人体成分的临床应用

上海交通大学医学院附属瑞金医院

临床营养科　　施咏梅

目录

- 人体成分与健康的关系
- 人体成分的测定方法
- 人体成分在临床疾病研究中的应用

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肥胖

糖尿病、高血压、冠心病、癌症、睡眠呼吸障碍……疾病发生的风险因素

insight review article

Obesity as a medical problem

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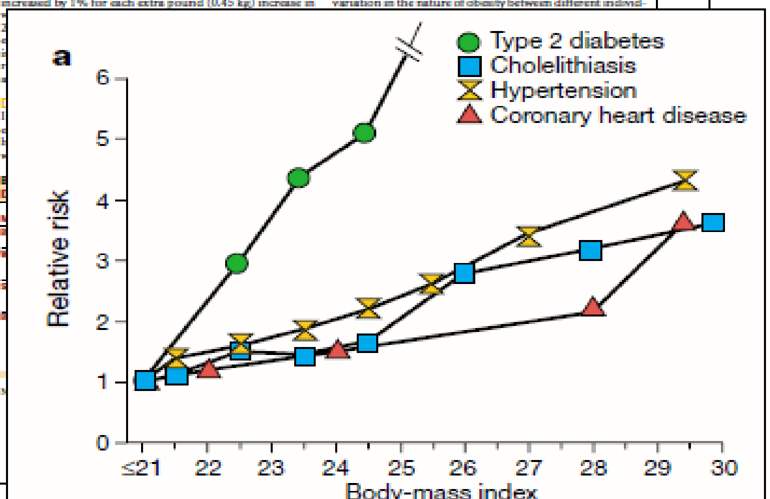
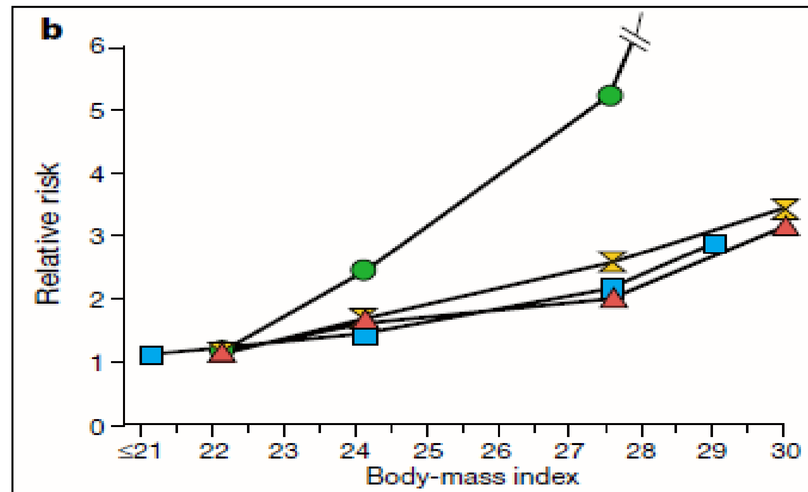
Obesity is now so common within the world's population that it is beginning to replace undernutrition and infectious diseases as the most significant contributor to ill health. In particular, obesity is associated with diabetes mellitus, coronary heart disease, certain forms of cancer, and sleep-breathing disorders. Obesity is defined by a body-mass index (weight divided by square of the height) of 30 kg m^{-2} or greater, but this does not take into account the morbidity and mortality associated with more modest degrees of overweight, nor the detrimental effect of intra-abdominal fat. The global epidemic of obesity results from a combination of genetic susceptibility, increased availability of high-energy foods and decreased requirement for physical activity in modern society. Obesity should no longer be regarded simply as a cosmetic problem affecting certain individuals, but an epidemic that threatens global well being.

Obesity causes or exacerbates many health problems, both independently and in association with other diseases[1]. In particular, it is associated with the development of type 2 diabetes mellitus, coronary heart disease (CHD), an increased incidence of certain forms of cancer, respiratory complications (obstructive sleep apnoea) and osteoarthritis of large and small joints. The Build and Blood Pressure Study has shown that the adverse effects of excess weight tend to be delayed, sometimes for ten years or longer[2]. Life-insurance data and epidemiological studies confirm that increasing degrees of overweight and obesity are important predictors of decreased longevity[3]. In the Framingham Heart Study, the risk of death within 26 years increased by 1% for each extra pound (0.45 kg) increase in

the formula most frequently used in epidemiological studies is body-mass index (BMI). Box 1 details the practical methods used in clinical practice to assess body fatness. A graded classification of overweight and obesity using BMI values provides valuable information about increasing body fatness. It allows meaningful comparisons of weight status within and between populations and the identification of individuals and groups at risk of morbidity and mortality. It also permits identification of priorities for intervention at an individual or community level and for evaluating the effectiveness of such interventions. It is important to appreciate that, owing to differences in body proportions, BMI may not correspond to the same degree of fatness across different populations. Nor does it account for the wide variation in the nature of obesity between different individ-





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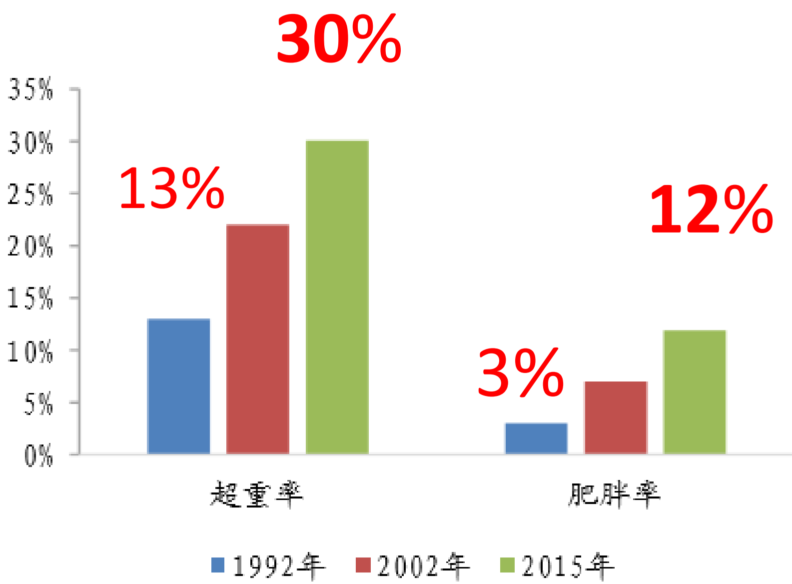
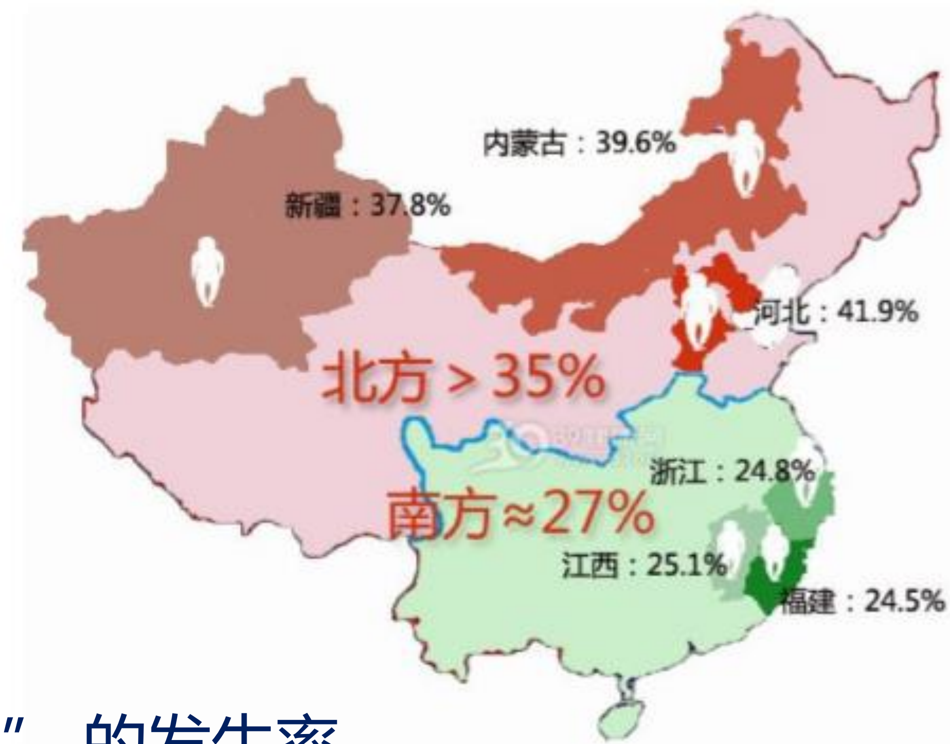
肥胖是世界性公共卫生问题





中国“肥胖”的发生率

数据来源：公开资料整理（网络）

BMI正常范围 = 健康？

BMI范围内，体脂率却高标准的这种状态，俗称之为隐形肥胖。

健 康 → 体 重

Health

↓

体成分

Body Compositon

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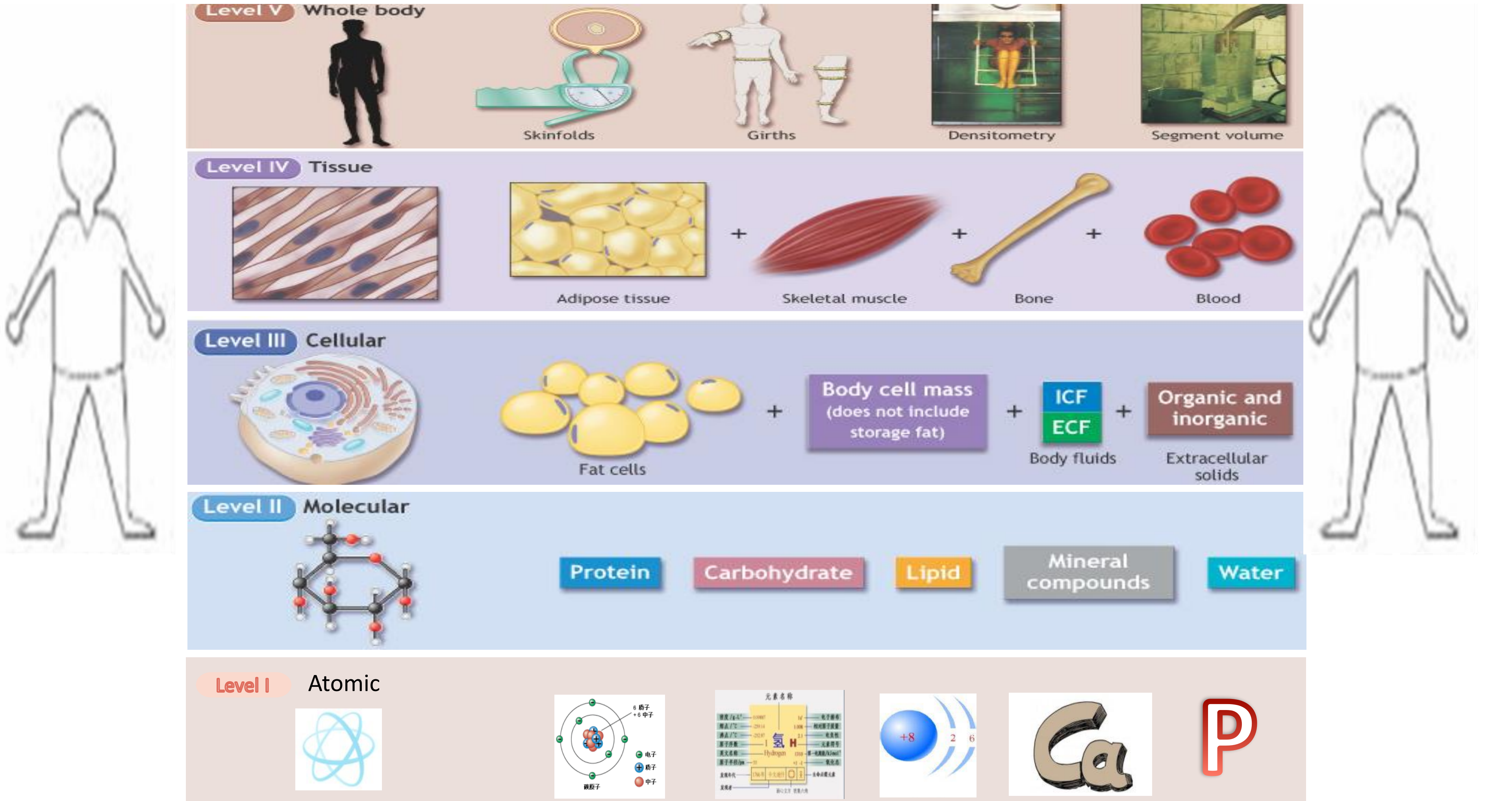
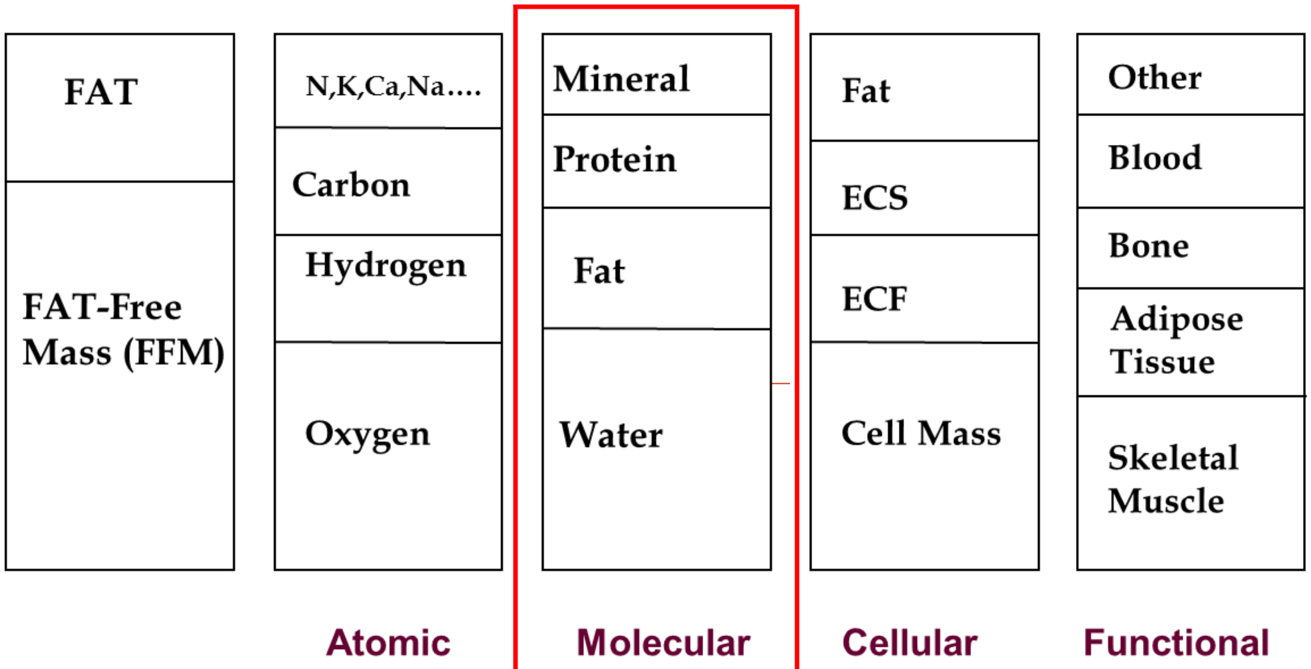
人体成分的”五模式水平”


Level V Whole body
Skinfolds
Girths
Densitometry
Segment volume
Level IV Tissue
Adipose tissue
+
Skeletal muscle
+
Bone
+
Blood
Level III Cellular
Fat cells
+
Body cell mass (does not include storage fat)
+
ICF
ECF
Body fluids
+
Organic and inorganic
Extracellular solids
Level II Molecular
Protein
Carbohydrate
Lipid
Mineral compounds
Water
Level I Atomic
氢 H
+8
2
6
Ca
P

人体成分

人体成分 身体脂肪组织（FM）和非脂肪组织 (FFM) 的含量在体重中所占比例。从分子的角度，将人体视为由 **水分子**、**蛋白质**、**无机盐** 和 **脂肪** 构成。

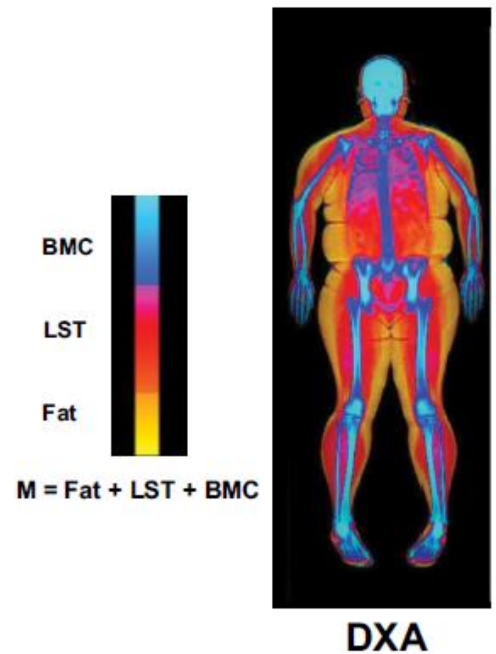


人体成分测定方法

- 水下称重法（又称“密度法”）
- 重水稀释法（又称“总液体容量法”）
- 影像技术
  - 双能X线吸收法法(dual-energy X-ray absorptiometry，DEXA)
  - CT
  - MRI
- *生物电阻抗法（Bioelectrical Impedance analysis；BIA）
- *人体测量学

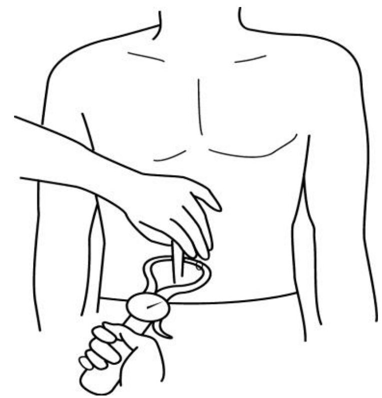
双能X线吸收法
(Dual Energy X-ray Absortiometry，DEXA)

- 特点:人体成分测量的金标准，可测量出节段肌肉量，节段无机盐、体脂肪含量
- 缺点: 设备昂贵、有辐射

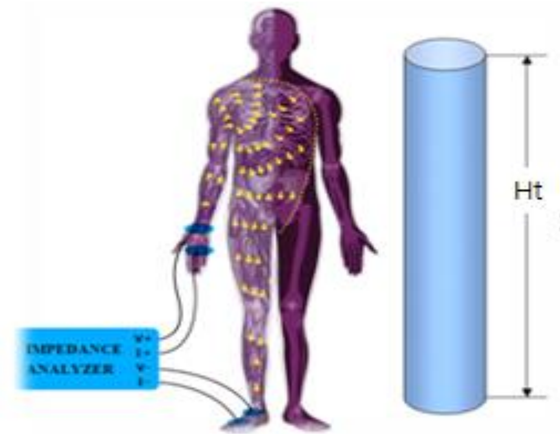


皮褶厚度法
(Skin-fold Thickness Measurement)

- 特点: 测量简便、经济
- 缺点: 根据测试者的熟练度而发生误差



生物电阻抗测量法
(Bioelectrical Impedance Analysis，BIA)



BIA原理：根据人体体成分不同的阻抗值。

体水分体积 → 根据阻抗指数得出体水分体积

去脂体重 → 去脂体重的约 73%为体水分
(去脂体重 = 体水分 / 0.73)

体脂肪 → 体脂肪 = 体重 – 去脂体重

人体成分测定方法对比

测定方法	简介	费用	难易度	精确度	脂肪分布
①DEXA	利用影像学方法测定脂肪、瘦组织和骨矿物质含量的方法	高	易	高	不能
②密度法	根据阿基米德定律测定脂肪和去脂体重的方法	中	高	高	不能
③重水稀释法	根据示踪法跟踪标记D_2O测定水分含量的方法	高	难	高	不能
④BIA	根据生物电学原理测定多项人体成分的方法	中	易	高	能
⑤ 人体测量学	体格检查（身高、上臂围、皮褶厚度等）	低	易	低	不能

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1. 人体成分在肥胖研究中的应用

Defining obesity

Method	Definition	Advantages/limitations
BMI	Weight in kilograms divided by square of the height in metres	BMI correlated strongly with densitometry measurements of fat mass; main limitation is that it does not distinguish fat mass from lean mass
Waist circumference	Measured (in centimetres) at midpoint between lower border of ribs and upper border of the pelvis	Waist circumference and waist-to-hip ratio provide measures for assessing upper body fat deposition; neither provide precise estimates of intra-abdominal (visceral) fat
Skinfold thickness	Measurement of skinfold thickness (in centimetres) with callipers provides a more precise assessment if taken at multiple sites	Measurements are subject to considerable variation between observers, require accurate callipers and do not provide any information on abdominal and intramuscular fat
Bioimpedance	Based on the principle that lean mass conducts current better than fat mass because it is primarily an electrolyte solution; measurement of resistance to a weak current (impedance) applied across extremities provides an estimate of body fat using an empirically derived equation	Devices are simple and practical but neither measure fat nor predict biological outcomes more accurately than simpler anthropometric measurements

肥胖诊断方法的对比

- BM I 无法区分脂肪和去脂体重
- 腰围无法区分皮下脂肪和内脏脂肪
- 皮褶厚度法无法精确评价脂肪量与
- 生物电阻抗技术是能便捷、判断肥胖含量和分布的方法

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1. 人体成分在肥胖研究中的应用

BMI可以准确评价肥胖吗？

在美国的一项纳入1393名研究对象的研究显示BMI诊断漏诊四成肥胖患者，BMI需要结合体脂率和瘦素来评价肥胖

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PLoS one

Measuring Adiposity in Patients: The Utility of Body Mass Index (BMI), Percent Body Fat, and Leptin

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Abstract

Background: Obesity is a serious disease that is associated with an increased risk of diabetes, hypertension, heart disease, stroke, and cancer, among other diseases. The United States Centers for Disease Control and Prevention (CDC) estimates a 20% obesity rate in the 50 states, with 12 states having rates of over 30%. Currently, the body mass index (BMI) is most commonly used to determine adiposity. However, BMI presents as an inaccurate obesity classification method that underestimates the epidemic and contributes to failed treatment. In this study, we examine the effectiveness of precise biomarkers and duel-energy x-ray absorptiometry (DXA) to help diagnose and treat obesity.

Methodology/Principal Findings: A cross-sectional study of adults with BMI, DXA, fasting leptin and insulin results were measured from 1998–2009. Of the participants, 63% were females, 37% were males, 75% white, with a mean age = 51.4 (SD = 14.2). Mean BMI was 27.3 (SD = 5.9) and mean percent body fat was 31.3% (SD = 9.3). BMI characterized 26% of the subjects as obese, while DXA indicated that 64% of them were obese. 39% of the subjects were classified as non-obese by BMI, but were found to be obese by DXA. BMI misclassified 25% men and 48% women. Meanwhile, a strong relationship was demonstrated between increased leptin and increased body fat.

Conclusions/Significance: Our results demonstrate the prevalence of false-negative BMIs, increased misclassifications in women of advancing age, and the reliability of gender-specific revised BMI cutoffs. BMI underestimates obesity prevalence, especially in women with high leptin levels (>30 ng/mL). Clinicians can use leptin-revised levels to enhance the accuracy of BMI estimates of percentage body fat when DXA is unavailable.

Table 2. Percent body fat and BMI for all patients.

	Men N = 518	Women N = 875	Total N = 1393
Concordant			
BMI non-obese, % body fat non-obese	265 (51%)	227 (26%)	492 (35%)
BMI obese, % body fat obese	122 (24%)	225 (26%)	347 (25%)
Discordant			
BMI non-obese, % body fat obese	116 (22%)	423 (48%)	539 (39%)
BMI obese, % body fat non-obese	15 (3%)	0 (0%)	15 (1%)

doi:10.1371/journal.pone.0033308.t002

Shah NR, Braverman ER (2012) Measuring Adiposity in Patients: The Utility of Body Mass Index (BMI), Percent Body Fat, and Leptin. PLoS ONE 7(4):e33308. doi:10.1371/journal.pone.0033308

1. 人体成分在肥胖研究中的应用

仅评估总脂肪含量是否足够？——通过脂肪分布部位，确定脂肪管理的紧迫性

脂肪分布情况对慢病的影响更为显著，如腹型肥胖、高内脏脂肪型肥胖

文章编号: 1001-0580(2008)08-0958-02 中图分类号: R 587.1 文献标志码: A

【论 著】

2 型糖尿病患者人体成分测定分析*

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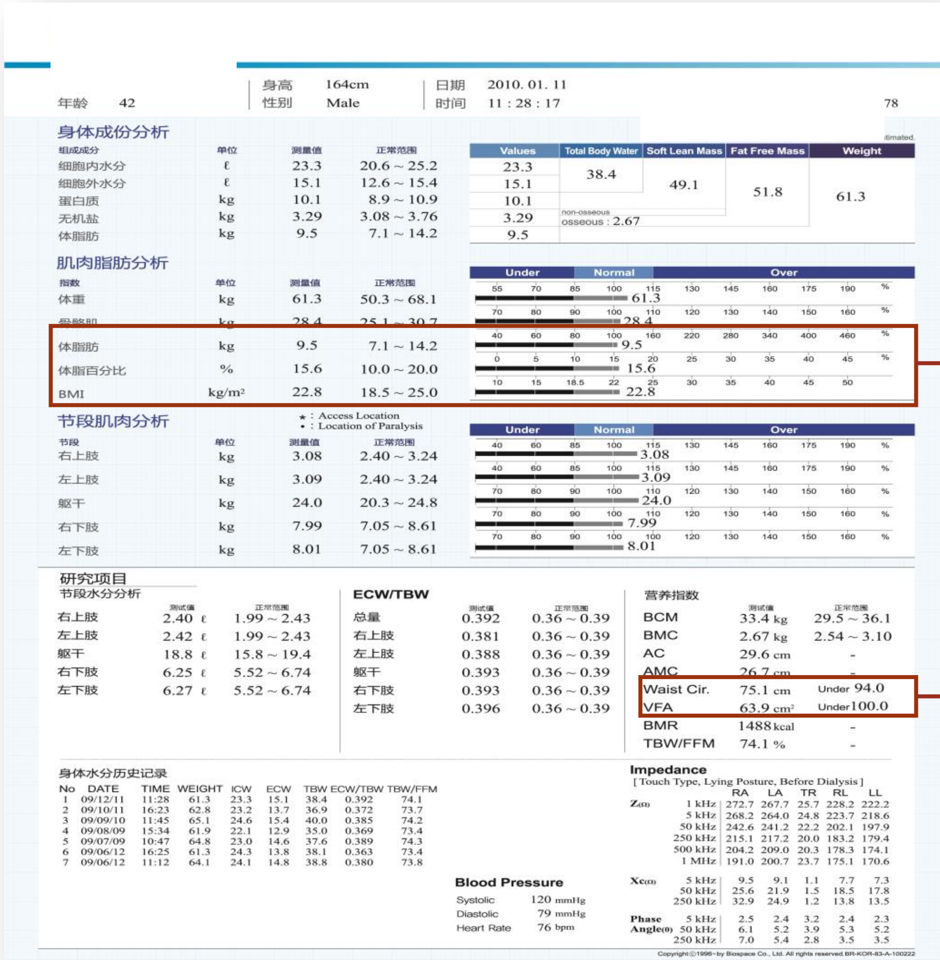
摘 要: **目的** 了解糖尿病患者与正常人群人体成分的差异，探讨中心性肥胖与糖尿病发生发展的关系。**方法** 完全随机选取糖尿病患者 67 名作为病例组，65 名健康体检者作为对照组。利用人体成分分析仪分别测量病例组和对照组的蛋白质含量、矿物质含量、脂肪含量、瘦体重、腰围、臀围等指标。同时测定血糖、甘油三酯、总胆固醇、高密度脂蛋白、低密度脂蛋白、碱性磷酸酶。**结果** 糖尿病患者的腰围和腰臀比分别为(91.768 ±5.200)，(0.948 ±0.045) cm，均明显高于对照组(87.597 ±9.630)，(0.931 ±0.053) cm ($P<0.05$)；其他指标差异无统计学意义。除体重、瘦体重、体质指数、体脂百分数外，性别对其他检测结果影响差异无统计学意义；并且糖尿病患者腰臀比、腰围均与高密度脂蛋白呈负相关($P<0.05$)。腰围与血糖，腰臀比与甘油三酯、碱性磷酸酶均呈正相关，差异有统计学意义($P<0.05$)。**结论** 糖尿病患者的人体成分除体脂分布异常外，其他指标均与健康人无明显差异。提示中心性肥胖与糖尿病发生可能存在一定关系。

表 1 病例组与对照组人体成分检测指标的比较($\bar{x}\pm s$)

指 标	病例组($n=67$)	对照组($n=65$)	t	P值
蛋白质含量(kg)	9.242 ±1.558	8.958 ±1.536	1.052	0.295
矿物质含量(kg)	3.1 12 ±0.412	3.039 ±0.416	1.011	0.314
脂肪含量(kg)	19.690 ±6.342	20.031 ±5.673	0.325	0.745
瘦体重(kg)	47.350 ±7.672	45.980 ±7.747	1.015	0.312
体重(kg)	67.025 ±10.419	66.015 ±9.701	0.576	0.566
身高(cm)	161.990 ±7.409	161.000 ±7.394	0.251	0.802
体脂百分数(%)	29.066 ±7.198	30.211 ±6.868	0.935	0.352
腰围(cm)	91.768 ±5.200	87.598 ±9.630	2.816	0.006
臀围(cm)	98.366 ±6.083	97.510 ±5.744	0.674	0.502
腰臀比*	0.948 ±0.045	0.931 ±0.053	2.409	0.043
肥胖度	122.420 ±18.400	121.079 ±15.614	0.451	0.653
肥胖指数	25.547 ±3.640	25.238 ±3.095	0.525	0.600
基础代谢能量(kJ)	5 302.546 ±622.951	5 174.999 ±615.841	1.184	0.239

注: * 腰臀比: 男 <0.90, 女 <0.85。

1. 人体成分在肥胖研究中的应用



年龄 42 | 身高 164cm | 性别 Male | 日期 2010. 01. 11 | 时间 11 : 28 : 17 | 78

身体成份分析

组成成分	单位	测量值	正常范围
细胞内水分	ℓ	23.3	20.6 ~ 25.2
细胞外水分	ℓ	15.1	12.6 ~ 15.4
蛋白质	kg	10.1	8.9 ~ 10.9
无机盐	kg	3.29	3.08 ~ 3.76
体脂肪	kg	9.5	7.1 ~ 14.2

Values	Total Body Water	Soft Lean Mass	Fat Free Mass	Weight
23.3	38.4	49.1	51.8	61.3
15.1				
10.1				
3.29	non-osseous osseous : 2.67			
9.5				

肌肉脂肪分析

指数	单位	测量值	正常范围
体重	kg	61.3	50.3 ~ 68.1
骨骼肌	kg	28.4	25.1 ~ 30.7
体脂肪	kg	9.5	7.1 ~ 14.2
体脂百分比	%	15.6	10.0 ~ 20.0
BMI	kg/m²	22.8	18.5 ~ 25.0

节段肌肉分析

★ : Access Location
• : Location of Paralysis

节段	单位	测量值	正常范围
右上肢	kg	3.08	2.40 ~ 3.24
左上肢	kg	3.09	2.40 ~ 3.24
躯干	kg	24.0	20.3 ~ 24.8
右下肢	kg	7.99	7.05 ~ 8.61
左下肢	kg	8.01	7.05 ~ 8.61

研究项目

节段水分分析

	测试值	正常范围
右上肢	2.40 ℓ	1.99 ~ 2.43
左上肢	2.42 ℓ	1.99 ~ 2.43
躯干	18.8 ℓ	15.8 ~ 19.4
右下肢	6.25 ℓ	5.52 ~ 6.74
左下肢	6.27 ℓ	5.52 ~ 6.74

ECW/TBW

	测试值	正常范围
总量	0.392	0.36 ~ 0.39
右上肢	0.381	0.36 ~ 0.39
左上肢	0.388	0.36 ~ 0.39
躯干	0.393	0.36 ~ 0.39
右下肢	0.393	0.36 ~ 0.39
左下肢	0.396	0.36 ~ 0.39

营养指数

	测试值	正常范围
BCM	33.4 kg	29.5 ~ 36.1
BMC	2.67 kg	2.54 ~ 3.10
AC	29.6 cm	-
AMC	26.7 cm	-
Waist Cir.	75.1 cm	Under 94.0
VFA	63.9 cm²	Under 100.0
BMR	1488 kcal	-
TBW/FFM	74.1 %	-

身体水分历史记录

No	DATE	TIME	WEIGHT	ICW	ECW	TBW	ECW/TBW	TBW/FFM
1	09/12/11	11:28	61.3	23.3	15.1	38.4	0.392	74.1
2	09/10/11	16:23	62.8	23.2	13.7	36.9	0.372	73.7
3	09/09/10	11:45	65.1	24.6	15.4	40.0	0.385	74.2
4	09/08/09	15:34	61.9	22.1	12.9	35.0	0.369	73.4
5	09/07/09	10:47	64.8	23.0	14.6	37.6	0.389	74.3
6	09/06/12	16:25	61.3	24.3	13.8	38.1	0.363	73.4
7	09/06/12	11:12	64.1	24.1	14.8	38.8	0.380	73.8

Blood Pressure

Systolic	120 mmHg
Diastolic	79 mmHg
Heart Rate	76 bpm

Impedance
[Touch Type, Lying Posture, Before Dialysis]

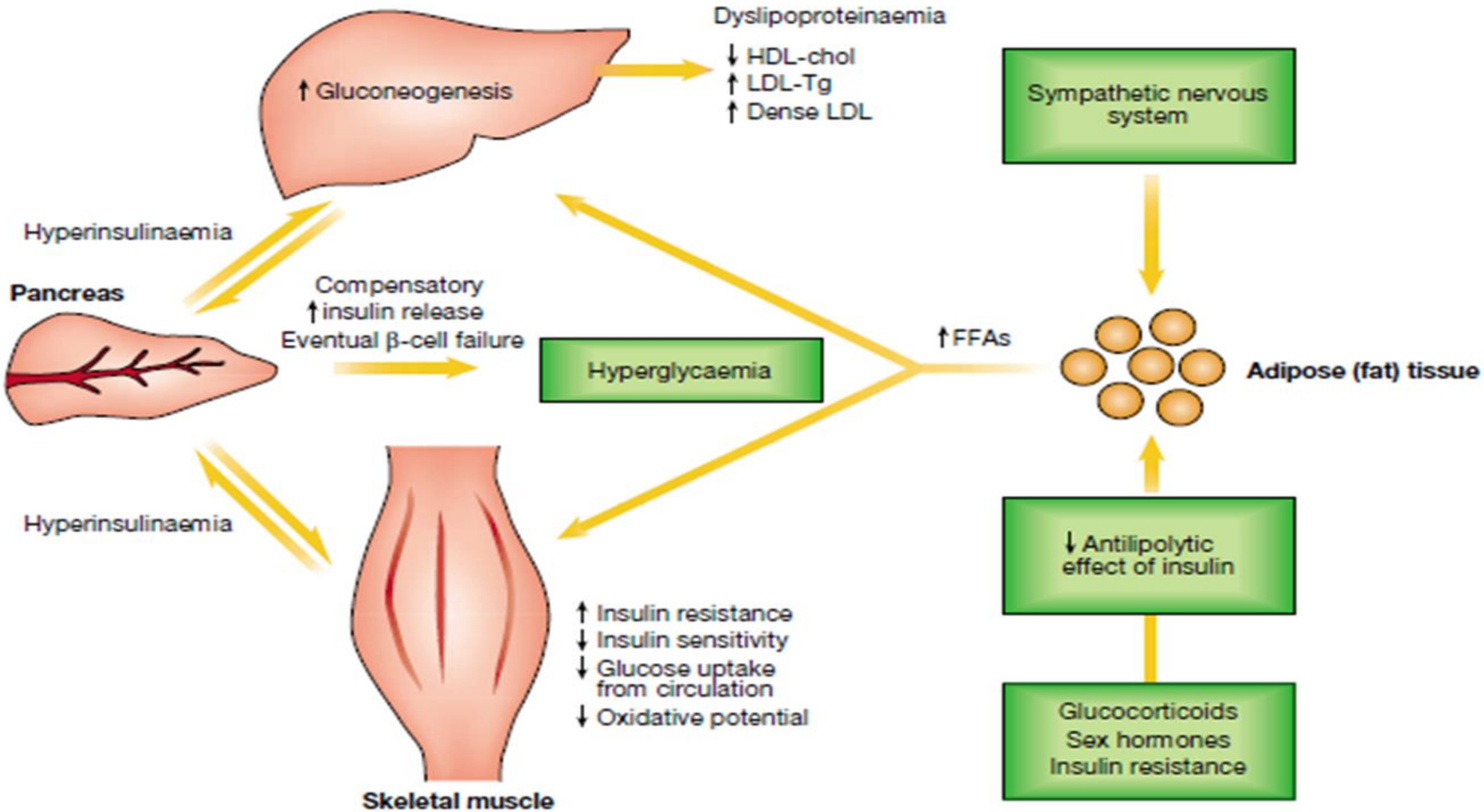
		RA	LA	TR	RL	LL
Z(Ω)	1 kHz	272.7	267.7	25.7	228.2	222.2
	5 kHz	268.2	264.0	24.8	223.7	218.6
	50 kHz	242.6	241.2	22.2	202.1	197.9
	250 kHz	215.1	217.2	20.0	183.2	179.4
	500 kHz	204.2	209.0	20.3	178.3	174.1
	1 MHz	191.0	200.7	23.7	175.1	170.6
Xc(Ω)	5 kHz	9.5	9.1	1.1	7.7	7.3
	50 kHz	25.6	21.9	1.5	18.5	17.8
	250 kHz	32.9	24.9	1.2	13.8	13.5
Phase Angle(θ)	5 kHz	2.5	2.4	3.2	2.4	2.3
	50 kHz	6.1	5.2	3.9	5.3	5.2
	250 kHz	7.0	5.4	2.8	3.5	3.5

肥胖评价要点：

1. BMI初筛肥胖
2. 体脂百分比筛选隐形肥胖，并排除掉肌肉强壮的“肥胖”人群
3. 腰臀比或者腰围筛选腹型肥胖
4. 内脏脂肪
5. 节段脂肪评价主要脂肪堆积部位，了解减重难度

2. 人体成分在糖尿病研究中的应用

脂肪含量增加→游离脂肪酸增加→糖异生增加→胰岛素抵抗增加
肌肉是利用胰岛素的靶器官之一：肌肉减少→胰岛素抵抗增加



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2. 人体成分在糖尿病研究中的应用

• 糖尿病用药期间的体重管理

磺脲类药物与胰岛素等糖尿病的治疗患者在10年的随访中发生体重增加

ORIGINAL ARTICLE
doi: 10.1111/j.1463-1326.2009.01072.x

Harnessing the weight-regulating properties of glucagon-like peptide-1 in the treatment of type 2 diabetes

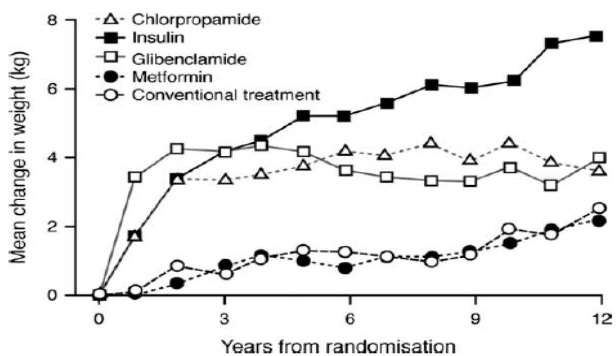


Fig. 1 Mean change in body weight over a 10-year follow-up period in patients with type 2 diabetes following conventional treatment (i.e. diet alone) or intensive treatment with insulin, chlorpropamide, glibenclamide or metformin. © 1998 Elsevier and reproduced with permission from UK Prospective Diabetes Study Group [6].

糖尿病治疗中体重增加进而导致：

- 胰岛素抵抗
- 代谢紊乱，控制难度增加
- 心血管风险增加

我们需要了解药物对 2 型糖尿病人体成分的改变是否导致脂肪增加或者肌肉减少

Diabetes, Obesity and Metabolism, 11 (Suppl. 3), 2009, 4 - 10

2. 人体成分在糖尿病研究中的应用

- **2型糖尿病患者的内脏脂肪与代谢指标的关联**
- **MNT 治疗减少内脏脂肪**

内脏脂肪面积与收缩压（SBP）、舒张压（DBP）空腹血糖（FPG）、空腹胰岛素（FINS）、胰岛素抵抗指数（HOMA-IR）、甘油三酯（TG）呈**正相关性**

表 3　内脏脂肪面积与代谢指标的相关性

指标	测量值	VFA	
		R 值	*P* 值
SBP(mmHg)	120.85 ± 18.34	0.368	0.001
DBP(mmHg)	78.03 ± 12.38	0.319	0.003
FBG(mmol/L)	5.78 ± 1.89	0.235	0.001
FINS(pmol/L)	38.78 ± 26.85	0.416	0.000
HOMA-IR	1.48 ± 1.82	0.459	0.000
TG(mmol/L)	1.98 ± 1.29	0.321	0.014

表 1　干预前后体格检查指标的变化

指标	干预组(n=35)		对照组(n=32)	
	干预前	干预后	干预前	干预后
体重(kg)	68.12 ± 13.14	66.32 ± 14.28	67.85 ± 11.12	67.03 ± 18.99
BMI	24.89 ± 3.56	23.38 ± 4.42	25.02 ± 3.96	24.56 ± 3.79
WC(cm)	85.13 ± 6.24	82.31 ± 5.08$^{*\#}$	84.76 ± 5.58	84.12 ± 3.28
WHR	0.87 ± 0.72	0.82 ± 0.39$^{*\#}$	0.88 ± 0.15	0.86 ± 0.63
SBP(mmHg)	138.12 ± 15.24	128.23 ± 13.19	140.34 ± 12.58	135.35 ± 13.29
DBP(mmHg)	88.73 ± 9.16	83.34 ± 7.28	87.29 ± 7.35	84.66 ± 4.86
蛋白质(kg)	7.86 ± 0.94	8.08 ± 0.92*	7.63 ± 1.02	6.62 ± 2.89
脂肪(kg)	16.12 ± 1.45	13.15 ± 0.89$^{*\#}$	16.34 ± 0.89	15.18 ± 0.92
VFA(cm^2)	104.56 ± 6.78	98.63 ± 5.56$^{*\#}$	103.08 ± 5.64	101.68 ± 6.72

与干预前比较，$^{*}P < 0.05$；与对照组比较，$^{\#}P < 0.05$。

表 2　干预前后生化指标的变化

指标	干预组(n=35)		对照组(n=32)	
	干预前	干预后	干预前	干预后
FBG(mmol/L)	9.46 ± 1.85	6.72 ± 1.36	9.35 ± 1.53	7.23 ± 1.87
PBG(mmol/L)	12.44 ± 3.89	8.99 ± 2.47$^{*\#}$	11.94 ± 3.24	9.78 ± 2.89
FINS(pmol/L)	70.48 ± 54.18	60.26 ± 43.48$^{*\#}$	71.13 ± 46.84	68.29 ± 40.88
TC(mmol/L)	5.72 ± 1.48	4.65 ± 1.73	5.64 ± 1.87	5.35 ± 1.68
TG(mmol/L)	1.98 ± 1.35	1.31 ± 0.92$^{*\#}$	1.93 ± 1.25	1.78 ± 0.23
LDL-C(mmol/L)	2.64 ± 1.28	2.05 ± 1.08$^{*\#}$	2.58 ± 1.16	2.26 ± 1.42
HDL-C(mmol/L)	0.98 ± 0.68	1.02 ± 0.24	0.96 ± 0.31	1.04 ± 0.45

与干预前比较，$^{*}P < 0.05$；与对照组比较，$^{\#}P < 0.05$。

MNT 减少2 型糖尿病内脏脂肪的研究.南京医科大学学报 2014,34(1):1542-1549

2. 人体成分在糖尿病研究中的应用

- 肌肉量增加有助于增加胰岛素的亲和力，减少胰岛素抵抗

ORIGINAL ARTICLE

Endocrine Research

Relative Muscle Mass Is Inversely Associated with Insulin Resistance and Prediabetes. Findings from The Third National Health and Nutrition Examination Survey

Preethi Srikanthan and Arun S. Karlamangla

Divisions of Endocrinology (P.S.) and Geriatrics (A.S.K.), Department of Medicine, David Geffen School of Medicine, Los Angeles, California 90095-1679

Context: Insulin resistance, the basis of type 2 diabetes, is rapidly increasing in prevalence; very low muscle mass is a risk factor for insulin resistance.

Objective: The aim was to determine whether increases in muscle mass at average and above average levels are associated with improved glucose regulation.

Design: We conducted a cross-sectional analysis of National Health and Nutrition Examination Survey III data.

Participants: Data from 13,644 subjects in a national study were evaluated.

Outcome Measurements: We measured homeostasis model assessment of insulin resistance (HOMA-IR), blood glycosylated hemoglobin level, prevalence of transitional/pre- or overt diabetes (PDM), and prevalence of overt diabetes mellitus.

Results: All four outcomes decreased from the lowest quartile to the highest quartile of skeletal muscle index (SMI), the ratio of total skeletal muscle mass (estimated by bioelectrical impedance) to total body weight. After adjusting for age, ethnicity, sex, and generalized and central obesity, each 10% increase in SMI was associated with 11% relative reduction in HOMA-IR (95% confidence interval, 6–15%) and 12% relative reduction in PDM prevalence (95% CI, 1–21%). In nondiabetics, SMI associations with HOMA-IR and PDM prevalence were stronger.

Conclusions: Across the full range, higher muscle mass (relative to body size) is associated with better insulin sensitivity and lower risk of PDM. ...

(J Clin Endocrinol Metab 96: 2898–2903, 2011)

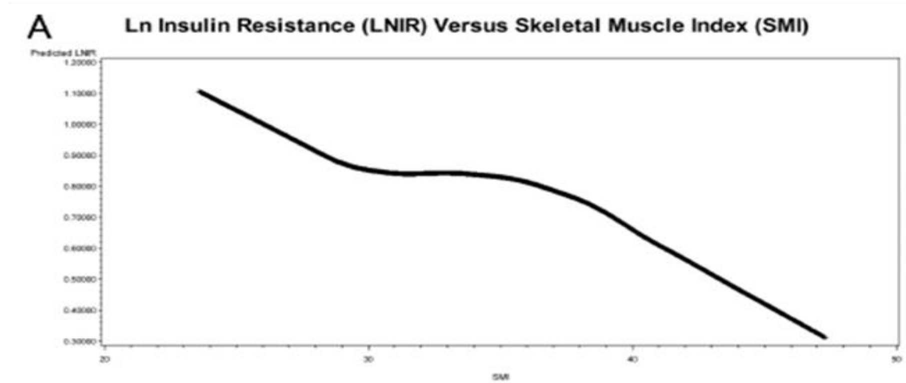
worldwide growth in the prevalence of diabetes, a major source of cardiovascular morbidity and health expenditure, is expected to accelerate. It is thus imperative that all major factors that contribute to the development of diabetes mellitus (DM) are identified. The adverse impact of sarcopenia, or low muscle mass, on insulin resistance and

resistance and diabetes risk outside the context of sarcopenia. Specifically, it is not known whether increasing muscle mass beyond the sarcopenic range increases insulin sensitivity and affords protection against incidence of diabetes. Because muscle is the primary tissue contributing to whole-body insulin-mediated glucose disposal, we hy-

ISSN Print 0021-972X ISSN Online 1945-7197
Printed in U.S.A.

doi: 10.1210/jc.2011-0435 Received February 17, 2011. Accepted June 27, 2011.
First Published Online July 21, 2011

Abbreviations: BI, Bioelectrical impedance; BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; HbA1C, glycosylated hemoglobin; HOMA-IR, homeostasis model assessment of insulin resistance; MEC, mobile examination center; MMI, muscle mass index; PDM, pre- or overt diabetes; SES, socioeconomic status; SMI, skeletal muscle index.



肌肉占比越高， 患糖尿病的危险性就越低

肌肉量每增加10%， 胰岛素抵抗降低11%， 进入糖尿病前期的风险下降12%

J Clin Endocrinol Metab, September 2011, 96(9):0000－0000

2. 人体成分在糖尿病研究中的应用

- **2型糖尿病患者的下肢肌肉量维持有助于纠正胰岛素抵抗**

METABOLIC SYNDROME AND RELATED DISORDERS
Volume 8, Number 2, 2010
© Mary Ann Liebert, Inc.
Pp. 137–142
DOI: 10.1089/met.2009.0043

Reduction of Skeletal Muscle, Especially in Lower Limbs, in Japanese Type 2 Diabetic Patients With Insulin Resistance and Cardiovascular Risk Factors

Yuji Tajiri, M.D., Ph.D., Tomoko Kato, M.D., Hitomi Nakayama, M.D., and Kentaro Yamada, M.D., Ph.D.

Abstract

Background: The aim of the present study was to evaluate characteristics of body composition in Japanese patients with type 2 diabetes.
Methods: Measurement of regional body composition was performed using bioelectrical impedance analysis (INBODY720) in 198 patients with type 2 diabetes (group D) and 198 apparently healthy subjects matched for age, gender, and body mass index (BMI) (group C), together with measurements of metabolic parameters.
Results: The percentage of skeletal muscle of whole body (M%) and in lower extremities (leg M%) was significantly lower in group D than that in group C. These sarcopenic features were manifest in patients with longer durations of diabetes or lack of exercise. M% and leg M% in diabetic patients were negatively correlated with the log-transformed triglyceride/high-density lipoprotein cholesterol (HDL-C) ratio, a marker of insulin resistance and atherosclerosis risk. Furthermore, reduced leg M% was significantly correlated with increasing numbers of risk factors for cardiovascular disease (CVD).
Conclusions: Because this distinctive feature of body composition becomes more evident as duration of diabetes is longer and less marked in patients with habitual exercise, early intervention, such as the instruction of exercise including resistance training, seems to be worthwhile for the prevention of future burdens in these patients.

Introduction

Regional body composition has an important influence on metabolic and cardiovascular risk factors. It is well established that increased visceral fat accumulation is associated with insulin resistance, type 2 diabetes, dyslipidemia, and hypertension. On the other hand, reduced skeletal muscle amount has been suggested as another important issue in forming insulin resistance.[1,2] Because skeletal muscle is one of the major target organs of insulin, it is quite rational that the reduction of skeletal muscle mass causes insulin resistance. However, measurement of skeletal muscle volume itself with regard to insulin resistance has not often been reported until now, probably due to the difficulty of its quantification. Magnetic resonance imaging (MRI) can be used to quantify the amount of muscle without losing spatial information,[3] but this method is not widely applicable because of the large number in cohorts, thus raising an issue of cost-effectiveness. The recently developed bioelectrical impedance analysis (BIA) method is an appropriate alternative way to provide reliable and quantitative information on body composition,[4,5] and enables us to estimate both fat and lean body mass in large numbers of subjects. The validity of this method has been established by comparison to the results derived from dual-energy X-ray absorptiometry (DXA).[6,7]

In the present study, regional body composition of patients with type 2 diabetes, together with that of age-, gender-, and BMI-matched healthy subjects, was analyzed using the impedance method. Although a tendency toward whole body muscle wasting in diabetes has been reported by some investigators,[8] each skeletal muscle region has not been discussed so far. Reduced skeletal muscle amounts, especially in lower extremities, was discussed as a function of insulin resistance, atherosclerosis, and cardiovascular disease (CVD).

Research Design and Methods

Recruitment and eligibility

Patients with type 2 diabetes who had been treated in the outpatient clinic and metabolic ward in Kurume University

Endocrinology and Metabolism Division, Kurume University School of Medicine, Kurume, Japan.

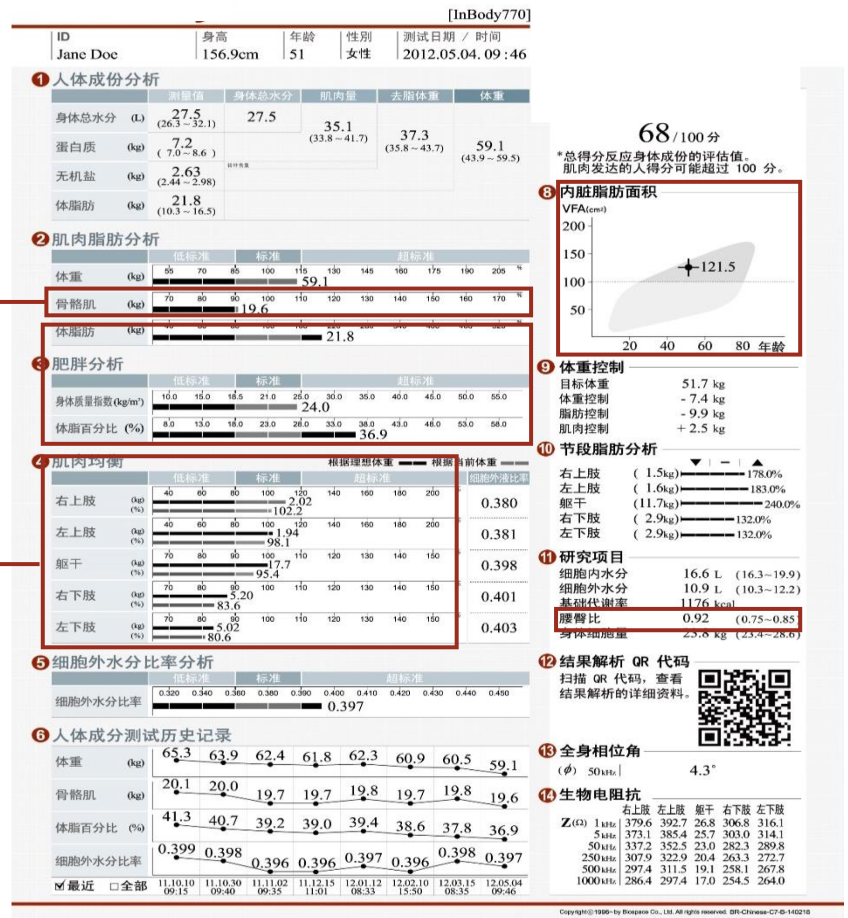
Table 3. Correlations Between Anthropometric Values and Duration of Diabetes or Exercise Status in Diabetic Patients

	Duration (n = 179)		Exercise status (n = 124)	
	r	P value	r	P value
F (kg)	0.295	0.11	–0.068	0.72
F (%)	0.257	0.1	–0.104	0.52
M (kg)	–0.292	0.13	0.35	0.07
M (%)	–0.308	0.04	0.159	0.32
Right arm M (kg)	–0.03	0.88	0.226	0.25
Right leg M (kg)	–0.314	0.08	0.398	0.02
Right arm M (%)	–0.006	0.97	0.015	0.93
Right leg M (%)	–0.375	0.02	0.306	0.04

II型糖尿病患者体成分的变化受病程长短和运动状态的影响

METABOLIC SYNDROME AND RELATED DISORDERS
Volume 8, Number 2, 2010

2. 人体成分在糖尿病研究中的应用


[InBody770]

ID	身高	年龄	性别	测试日期 / 时间
Jane Doe	156.9cm	51	女性	2012.05.04. 09:46

1 人体成份分析

	测量值	身体总水分	肌肉量	去脂体重	体重
身体总水分 (L)	27.5 (26.3～32.1)	27.5	35.1 (33.8～41.7)	37.3 (35.8～43.7)	59.1 (43.9～59.5)
蛋白质 (kg)	7.2 (7.0～8.6)				
无机盐 (kg)	2.63 (2.44～2.98)				
体脂肪 (kg)	21.8 (10.3～16.5)				

2 肌肉脂肪分析

	低标准 / 标准 / 超标准
体重 (kg)	59.1
骨骼肌 (kg)	19.6
体脂肪 (kg)	21.8

3 肥胖分析

	低标准 / 标准 / 超标准
身体质量指数 (kg/m²)	24.0
体脂百分比 (%)	36.9

4 肌肉均衡

	(kg)	(%)	细胞外液比率
右上肢	2.02	102.2	0.380
左上肢	1.94	98.1	0.381
躯干	17.7	95.4	0.398
右下肢	5.20	83.6	0.401
左下肢	5.02	80.6	0.403

5 细胞外水分比率分析

细胞外水分比率 0.397

6 人体成分测试历史记录

	11.10.10 09:15	11.10.30 09:40	11.11.02 09:35	11.12.15 11:01	12.01.12 08:33	12.02.10 15:50	12.03.15 08:35	12.05.04 09:46
体重 (kg)	65.3	63.9	62.4	61.8	62.3	60.9	60.5	59.1
骨骼肌 (kg)	20.1	20.0	19.7	19.7	19.8	19.7	19.8	19.6
体脂百分比 (%)	41.3	40.7	39.2	39.0	39.4	38.6	37.8	36.9
细胞外水分比率	0.399	0.398	0.396	0.396	0.397	0.396	0.398	0.397

☑最近 □全部

68/100 分

*总得分反应身体成份的评估值。肌肉发达的人得分可能超过 100 分。

8 内脏脂肪面积

VFA(cm²) 121.5

9 体重控制

目标体重	51.7 kg
体重控制	- 7.4 kg
脂肪控制	- 9.9 kg
肌肉控制	+ 2.5 kg

10 节段脂肪分析

右上肢	(1.5kg)	178.0%
左上肢	(1.6kg)	183.0%
躯干	(11.7kg)	240.0%
右下肢	(2.9kg)	132.0%
左下肢	(2.9kg)	132.0%

11 研究项目

细胞内水分	16.6 L	(16.3～19.9)
细胞外水分	10.9 L	(10.3～12.2)
基础代谢率	1176 kcal	
腰臀比	0.92	(0.75～0.85)
身体细胞量	23.8 kg	(23.4～28.6)

12 结果解析 QR 代码

扫描 QR 代码，查看结果解析的详细资料。

13 全身相位角

(ϕ) 50kHz 4.3°

14 生物电阻抗

Z(Ω)	右上肢	左上肢	躯干	右下肢	左下肢
1kHz	379.6	392.7	26.8	306.8	316.1
5kHz	373.1	385.4	25.7	303.0	314.1
50kHz	337.2	352.5	23.0	282.3	289.8
250kHz	307.9	322.9	20.4	263.3	272.7
500kHz	297.4	311.5	19.1	258.1	267.8
1000kHz	286.4	297.4	17.0	254.5	264.0

肌肉状态评价

关注低骨骼肌量

关注低下肢肌肉量

3.人体成分在肾病研究中的应用

- **KDOQI指南提出调节水分过多状态和高血压，可减少心血管疾病的发生!!**

为调节血液透析患者的血压和预防心血管疾病合并症的发生，维持适当的体液状态非常重要。

I. CLINICAL PRACTICE GUIDELINES FOR HEMODIALYSIS ADEQUACY

GUIDELINE 5. CONTROL OF VOLUME AND BLOOD PRESSURE

There is ample evidence in the non-CKD population that optimal control of blood pressure influences mortality. In the HD population, available evidence indicates that control of a patient's fluid volume influences outcome. Volume and blood pressure are linked; thus, it is important to optimize ultrafiltration and dry weight to control blood pressure in an effort to improve patient outcome.

RATIONALE

The volume status of a maintenance dialysis patient is mainly a function of sodium intake, water intake, urine output, and removal of excess fluid by ultrafiltration during dialysis. Because cellular membranes are freely permeable to water, the osmotic gradient generated by the addition of dietary sodium to the ECF compartment causes water to move from cells into the ECF space, thus expanding ECF volume at the expense of the intracellular fluid compartment. The increase in ECF osmolality stimulates the thirst center of the hypothalamus, increasing water intake. Thus, the combined influence of both positive sodium and water balances causes expansion, primarily of the ECF volume.[108] Such volume expansion can be especially marked in dialysis patients with poor RKF.

Ref. NKF KDOQI(Kidney Disease Outcomes Quality Initiative) Guideline

3.人体成分在肾病研究中的应用

- 肾病患者细胞外水分比率与SGA评分、糖尿病、心血管疾病、血压具有显著相关性

OPEN ACCESS Freely available online PLOS ONE

Prevalence and Risk Factors of Fluid Overload in Southern Chinese Continuous Ambulatory Peritoneal Dialysis Patients

Qunying Guo[¶], Chunyan Yi[¶], Jianying Li, Xiaofeng Wu, Xiao Yang, Xueqing Yu*

Department of Nephrology, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, Guangdong, China

Abstract

Background: Fluid overload is frequently present in CAPD patients and one of important predictors of mortality. The aim of this study is to investigate the prevalence and associated risk factors in a cohort study of Southern Chinese CAPD patients.

Methods: The patients (receiving CAPD 3 months and more) in our center were investigated from January 1, 2008 to December 31, 2009. Multi-frequency bioelectrical impedance analysis was used to assess the patient's body composition and fluid status.

Results: A total of 307 CAPD patients (43% male, mean age 47.8±15.3 years) were enrolled, with a median duration of PD 14.6 (5.9–30.9) months. Fluid overload (defined by Extracellular water/Total body water (ECW/TBW)≥0.40) was present in 205 (66.8%) patients. Univariate analysis indicated that ECW/TBW were inversely associated with body mass index ($r=-0.11$, $P=0.047$), subjective global assessment score ($r=-0.11$, $P=0.004$), body fat mass ($r=-0.15$, $P=0.05$), serum albumin ($r=-0.32$, $P<0.001$), creatinine ($r=-0.14$, $P=0.02$), potassium ($r=-0.15$, $P=0.02$), and residual urine output ($r=-0.14$, $P=0.01$), positively associated with age ($r=0.27$, $P<0.001$), Chalrlson Comorbidity Index score ($r=0.29$, $P<0.001$), and systolic blood pressure ($r=0.22$, $P<0.001$). Multivariate linear regression showed that lower serum albumin ($\beta=-0.223$, $P<0.001$), lower body fat mass ($\beta=-0.166$, $P=0.033$), old age ($\beta=0.268$, $P<0.001$), higher systolic blood pressure ($\beta=0.16$, $P=0.006$), less residual urine output ($\beta=-0.116$, $P=0.042$), and lower serum potassium ($\beta=-0.126$, $P=0.03$) were independently associated with higher ECW/TBW. After 1 year of follow-up, the cardiac event rate was significantly higher in the patients with fluid overload (17.1% vs 6.9%, $P=0.023$) than that of the normal hydrated patients.

Conclusions: The prevalence of fluid overload was high in CAPD patients. Fluid overload in CAPD patients were independently associated with protein-energy wasting, old age, and decreased residual urine output. Furthermore, CAPD patients with fluid overload had higher cardiac event rate than that of normal hydrated patents.

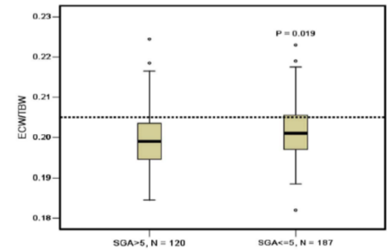


Figure 2. ECW/TBW in the CAPD patients with and without malnutrition. *, P<0.05; SGA, subjective global assessment.
doi:10.1371/journal.pone.0053294.g002

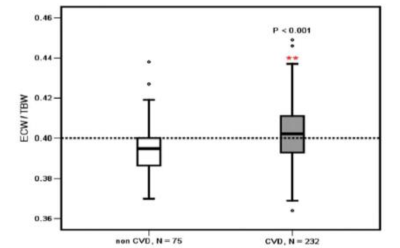


Figure 3. ECW/TBW in the CAPD patients with and without CVD. **, P<0.01; CVD, cardiovascular disease.
doi:10.1371/journal.pone.0053294.g003

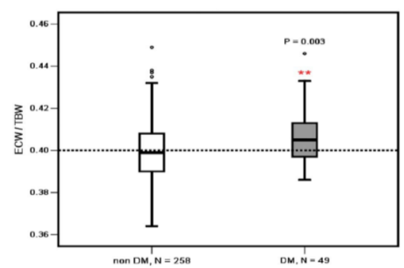


Figure 4. ECW/TBW in the diabetic and non-diabetic CAPD patients. **, P<0.01; DM: diabetes mellitus.

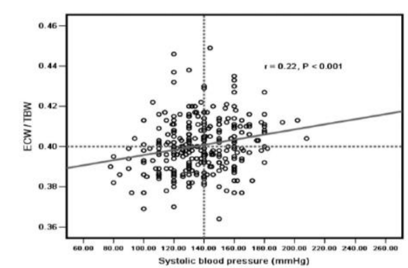
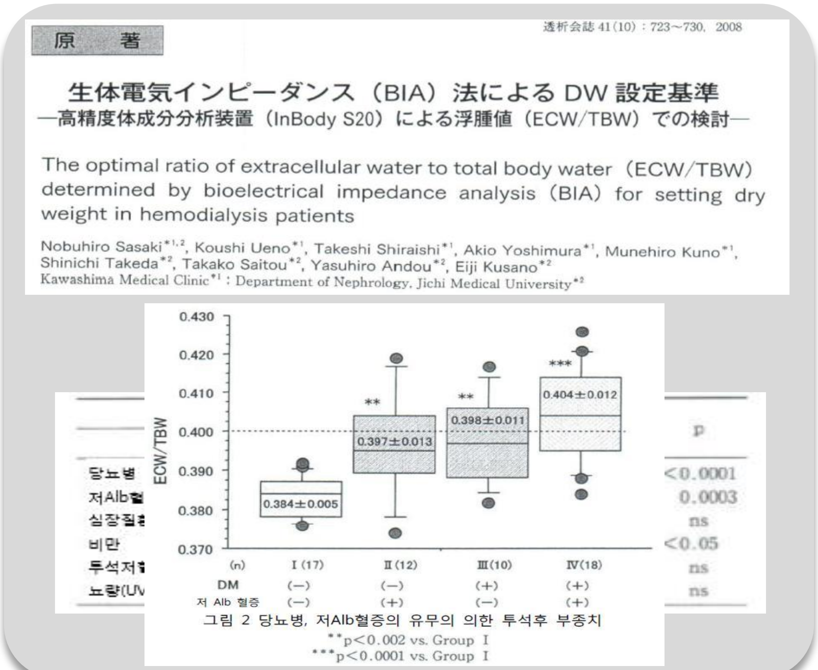


Figure 5. ECW/TBW was positively correlated with systolic blood pressure (mmHg).

3.人体成分在肾病研究中的应用

- **通过BIA技术了解细胞外水分比率结合合并发症，评价血液透析患者透析充分性**

合并有与浮肿相关的糖尿病或低蛋白血症的患者ECW/TBW标准应调高。


原　著

透析会誌 41(10)：723～730，2008

生体電気インピーダンス（BIA）法による DW 設定基準
—高精度体成分分析装置（InBody S20）による浮腫値（ECW/TBW）での検討—

The optimal ratio of extracellular water to total body water (ECW/TBW) determined by bioelectrical impedance analysis (BIA) for setting dry weight in hemodialysis patients

Nobuhiro Sasaki*1,2, Koushi Ueno*1, Takeshi Shiraishi*1, Akio Yoshimura*1, Munehiro Kuno*1, Shinichi Takeda*2, Takako Saitou*2, Yasuhiro Andou*2, Eiji Kusano*2
Kawashima Medical Clinic*1 : Department of Nephrology, Jichi Medical University*2

그림 2 당뇨병, 저Alb혈증의 유무의 의한 투석후 부종치
**p<0.002 vs. Group I
***p<0.0001 vs. Group I

一般健康人的ECW/TBW 约维持在0.380，2008年发表在日本透析会刊的显示透析患者按有无合并某些疾病而定合适的ECW/TBW。

没有合并糖尿病或低蛋白血症的患者为 < 0.385, (0.38~0.385)

合并糖尿病或低蛋白血症的患者为 < 0.395, (0.395~0.40)

合并糖尿病和低蛋白血症的患者为 < 0.405以下。(0.40~0.405)

* 注！ 给出的理想水分比率是根据此文献给出的参考值，并不是标准值。

The optimal ratio of extracellular water to total body water determined by bioelectrical impedance analysis for setting dry weight in hemodialysis patients，透析会誌4110：723～730，2008

3.人体成分在肾病研究中的应用

- **关注肾病患者节段瘦组织含量（四肢瘦组织/躯干瘦组织）**

ORIGINAL RESEARCH

Limb/Trunk Lean Mass Ratio as a Risk Factor for Mortality in Peritoneal Dialysis Patients

Seok Hui Kang, MD, Jong Won Park, MD, PhD, Kyung Woo Yoon, MD, PhD, and Jun Young Do, MD, PhD

In summary, lean mass measurement can be an important indicator of PEW. Regional lean mass may be more important than the total lean mass. Therefore, distribution or changes in regional lean mass would be more useful for predicting the nutritional status and other mass indices. LTLM is associated with other mass indices, nutritional status, and mortality in CAPD patients. This study demonstrates LTLM as a new marker with utility as a predicting parameter for nutritional status and mortality in CAPD patients.

瘦组织是评价蛋白质热能消耗的有效指标，节段瘦组织的重要性要优于全身。所以节段瘦组织的分布可以有效的评价营养状态。LTLM与CAPD患者的营养状态和存活率密切相关。

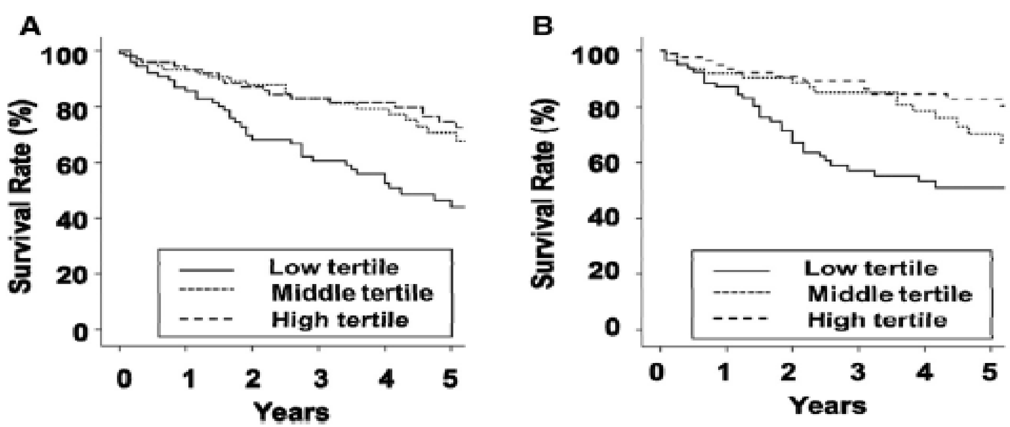


Figure 4. Kaplan–Meier survival curve according to initial LTLM ratio tertile. (A) Survival rate in males (85.7% at 1 year and 44.1% at 5 years in low tertile; 93.4% at 1 year and 70.7% at 5 years in middle tertile; 93.3% at 1 year and 74.5% at 5 years in high tertile; *P* < .001). (B) Survival rate in females (87.3% at 1 year and 50.9% at 5 years in low tertile; 92.2% at 1 year and 70.4% at 5 years in middle tertile; 93.7% at 1 year and 82.8% at 5 years in high tertile; *P* < .001).

LTLM=四肢瘦组织量/躯干瘦组织量

男性	女性
低＜0.7943	低＜0.7100
中0.7943-0.8745	中0.7100-0.8116
高＞0.8745	高＞0.8116

Journal of Renal Nutrition, Vol 23, No 4 (July), 2013: pp 315-323

3.人体成分在肾病研究中的应用

● 关注肾病患者相位角

相位角(PA)可应用于判断肾脏疾病患者的营养状态和生存率。

Kidney International, Vol. 64 (2003), pp. S53–S56

Relationship of bioelectrical impedance parameters to nutrition and survival in peritoneal dialysis patients

ROBERT MUSHNICK, PAUL A. FEIN, NEAL MITTMAN, NAVEEN GOEL, JYOTIPRAKAS CHATTOPADHYAY, and MORRELL M. AVRAM

Avram Division of Nephrology, Long Island College Hospital, Brooklyn, New York

⋮

(relative risk = 0.39, P = 0.027) of more than two years' survival in PD patients. Serum prealbumin was directly correlated with phase angle (r = 0.54, P < 0.0001), reactance (r = 0.55, P < 0.0001), and resistance (r = 0.29, P = 0.06).

Conclusion. BIA indexes reflect nutritional status and may be useful in monitoring nutritional status in PD patients. Phase angle is a strong prognostic index in PD patients. It is useful to incorporate prealbumin and BIA parameters in the regular assessment of PD patients, whose survival may be improved by better management of malnutrition and overall health status.

相位角：电流通过细胞膜产生的阻抗，用角度来表示.

前白蛋白因血中急速交换速度、短半衰期，作为最敏感的营养评价指标及预测生存率的有用工具。

本研究结果显示前白蛋白与phase angle具有显著相关

Kidney International, Vol. 64 (2003), pp. S53－S56

3.人体成分在肾病研究中的应用

	身高	年龄	性别	测试日期 / 时间
16032921	162cm	54	男性	2016.03.29. 14:39

身体水分组成

	低标准 / 标准 / 超标准
身体水分含量 (L)	39.4
细胞内水分 (L)	23.0
细胞外水分 (L)	16.4

细胞外水分比率分析

	低标准 / 标准 / 超标准
细胞外水分比率	0.416

节段水分分析

	低标准 / 标准 / 超标准
右上肢 (L)	2.23
左上肢 (L)	2.34
躯干 (L)	17.7
右下肢 (L)	6.75
左下肢 (L)	6.53

节段细胞外水分比率分析

浮肿 / 轻度浮肿 / 正常

右上肢	左上肢	躯干	右下肢	左下肢
0.395	0.402	0.415	0.424	0.425

身体水分历史记录

体重 (kg)	67.2
身体总水分 (L)	39.4
细胞内水分 (L)	23.0
细胞外水分 (L)	16.4
细胞外水分比率	0.416

☑最近 □全部

身体水分组成

身体总水分	39.4 L	(32.5～39.7)
细胞内水分	23.0 L	(20.2～24.6)
细胞外水分	16.4 L	(12.3～15.1)

节段水分分析

右上肢	2.23 L	(1.83～2.47)
左上肢	2.34 L	(1.83～2.47)
躯干	17.7 L	(15.5～18.9)
右下肢	6.75 L	(5.39～6.59)
左下肢	[illegible]	[illegible]

人体成份分析

蛋白质	9.9 kg	(8.7～10.7)
无机盐	3.53 kg	(3.01～3.67)
体脂肪	14.4 kg	(6.9～13.9)
去脂体重	52.8 kg	(44.2～54.0)
骨矿物质含量	2.84 kg	(2.47～3.03)

肌肉脂肪分析

体重	67.2 kg	(49.0～66.4)
骨骼肌含量	28.0 kg	(24.5～29.9)
肌肉量	50.0 kg	(41.7～50.9)
体脂肪含量	14.4 kg	(6.9～13.9)

肥胖分析

BMI	25.6 kg/m²	(18.5～23.0)
体脂百分比	21.5 %	(10.0～20.0)

研究项目

基础代谢率	1510 kcal	
内脏脂肪面积	76.2 cm²	
身体细胞量	32.9 kg	(28.8～35.2)
上臂肌肉围度	27.3 cm	
TBW/FFM	74.6 %	

水分控制

细胞外水分比率	0.385	- 2.0 L / 65.2 kg
细胞外水分比率	0.395	- 1.4 L / 65.8 kg
细胞外水分比率	0.405	- 0.7 L / 66.5 kg

全身相位角

3.7 °

	右上肢	左上肢	躯干	右下肢	左下肢
ϕ(°) 50 kHz	4.0	3.4	4.2	3.3	3.3

生物电阻抗

Z(Ω)	右上肢	左上肢	躯干	右下肢	左下肢
1 kHz	379.6	392.7	26.8	306.8	316.1
5 kHz	373.1	385.4	25.7	303.0	314.1
50 kHz	337.2	352.5	23.0	282.3	289.8
250 kHz	307.9	322.9	20.4	263.3	272.7
500 kHz	297.4	311.5	19.1	258.1	267.8
1000 kHz	286.4	297.4	17.0	254.5	264.0

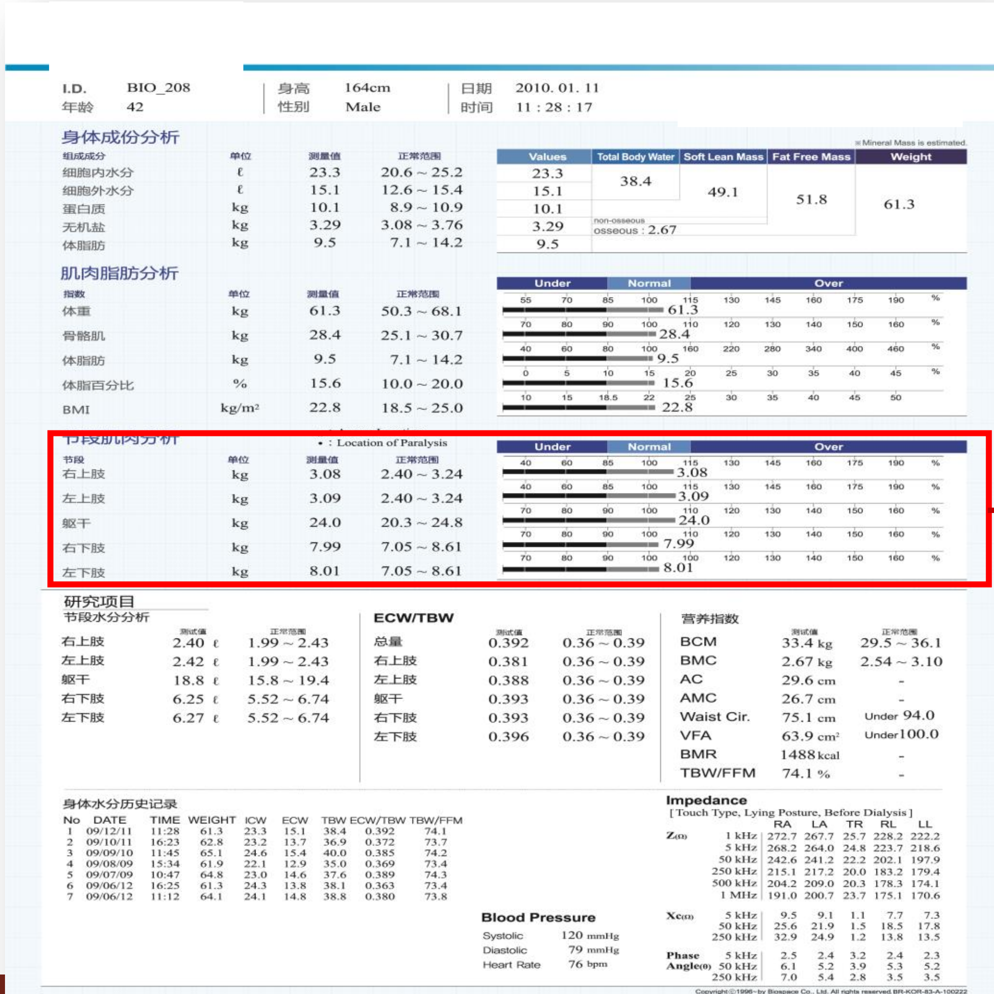
评价透析充分性

评价严重程度

阶段相位角＜3 （CRF）

提示营养不良

3.人体成分在肾病研究中的应用



I.D.	BIO_208	身高	164cm	日期	2010. 01. 11
年龄	42	性别	Male	时间	11 : 28 : 17

身体成份分析

※Mineral Mass is estimated.

组成成分	单位	测量值	正常范围
细胞内水分	ℓ	23.3	20.6 ~ 25.2
细胞外水分	ℓ	15.1	12.6 ~ 15.4
蛋白质	kg	10.1	8.9 ~ 10.9
无机盐	kg	3.29	3.08 ~ 3.76
体脂肪	kg	9.5	7.1 ~ 14.2

Values	Total Body Water	Soft Lean Mass	Fat Free Mass	Weight
23.3	38.4	49.1	51.8	61.3
15.1				
10.1				
3.29	non-osseous osseous : 2.67			
9.5				

肌肉脂肪分析

指数	单位	测量值	正常范围
体重	kg	61.3	50.3 ~ 68.1
骨骼肌	kg	28.4	25.1 ~ 30.7
体脂肪	kg	9.5	7.1 ~ 14.2
体脂百分比	%	15.6	10.0 ~ 20.0
BMI	kg/m²	22.8	18.5 ~ 25.0

节段肌肉分析

• : Location of Paralysis

节段	单位	测量值	正常范围
右上肢	kg	3.08	2.40 ~ 3.24
左上肢	kg	3.09	2.40 ~ 3.24
躯干	kg	24.0	20.3 ~ 24.8
右下肢	kg	7.99	7.05 ~ 8.61
左下肢	kg	8.01	7.05 ~ 8.61

研究项目

节段水分分析

	测试值		正常范围
右上肢	2.40	ℓ	1.99 ~ 2.43
左上肢	2.42	ℓ	1.99 ~ 2.43
躯干	18.8	ℓ	15.8 ~ 19.4
右下肢	6.25	ℓ	5.52 ~ 6.74
左下肢	6.27	ℓ	5.52 ~ 6.74

ECW/TBW

	测试值	正常范围
总量	0.392	0.36 ~ 0.39
右上肢	0.381	0.36 ~ 0.39
左上肢	0.388	0.36 ~ 0.39
躯干	0.393	0.36 ~ 0.39
右下肢	0.393	0.36 ~ 0.39
左下肢	0.396	0.36 ~ 0.39

营养指数

	测试值	正常范围
BCM	33.4 kg	29.5 ~ 36.1
BMC	2.67 kg	2.54 ~ 3.10
AC	29.6 cm	-
AMC	26.7 cm	-
Waist Cir.	75.1 cm	Under 94.0
VFA	63.9 cm²	Under 100.0
BMR	1488 kcal	-
TBW/FFM	74.1 %	-

身体水分历史记录

No	DATE	TIME	WEIGHT	ICW	ECW	TBW	ECW/TBW	TBW/FFM
1	09/12/11	11:28	61.3	23.3	15.1	38.4	0.392	74.1
2	09/10/11	16:23	62.8	23.2	13.7	36.9	0.372	73.7
3	09/09/10	11:45	65.1	24.6	15.4	40.0	0.385	74.2
4	09/08/09	15:34	61.9	22.1	12.9	35.0	0.369	73.4
5	09/07/09	10:47	64.8	23.0	14.6	37.6	0.389	74.3
6	09/06/12	16:25	61.3	24.3	13.8	38.1	0.363	73.4
7	09/06/12	11:12	64.1	24.1	14.8	38.8	0.380	73.8

Blood Pressure

Systolic	120 mmHg
Diastolic	79 mmHg
Heart Rate	76 bpm

Impedance

[Touch Type, Lying Posture, Before Dialysis]

		RA	LA	TR	RL	LL
Z(Ω)	1 kHz	272.7	267.7	25.7	228.2	222.2
	5 kHz	268.2	264.0	24.8	223.7	218.6
	50 kHz	242.6	241.2	22.2	202.1	197.9
	250 kHz	215.1	217.2	20.0	183.2	179.4
	500 kHz	204.2	209.0	20.3	178.3	174.1
	1 MHz	191.0	200.7	23.7	175.1	170.6
Xc(Ω)	5 kHz	9.5	9.1	1.1	7.7	7.3
	50 kHz	25.6	21.9	1.5	18.5	17.8
	250 kHz	32.9	24.9	1.2	13.8	13.5
Phase Angle(°)	5 kHz	2.5	2.4	3.2	2.4	2.3
	50 kHz	6.1	5.2	3.9	5.3	5.2
	250 kHz	7.0	5.4	2.8	3.5	3.5

评价节段瘦组织状态

LTLM＝四肢瘦组织量/躯干瘦组织量

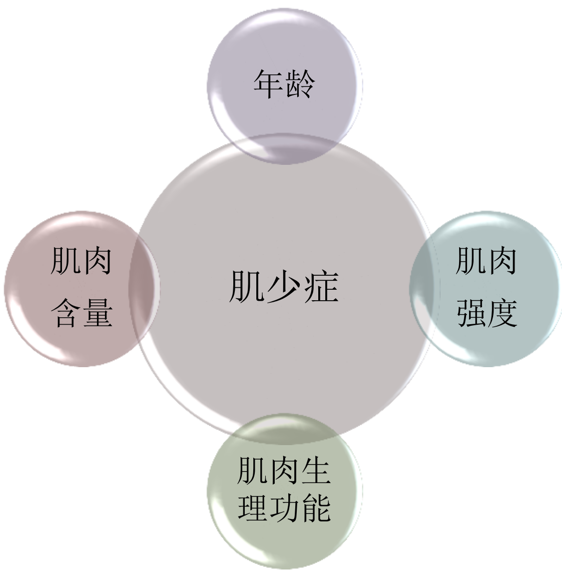
男性:低＜0.7943　　女性:低＜0.7100

提示营养状态差

4. 人体成分在老年/肌少症研究中的应用

- **关注肌肉减少症**

肌肉减少症（Sarcopenia，简称肌少症）： 进行性、肌量减少和/或肌强度下降或肌肉生理功能减退。



中华骨质疏松和骨矿盐疾病杂志2016；9（3）

4. 人体成分在老年/肌少症研究中的应用

- **老年人群肌肉减少的年龄特性——随着年龄的增加而发病率递增**

Low Relative Skeletal Muscle Mass (Sarcopenia) in Older Persons Is Associated with Functional Impairment and Physical Disability

Ian Janssen, PhD, Steven B. Heymsfield, MD,‡ and Robert Ross, PhD*†*

CONCLUSIONS: Reduced relative skeletal muscle mass in older Americans is a common occurrence that is significantly and independently associated with functional impairment and disability, particularly in older women. These observations provide strong support for the prevailing view that sarcopenia may be an important and potentially reversible cause of morbidity and mortality in older persons.

美国老年病学学会研究显示随着年龄的增加少肌症的发病率逐步增加

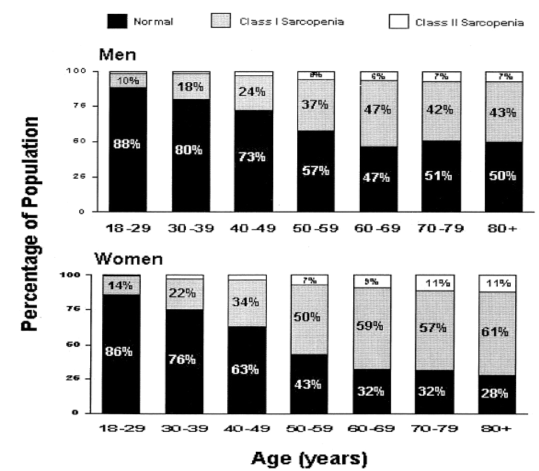


Figure 1. The prevalence of men (top) and women (bottom) with a normal skeletal muscle index (SMI = muscle mass/body mass × 100), class I sarcopenia, and class II sarcopenia according to decade.

J Am Geriatr Soc 50:889-896,2002

4. 人体成分在老年/肌少症研究中的应用

- **老年人群肌肉减少的年龄特性——发病率随着年龄的增加而递增**

台北研究：年龄每增加0.1，肌少症的发病风险增加11%

Journal of Geriatric Cardiology (2016) 13: 261–266

Letter to the Editor · Open Access ·

Using nutritional assessment to predict gender-specific risks of sarcopenia among the elderly receiving health check-up in Taipei

Ya-Hui HUANG[1], Yi-Fen LIN[1], Mei-Ju CHEN[2,3,*]

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Table 2. Multivariable regression models of sarcopenia.

	Odds ratio (95% CI)		B*	SE*	*P**
	Unadjusted	Adjusted			
Age	1.09 (1.06–1.11)	1.11 (1.08–1.14)	0.10	0.01	< 0.0001
Having the ability to live independently	1.82 (0.99–3.33)	1.01 (0.50–2.05)	0.01	0.36	0.9747
Serum albumin level	0.71 (0.50–1.03)	0.93 (0.63–1.36)	–0.07	0.20	0.7047
Mini-MNA	0.10 (0.06–0.16)	0.08 (0.05–0.14)	–2.49	0.27	< 0.0001

*Controlled for ability to live independently, serum albumin level. Mini-MNA: satisfactory *vs.* at risk for malnutrition.

Journal of Geriatric Cardiology (2016) 13: 261

4. 人体成分在老年/肌少症研究中的应用

• 老年人群肌肉减少症观察指标 ：骨骼肌指数

骨骼肌指数（SMI）=（左上肢肌肉量+右上肢肌肉量+左下肢肌肉量+右下肢肌肉量）/身高^2 （单位：kg/m^2）

JAMDA 15 (2014) 95–101

ELSEVIER

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Review

Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia

Liang-Kung Chen MD, PhD[a,*], Li-Kuo Liu MD, PhD[a], Jean Woo MD[b], Prasert Assantachai MD, PhD[c], Tung-Wai Auyeung MD[b], Kamaruzzaman Shahrul Bahyah MD[d], Ming-Yueh Chou MD[e], Liang-Yu Chen MD[a], Pi-Shan Hsu MD[f], Orapitchaya Krairit MD[g], Jenny S.W. Lee MD[b], Wei-Ju Lee MD, MSc[h], Yunhwan Lee MD, PhD[i], Chih-Kuang Liang MD[e], Panita Limpawattana MD, PhD[j], Chu-Sheng Lin MD[k], Li-Ning Peng MD, MSc[a], Shosuke Satake MD, PhD[l], Takao Suzuki MD, PhD[m], Chang Won Won MD, PhD[n], Chih-Hsing Wu MD[o], Si-Nan Wu MD[p], Teimei Zhang MD, PhD[p], Ping Zeng MD[p], Masahiro Akishita MD, PhD[q], Hidenori Arai MD, PhD[r,*]

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Keywords:
Sarcopenia
frailty
muscle mass
muscle quality
muscle strength
physical performance

A B S T R A C T

Sarcopenia, a newly recognized geriatric syndrome, is characterized by age-related decline of skeletal muscle plus low muscle strength and/or physical performance. Previous studies have confirmed the association of sarcopenia and adverse health outcomes, such as falls, disability, hospital admission, long term care placement, poorer quality of life, and mortality, which denotes the importance of sarcopenia in the health care for older people. Despite the clinical significance of sarcopenia, the operational definition of sarcopenia and standardized intervention programs are still lacking. It is generally agreed by the different working groups for sarcopenia in the world that sarcopenia should be defined through a combined approach of muscle mass and muscle quality, however, selecting appropriate diagnostic cutoff values for all the measurements in Asian populations is challenging. Asia is a rapidly aging region with a huge population, so the impact of sarcopenia to this region is estimated to be huge as well. Asian Working Group for Sarcopenia (AWGS) aimed to promote sarcopenia research in Asia, and we collected the best available evidences of sarcopenia researches from Asian countries to establish the consensus for sarcopenia diagnosis. AWGS has agreed with the previous reports that sarcopenia should be described as

The authors declare no conflicts of interest.

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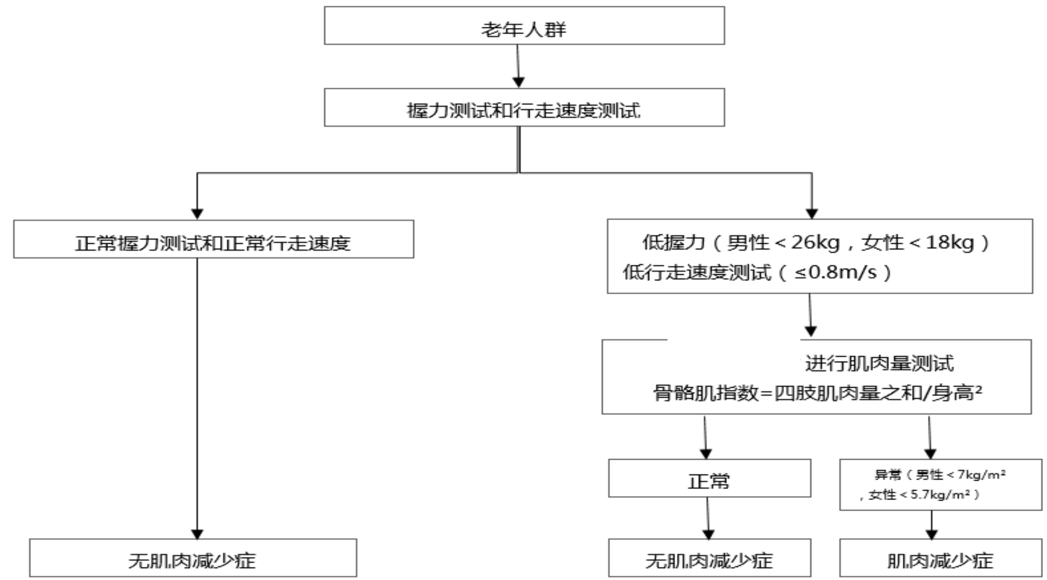
E-mail addresses: lkchen2@vghtpe.gov.tw (L.-K. Chen), harai@kuhp.kyoto-u.ac.jp (H. Arai).

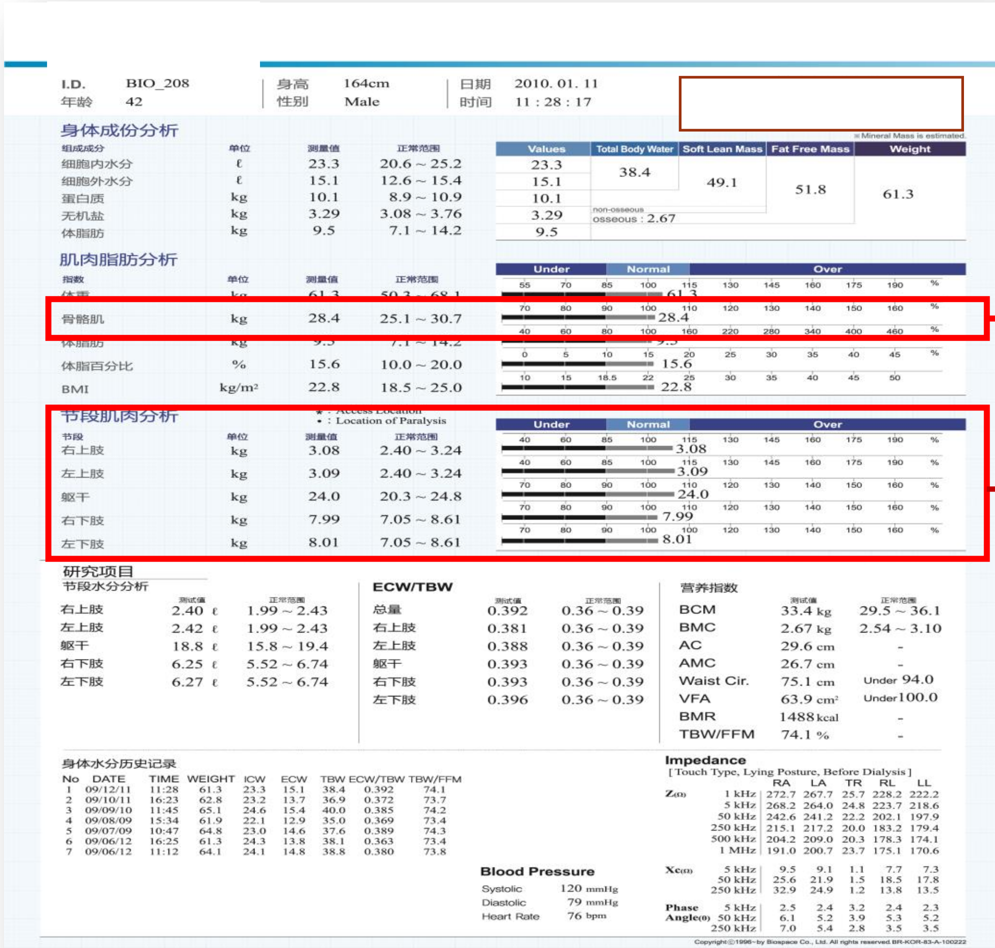
http://dx.doi.org/10.1016/j.jamda.2013.11.025

操作流程：



JAMDA 15 (2014) 95e101

4. 人体成分在老年/肌少症研究中的应用



I.D.	BIO_208	身高	164cm	日期	2010. 01. 11
年龄	42	性别	Male	时间	11 : 28 : 17

身体成份分析

组成成分	单位	测量值	正常范围
细胞内水分	ℓ	23.3	20.6 ~ 25.2
细胞外水分	ℓ	15.1	12.6 ~ 15.4
蛋白质	kg	10.1	8.9 ~ 10.9
无机盐	kg	3.29	3.08 ~ 3.76
体脂肪	kg	9.5	7.1 ~ 14.2

※ Mineral Mass is estimated.

Values	Total Body Water	Soft Lean Mass	Fat Free Mass	Weight
23.3	38.4	49.1	51.8	61.3
15.1				
10.1				
3.29	non-osseous osseous : 2.67			
9.5				

肌肉脂肪分析

指数	单位	测量值	正常范围	Under / Normal / Over
体重	kg	61.3	50.3 ~ 68.1	61.3
骨骼肌	kg	28.4	25.1 ~ 30.7	28.4
体脂肪	kg	9.5	7.1 ~ 14.2	9.5
体脂百分比	%	15.6	10.0 ~ 20.0	15.6
BMI	kg/m²	22.8	18.5 ~ 25.0	22.8

节段肌肉分析

★ : Access Location
• : Location of Paralysis

节段	单位	测量值	正常范围	Under / Normal / Over
右上肢	kg	3.08	2.40 ~ 3.24	3.08
左上肢	kg	3.09	2.40 ~ 3.24	3.09
躯干	kg	24.0	20.3 ~ 24.8	24.0
右下肢	kg	7.99	7.05 ~ 8.61	7.99
左下肢	kg	8.01	7.05 ~ 8.61	8.01

研究项目

节段水分分析

	测试值	正常范围
右上肢	2.40 ℓ	1.99 ~ 2.43
左上肢	2.42 ℓ	1.99 ~ 2.43
躯干	18.8 ℓ	15.8 ~ 19.4
右下肢	6.25 ℓ	5.52 ~ 6.74
左下肢	6.27 ℓ	5.52 ~ 6.74

ECW/TBW

	测试值	正常范围
总量	0.392	0.36 ~ 0.39
右上肢	0.381	0.36 ~ 0.39
左上肢	0.388	0.36 ~ 0.39
躯干	0.393	0.36 ~ 0.39
右下肢	0.393	0.36 ~ 0.39
左下肢	0.396	0.36 ~ 0.39

营养指数

	测试值	正常范围
BCM	33.4 kg	29.5 ~ 36.1
BMC	2.67 kg	2.54 ~ 3.10
AC	29.6 cm	-
AMC	26.7 cm	-
Waist Cir.	75.1 cm	Under 94.0
VFA	63.9 cm²	Under 100.0
BMR	1488 kcal	-
TBW/FFM	74.1 %	-

身体水分历史记录

No	DATE	TIME	WEIGHT	ICW	ECW	TBW	ECW/TBW	TBW/FFM
1	09/12/11	11:28	61.3	23.3	15.1	38.4	0.392	74.1
2	09/10/11	16:23	62.8	23.2	13.7	36.9	0.372	73.7
3	09/09/10	11:45	65.1	24.6	15.4	40.0	0.385	74.2
4	09/08/09	15:34	61.9	22.1	12.9	35.0	0.369	73.4
5	09/07/09	10:47	64.8	23.0	14.6	37.6	0.389	74.3
6	09/06/12	16:25	61.3	24.3	13.8	38.1	0.363	73.4
7	09/06/12	11:12	64.1	24.1	14.8	38.8	0.380	73.8

Blood Pressure

Systolic	120 mmHg
Diastolic	79 mmHg
Heart Rate	76 bpm

Impedance

[Touch Type, Lying Posture, Before Dialysis]

		RA	LA	TR	RL	LL
Z(Ω)	1 kHz	272.7	267.7	25.7	228.2	222.2
	5 kHz	268.2	264.0	24.8	223.7	218.6
	50 kHz	242.6	241.2	22.2	202.1	197.9
	250 kHz	215.1	217.2	20.0	183.2	179.4
	500 kHz	204.2	209.0	20.3	178.3	174.1
	1 MHz	191.0	200.7	23.7	175.1	170.6
Xc(Ω)	5 kHz	9.5	9.1	1.1	7.7	7.3
	50 kHz	25.6	21.9	1.5	18.5	17.8
	250 kHz	32.9	24.9	1.2	13.8	13.5
Phase Angle(θ)	5 kHz	2.5	2.4	3.2	2.4	2.3
	50 kHz	6.1	5.2	3.9	5.3	5.2
	250 kHz	7.0	5.4	2.8	3.5	3.5

肌肉减少症

- 低骨骼肌含量
- 低SMI

  SMI=四肢肌肉量之和/身高²（单位：kg/m²）

  男性＜7 kg/m²，女性＜5.7 kg/m² 为肌肉量减少

5. 人体成分在外科手术患者研究中的应用

日本医科大学附属医院研究了三种不同的胃切除手术方式，术后患者营养状态变化

全胃切除术（ TG ）较腹腔镜下胃切除术（ LAG ）和远端胃切除术（ DG ）在术后**蛋白质、脂肪**丢失要更为严重

Postoperative Changes in Body Composition After Gastrectomy

Teruo Kiyama, M.D., Takashi Mizutani, M.D., Takeshi Okuda, M.D., Itsuro Fujita, M.D., Akira Tokunaga, M.D., Takashi Tajiri, M.D., Adrian Barbul, M.D., F.A.C.S.

Table 3. Preoperative nutritional assessment

	LAG (n = 24)	DG (n = 39)	TG (n = 45)
Body weight (kg)	54.4 ± 9.1	57.2 ± 11.3	59.6 ± 10.1
Degree of obesity (%)	106 ± 19	108 ± 16	112 ± 17
Body protein (kg)	38.6 ± 7.3	40.8 ± 8.0	42.6 ± 8.3
Fat (kg)	13.5 ± 5.2	13.9 ± 5.5	14.5 ± 5.8
BMI (kg/m^2)	21.8 ± 3.5	22.3 ± 3.2	23.2 ± 3.4

LAG = laparoscopy-assisted gastrectomy; DG = distal gastrectomy; TG = total gastrectomy; BMI = body mass index.

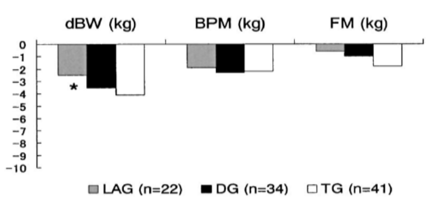


Fig. 2. Comparison of perioperative changes in the body composition of patients undergoing laparoscopy-assisted (LAG), distal (DG), and total gastrectomy (TG), from before surgery to 14th postoperative day. *P = 0.039 vs. DG and P = 0.002 vs. TG. dBW = change in body weight; BPM = body protein mass; FM = fat mass.

术后14天内

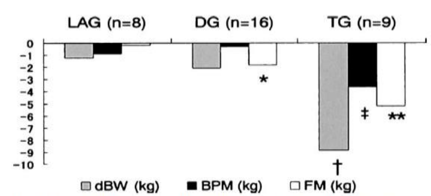


Fig. 3. Overall changes in the body composition of patients undergoing laparoscopy-assisted (LAG), distal (DG), and total gastrectomy (TG), from before surgery until 6 months after surgery. *P = 0.031, †P = 0.0003, ‡P = 0.0001, **P = 0.0038. dBW = change in body weight; BPM = body protein mass; FM = fat mass.

术后6个月

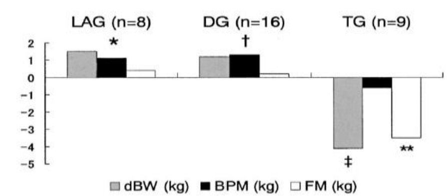


Fig. 4. Postoperative changes in body composition of patients undergoing laparoscopy-assisted (LAG), distal (DG), and total gastrectomy (TG), from the 14th postoperative day until 12 months after surgery. *P = 0.020, †P = 0.0027, ‡P = 0.0036, **P = 0.0077. dBW = change in body weight; BPM = body protein mass; FM = fat mass.

术后12个月

J GASTROINTEST SURG 2005;9:313－319

6.人体成人在危重症中的应用

关注身体细胞量和相位角（Phase Angle，PA）低标准

Use of Bioelectrical Impedance Analysis for the Assessment of Nutritional Status in Critically Ill Patients

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Conclusion

BIA is a useful method in the nutritional assessment and prognosis of critically ill patients. Low PhA and high ECW/TBW can significantly imply malnutrition; these variables also showed significant correlations with biochemical data, which are conventional nutritional assessment indicators. High ECW/TBW was correlated with long duration of mechanical ventilation. PhA was also lower and ECW/TBW higher among non-survivors than survivors, which implies utility of BIA for predicting survival rate.

Table 5. Comparison of BMI, biochemical data, and BIA data between survivors and non-survivors

	Variables	Non-survivors (n = 8)	Survivors (n = 58)	p value
BMI	BMI, kg/m²	22.7 ± 2.3*	23.7 ± 3.5	0.30
Bio-chemical data	Albumin, g/dL	3.0 ± 0.3	3.3 ± 0.6	0.06
	TLC, cells/mm³	616.3 ± 330.9	1039.7 ± 663.4	0.01†
	Hemoglobin, g/dL	10.8 ± 1.5	10.8 ± 1.7	0.89
BIA data	PhA, °	2.9 ± 0.8	4.1 ± 1.2	< 0.01†
	Intracellular water (ICW), L	20.7 ± 2.2	21.3 ± 4.9	0.52
	Extracellular water (ECW), L	15.0 ± 1.8	14.2 ± 3.0	0.32
	Total body water (TBW), L	35.7 ± 3.8	35.6 ± 7.8	0.95
	ECW/TBW	0.42 ± 0.01	0.40 ± 0.02	< 0.01†
	%TBW/FFM, %	74.3 ± 0.3	74.0 ± 0.6	0.04‡
	Protein, kg	8.9 ± 1.0	9.2 ± 2.1	0.48
	Mineral, kg	3.4 ± 0.3	3.3 ± 0.6	0.33
	Soft lean mass (SLM), kg	45.1 ± 4.8	45.4 ± 10.0	0.92
	Fat free mass (FFM), kg	48.0 ± 5.0	48.0 ± 10.4	0.98
	Fat mass (FM), kg	16.6 ± 9.1	16.2 ± 7.9	0.92
	%Body fat (%BF), %	25.3 ± 11.0	25.0 ± 10.8	0.95
	Skeletal muscle mass (SMM), kg	24.1 ± 2.7	25.8 ± 6.3	0.23
	Body cell mass (BCM), kg	28.7 ± 3.0	30.4 ± 6.9	0.28
	Bone mineral content (BMC), kg	2.9 ± 0.3	2.7 ± 0.5	0.23

BMI: body mass index, TLC: total lymphocyte count, BIA: bioelectrical impedance analysis, PhA: phase angle, ECW/TBW: extracellular water/total body water, TBW/FFM: total body water/fat free mass.
*Mean ± Standard Deviation; †p < 0.01; ‡p < 0.05

BIA检测的相位角及ECW/TBW是评价重症患者营养状况的有效指标，相位角低标准、ECW/TBW高标准可预测患者生存率不良。

Clin Nutr Res 2015;forthcoming pISSN 2287-3732 · eISSN 2287-3740

小 结

- 人体成分是营养评估的一个必要指标。
- BIA法是便捷、无创、有效的人体成分测量方法。
- 人体成分是营养治疗中一个有效的监测指标。

Thank You!

感谢您的聆听