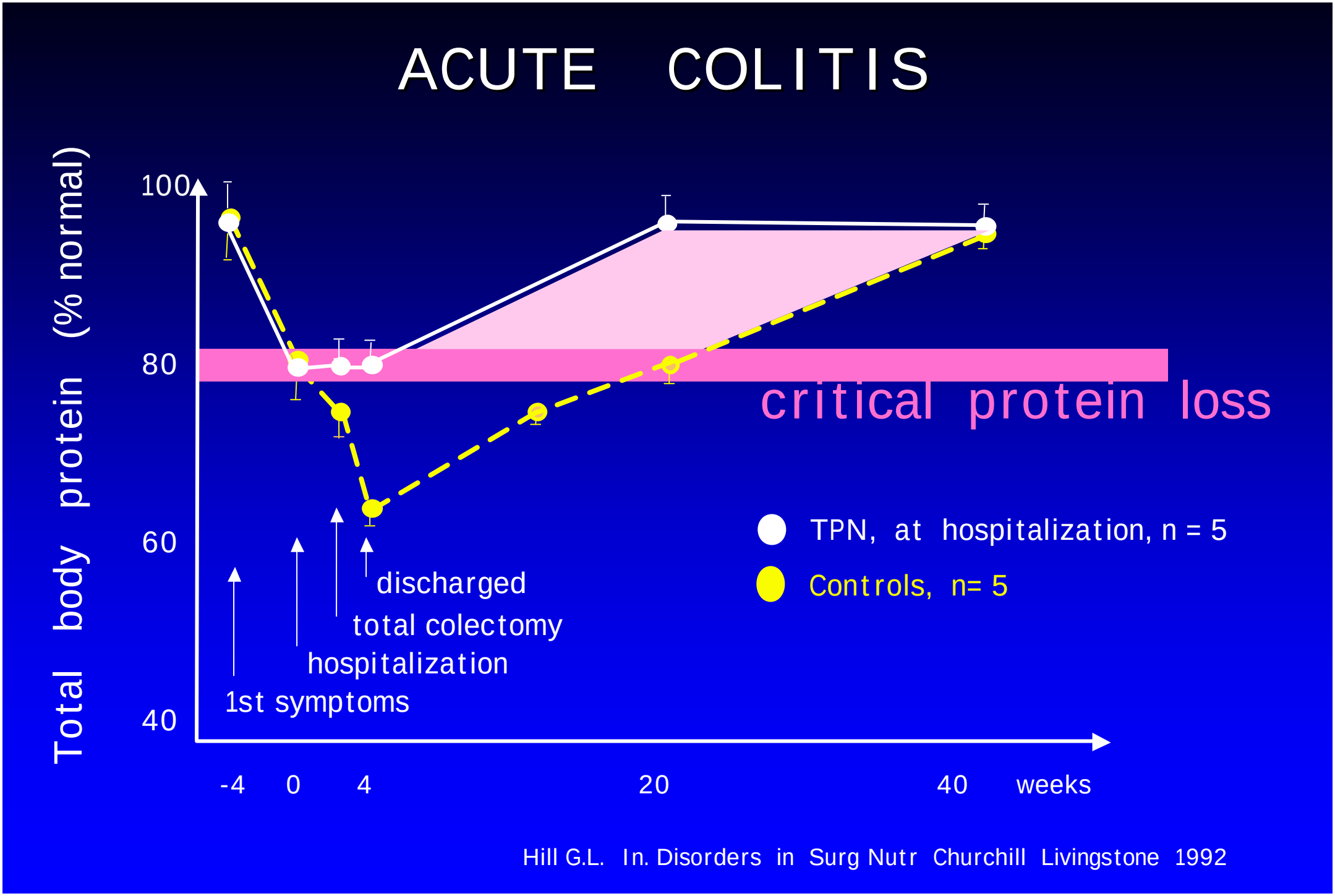
4. Allows to tailor treatments to patient's characteristics

ACUTE COLITIS



Hill G.L, In. Disorders in Surg Nutr Churchill Livingstone 1992

ACUTE COLITIS



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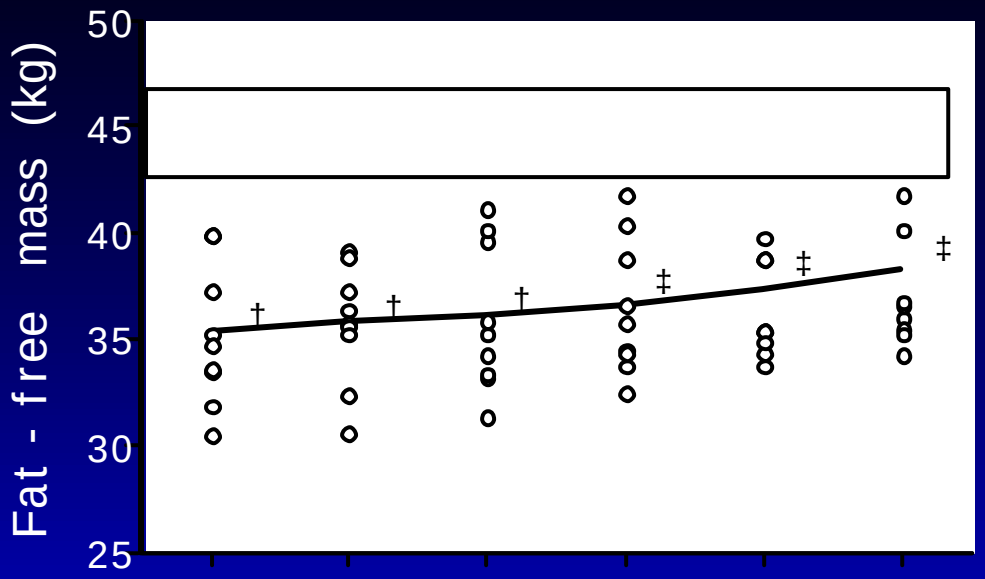
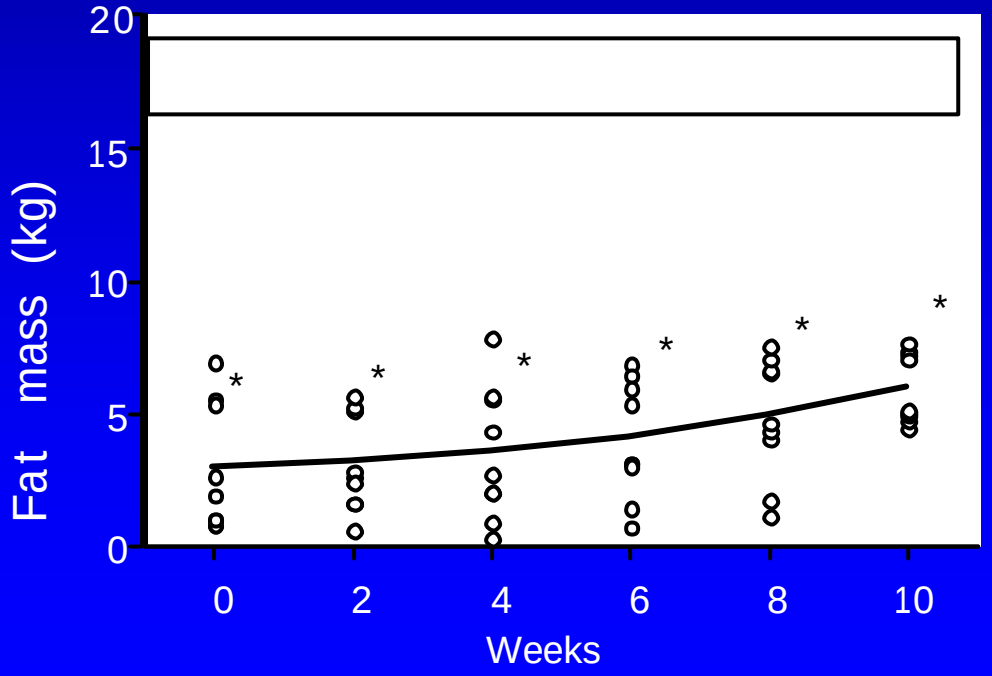
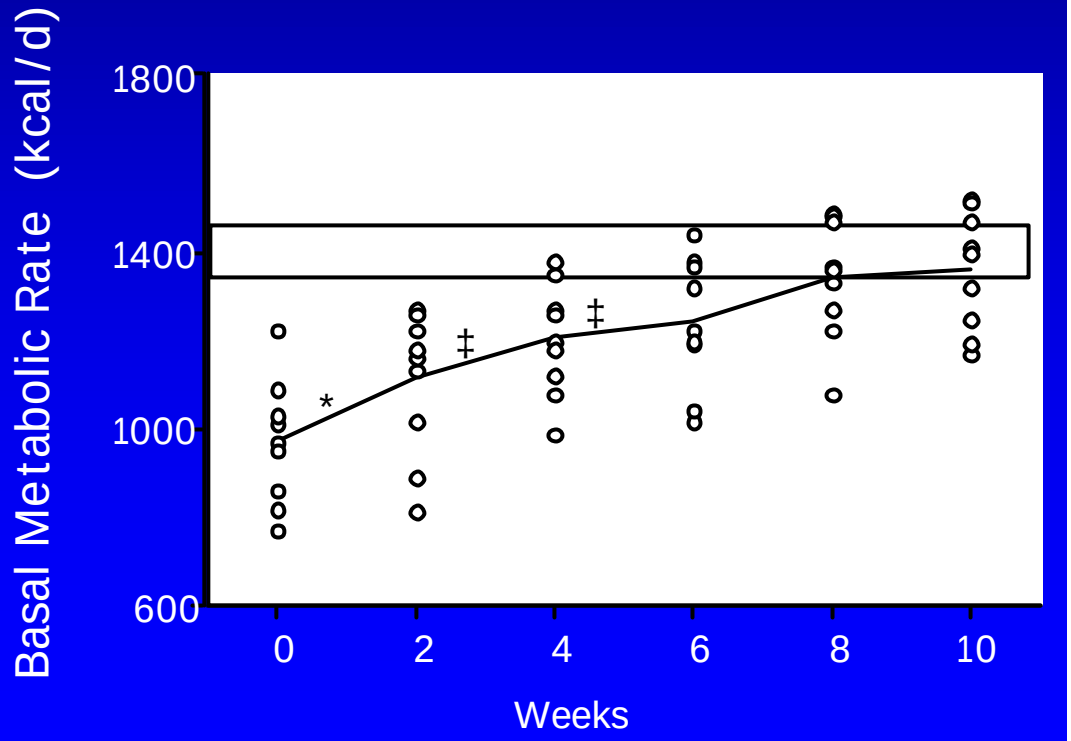


Energy expenditure in anorexia nervosa: can FFM as measured by BIA predict energy expenditure in hospitalized patients ?

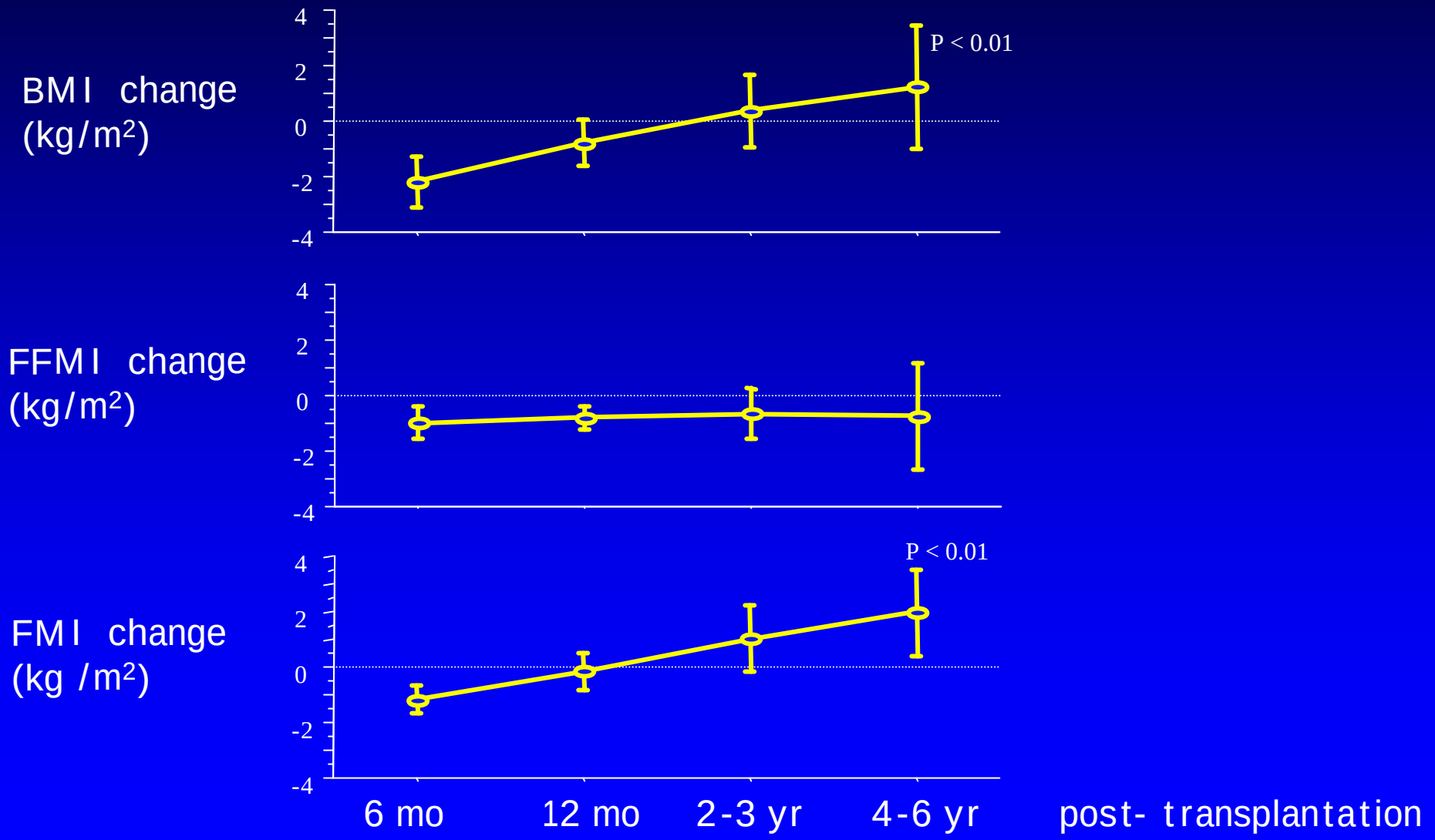
Pichard C et al. Clin Nutr 15, 109-114, 1996





Longitudinal follow-up of body composition in 82 hematopoietic stem cell transplant patients

Kyle UG et al. Bone Marrow Transplantation 2005; 35: 1171-1177



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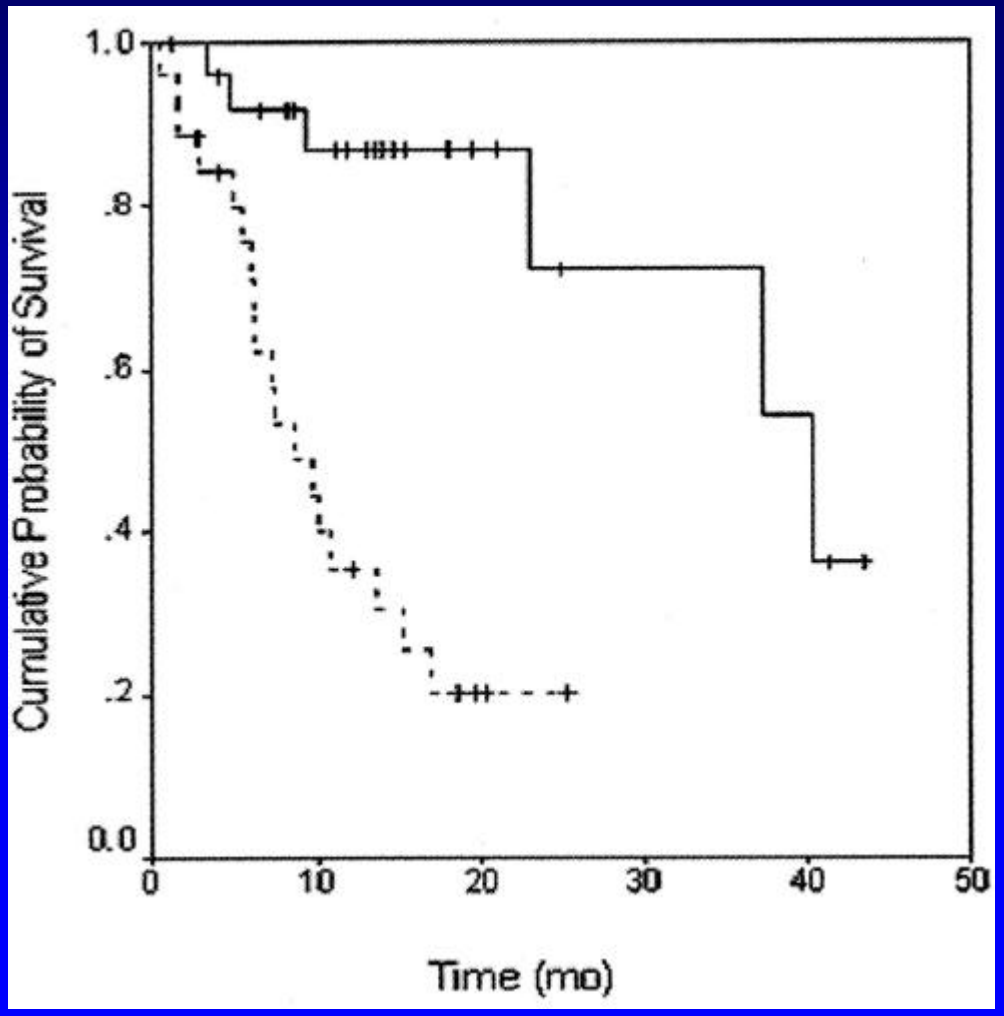
Body Composition measurements in oncology

BIA phase angle in clinical practice: implications for prognosis in 52 advanced colorectal cancer

Gupka D al. Am J Clin Nutrition 2004, 80: 1634-1638



Survival stratified by phase angle categories

= 5.57 (dashed line)

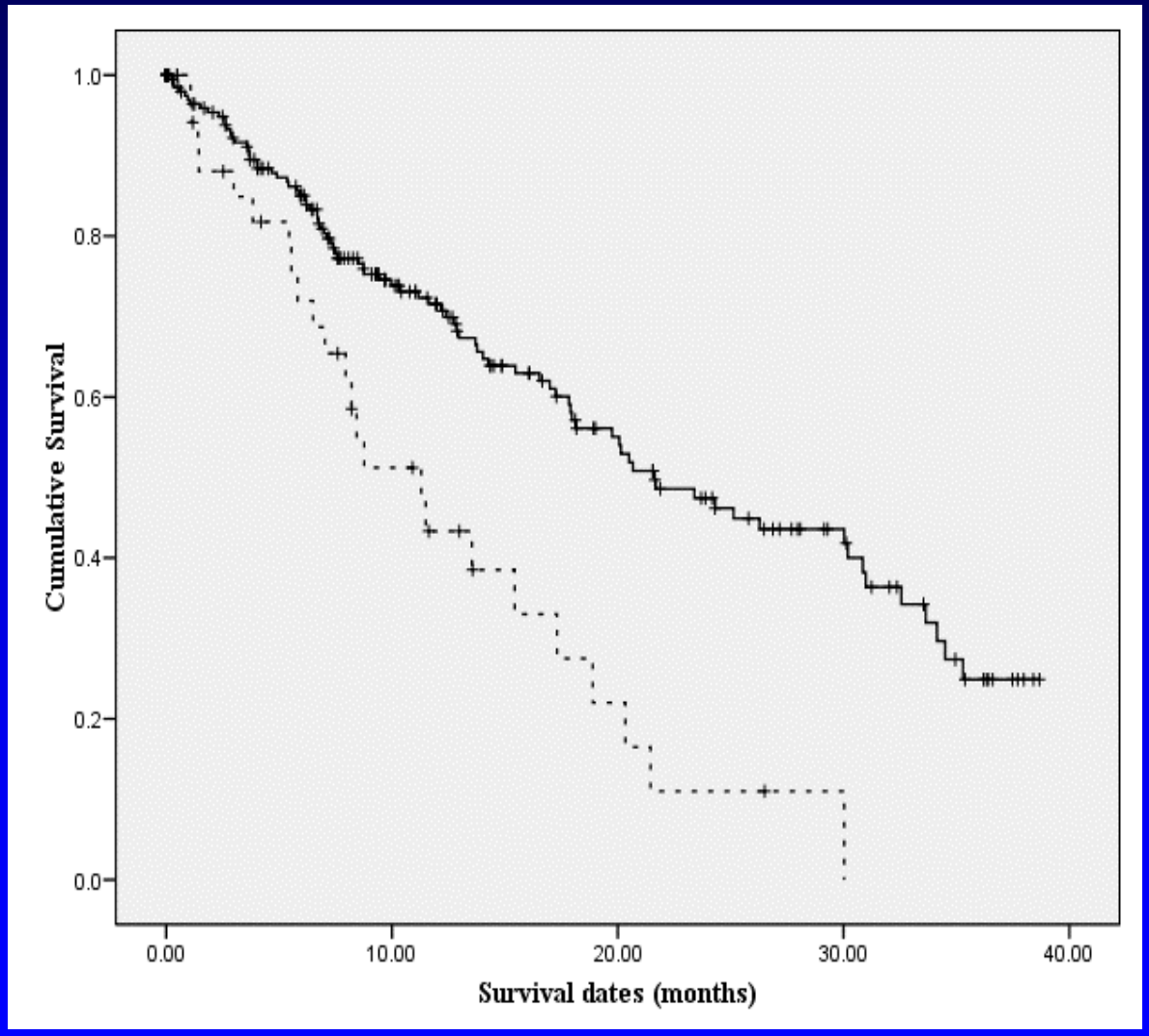
> 5.57 (solid line)

95% CI : 21.9, 58.8

P < 0.0001

Prevalence and clinical implications of sarcopenic obesity in 250 patients with solid tumours of the respiratory and GI tracts

Prado CM et al. Lancet Oncol 2008, 9: 605-607



Sarcopenic obesity is an independent predictor of survival (HR 4.2 [2.4 – 7.2], p<0,0001)

… links body composition, especially sarcopenic obesity, to clinical parameters (functional status, survival, and potentially, chemotherapy toxicity

Sarcopenia as a determinant of chemotherapy toxicity and time to tumor progression in metastatic breast cancer patients receiving capecitabine treatment

Prado CM, et al. Clin Cancer Res 2009, 15: 2920-2926

	Sarcopenic n = 14	Non-sarcopenic n = 41	p-value
Toxicity			
Present	7 (50.0%)*	8 (20%)*	0.03
Absent	7 (50.0%)*	33 (80%)*	
	65.6 (11.4)	71.4 (16.7)	0.23
Weight (kg)			
BMI (kg/m^2)	24.6 (4.0)	27.8 (5.7)	0.06
BSA (m^2)	1.7 (0.2)	1.8 (0.2)	0.42
Lumbar skeletal muscle index (cm^2/m^2)	35.0 (3.3)	47.4 (5.0)	<0.0001
Whole body lean mass (kg)	34.0 (3.3)	42.5 (5.0)	<0.0001
Mg capecitabine / kg FFM	104.2 (16.1)	86.9 (13.7)	<0.0001

A practical and precise approach to quantification of body composition in cancer patients using computed tomography images acquired during routine care

Mourtzakis M et al. Appl Physiol Nutr Metab. 2008, 33: 997-1006

Aim: to evaluate clinically accessible methods to achieve practical and precise measures of body composition in cancer patients.

DXA-FM and -FFM performed in 50 cancer patients and compared with BIA, DXA, CT-scan available in patients' medical records.

BIA overestimated or underestimated FFM vs. DXA (up to 9.3 kg difference).

Significant FFM changes over time detected with DXA in a subset of 21 patients (+2.2 +/- 3.2%/100 days, $p = 0.003$) was beyond the limits of detection of BIA.

Regional analysis of FM and FFM at the 3rd lumbar vertebra with either DXA or CT predicted FM and FFM ($r = 0.86$-0.94; $p < 0.001$).

CT scan provided detail on specific muscles, adipose tissues and organs, not provided by DXA or BIA. CT presents great practical significance due to the prevalence of these images in patient diagnosis and follow-up.

Sarcopenia significant predictor of chemotherapy toxicity : Fluoropyrimidines

Body composition as an independent determinant of

5-fluorouracil-based chemotherapy toxicity

Prado CM et al. Clin Cancer Res. 2007; 13: 3264-3268

Sarcopenia as a determinant of chemotherapy toxicity and time to tumor progression in metastatic breast cancer patients

receiving capecitabine treatment

Prado CM, et al. Clin Cancer Res 2009, 15: 2920-2926

Sarcopenia

- Physical disability
- Falls
- Extended hospitalization
- Infectious, non-infectious complications
- Mortality in cancer patients
- *Treatment toxicity in cancer patients*

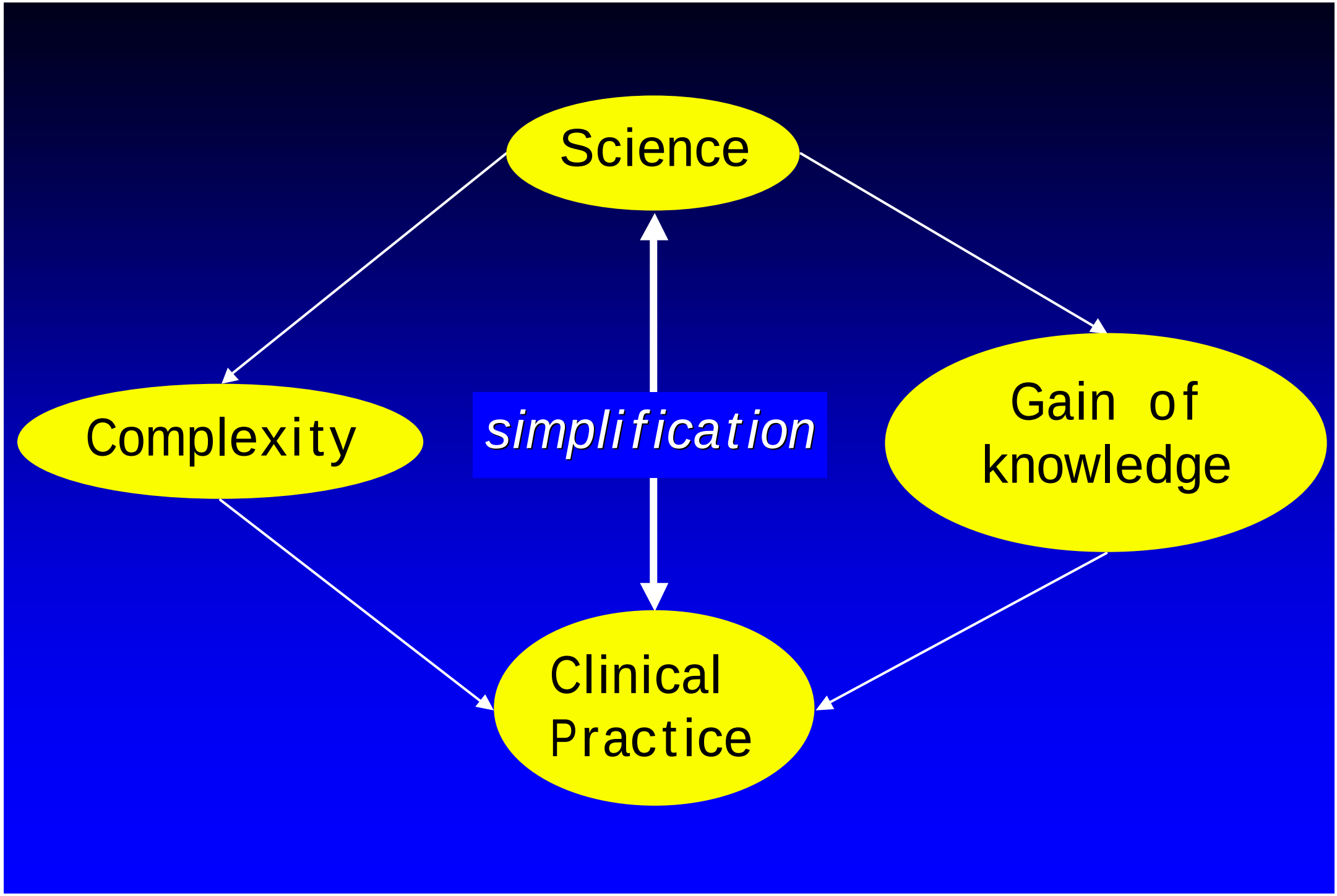
*The emerging role of computerized tomography in assessing cancer cachexia. Prado CM, Birdsell LA, Baracos VE. Curr Opin Support Palliat Care 2009 Aug 6

Chemotherapy & BC

-> « Era of sarcopenic obesity »

- Optimal dosage of chemotherapy agents
- Better prevention of side effects
- Improved cost-efficiency

Simplification of Body Composition


Science
Complexity
simplification
Gain of knowledge
Clinical Practice

Body Composition Interpretation: Contribution of fat-free mass index & body fat mass index

Kyle UG, et al.
Nutrition 2003 , 19: 597-604

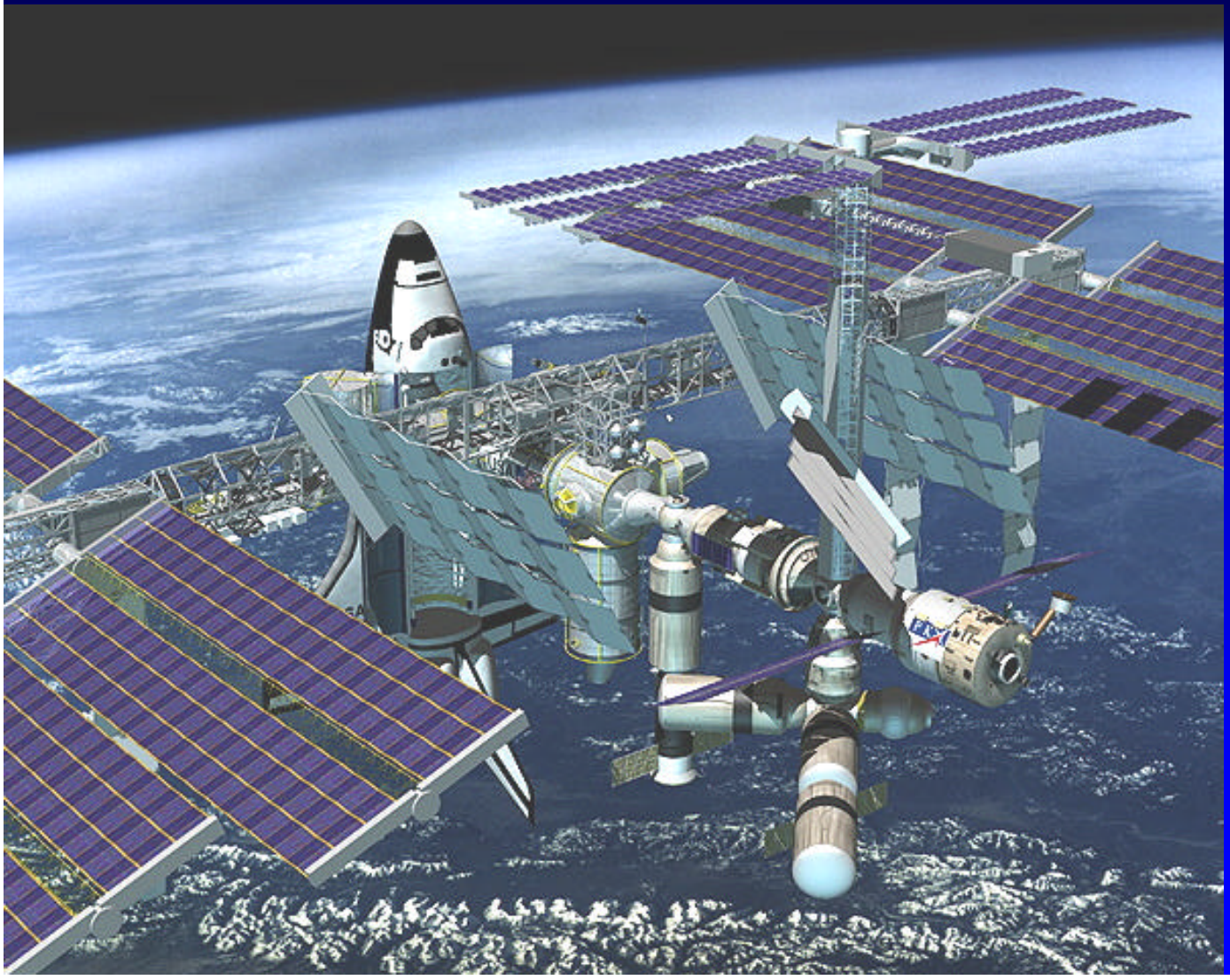
BMI	FFMI	BFMI
kg/m^2	kg/m^2	kg/m^2
MEN n=2982 (18-98)		
30.0	21.7	8.3
27.8	20.9	6.9
25.0	19.8	5.2
20.0	17.5	2.5
18.5	16.7	1.8
WOMEN n=2647 (18-98)		
30.0	18.2	11.8
27.3	17.5	9.8
25.0	16.8	8.2
20.0	15.1	4.9
18.5	14.6	3.9

Body Composition measurements: Interpretation finally made easy for clinical use

Kyle UG et al. Curr Op Clin Nutr Metab Care 2003; 6: 387-93

"…The use of percentiles and height-normalized FFM and FM permit the classification of patients… and risk evaluation"

Body composition in the future…

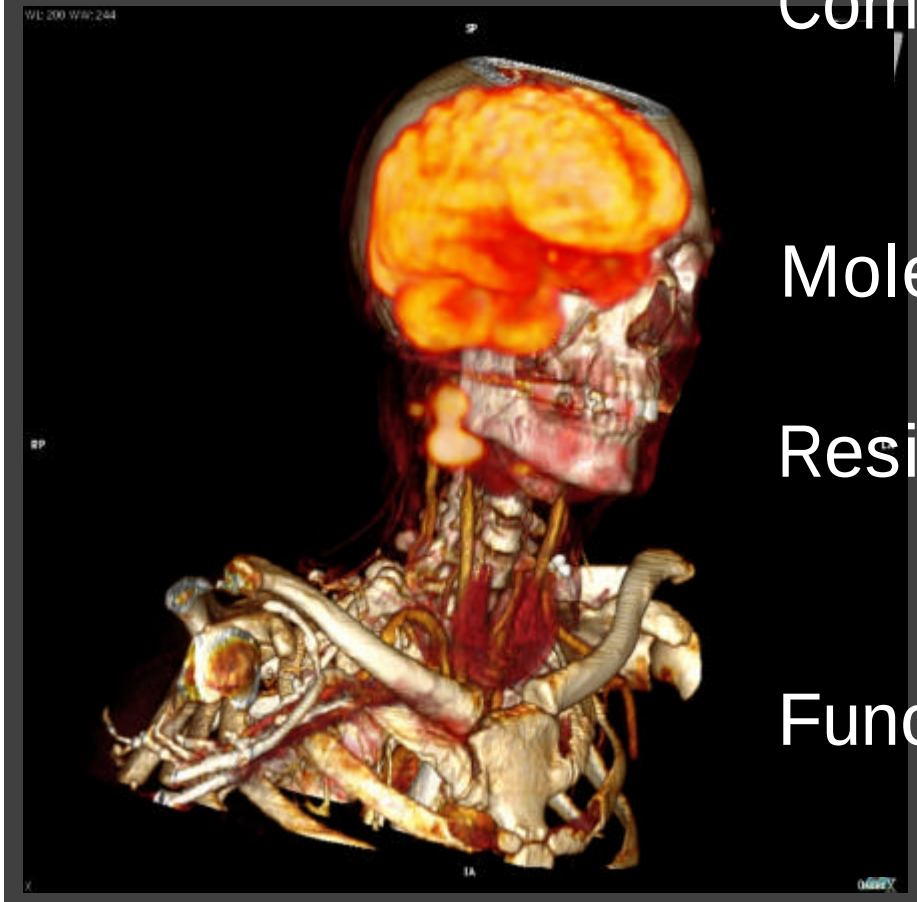


You are what you eat: describing the foraging ecology of southern elephant seals using blubber fatty acids.
Bradshaw CJ et al. Proc Biol Sci. 2003, 22: 1283-92

Assessing the risks of persistent organic pollutants to top predators: a review of approaches.
Leonards PE et al. Integr Environ Assess Manag. 2008, 4: 386-98

Kindly provided by Pr A Laviano

Body composition machine in 20…



Compartments:

- Lean mass P90
- Fat mass P10

Molecular:

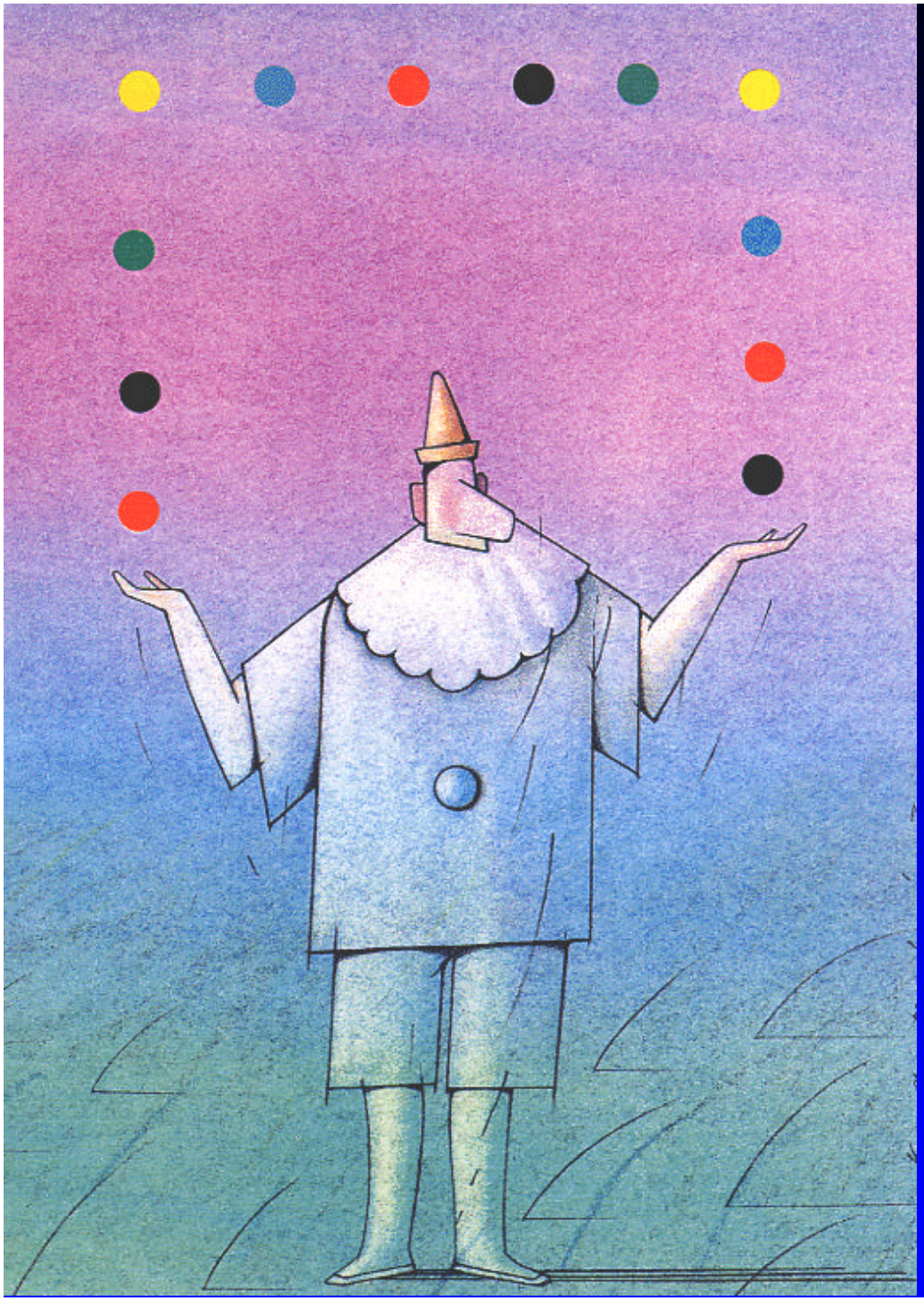
- CrP P90

Residues:

- Explosive agents
- « Martini on the rock »

Functions:

- Muscular ATP P97
- Sexual P out of range



Conclusion

Why is malnutrition underrecognized ?

Published papers about BIA

1972 : 7

1982 : 11

1992 : 103

1996 : 236

2000 : 351

2004 : 880

2008 : 1051

2009 (August): 543

Body Composition « added value » :

- Measurable facts
  - Objective initial assessment
  - Follow-up, -> $/ kg FFM
- Optimal treatment
- Printed report
- Credibility
- Institutional visibility

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Abdelkarim Allal

Philippe Nouet

Bruno Robert

Dominique Wohlwend


Merci