Beyond BMI:

Towards Improving obesity diagnosis for better prevention, diagnosis, stratification and treatment of patients with a high risk of co-morbidity
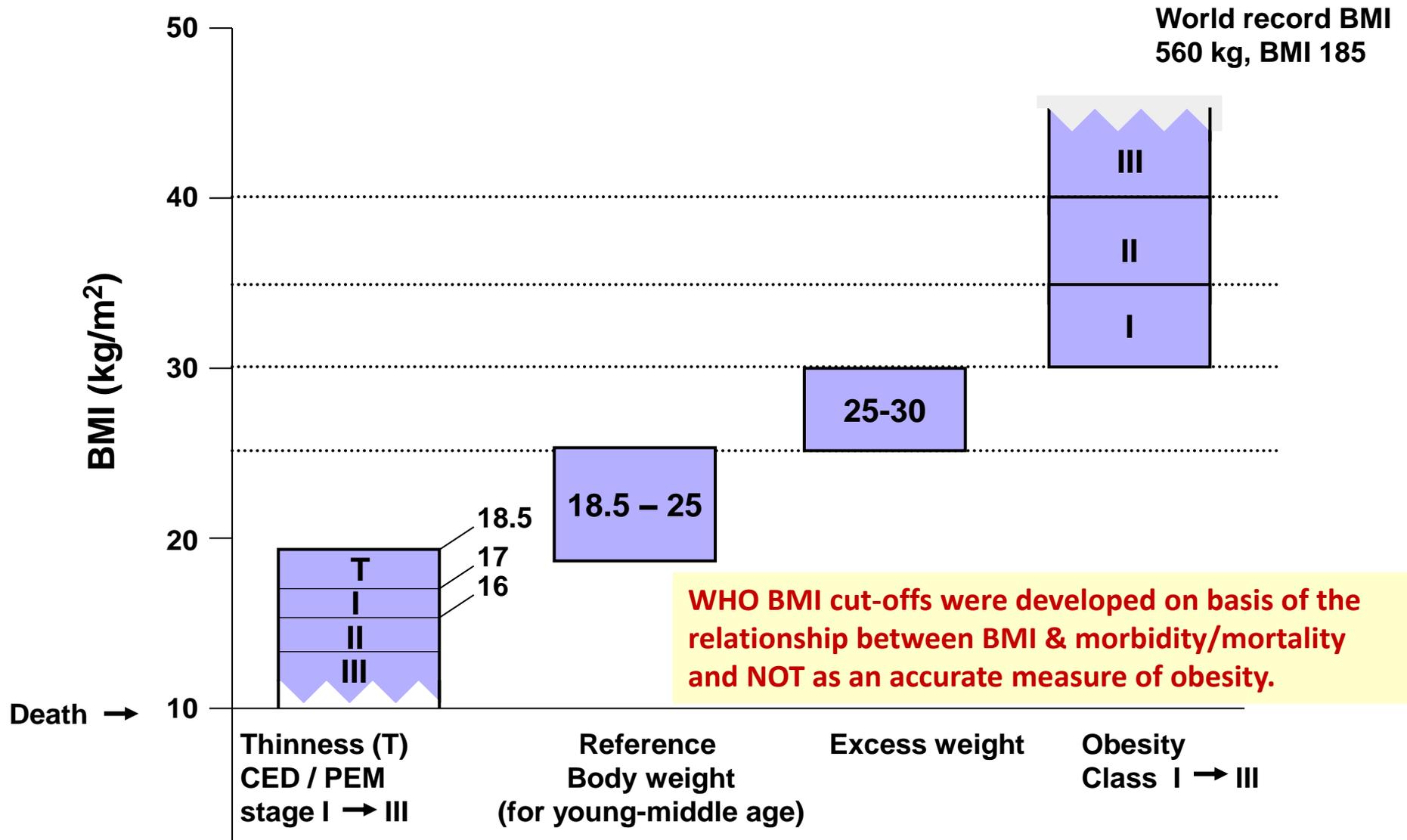
Beyond BMI: phenotyping the obesities

Abdul G. Dulloo

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University of Fribourg
Switzerland

UNI FR

Classification & cut-off points for overweight & obesity & thinness
## *according to World Health Organization*

World record BMI
560 kg, BMI 185

BMI (kg/m²)

50

40

30

20

Death → 10

T

I

II

III

18.5
17
16

18.5 – 25

25-30

III

II

I

Thinness (T)
CED / PEM
stage I → III

Reference
Body weight
(for young-middle age)

Excess weight

Obesity
Class I → III

WHO BMI cut-offs were developed on basis of the
relationship between BMI & morbidity/mortality
and NOT as an accurate measure of obesity.

Dulloo et al .Int J Obes (2010); 34 (Suppl 2): S4-17

Relative Risk of Mortality, Coronary Heart Disease (CHD), and Type 2 Diabetes According to BMI

Relative risk of:

Mortality

BMI (kg/m²)
<19.0 → ≥32.0

CHD

BMI (kg/m²)
<21.0 → ≥29.0

Diabetes

BMI (kg/m²)
<22.0 → ≥35.0
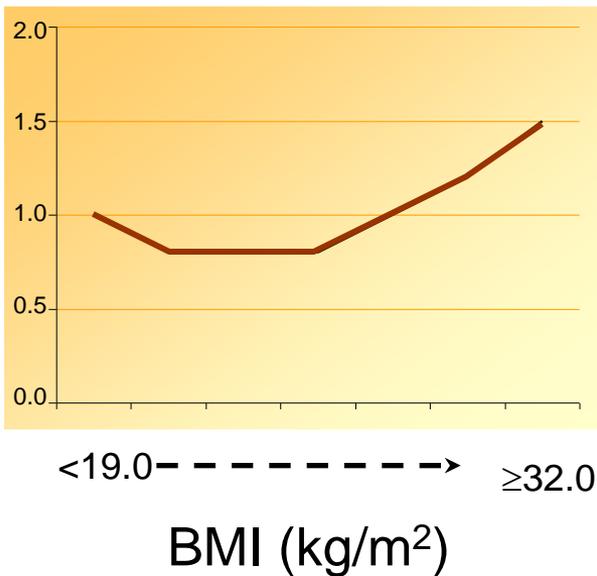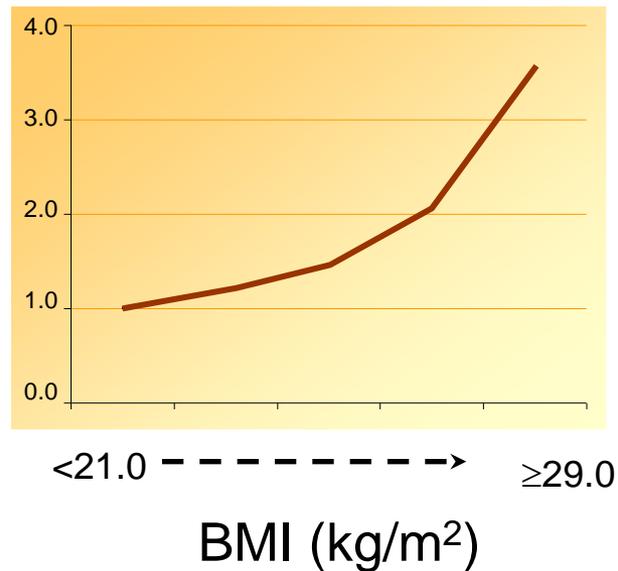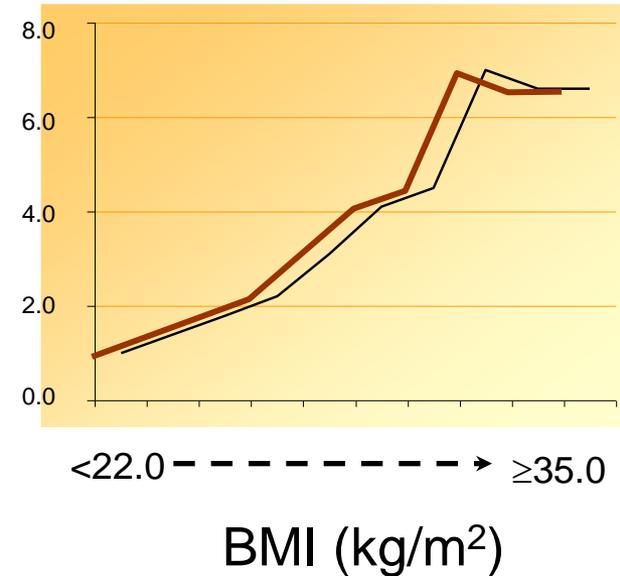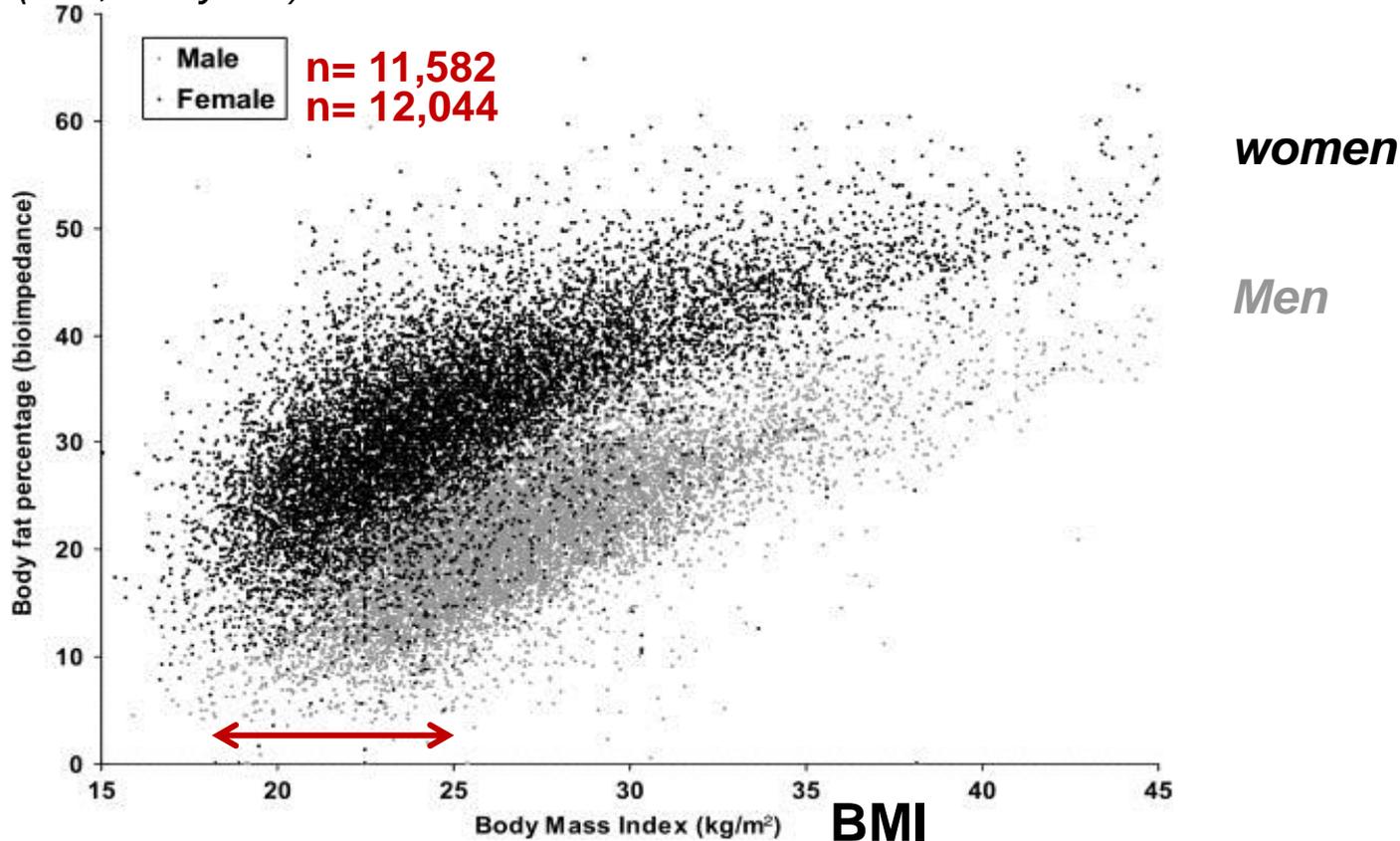
Adapted from Manson JE et al. N Engl J Med 1995; 333: 677–85
Willett WC et al. JAMA 1995; 273: 461–5 |
Colditz GA et al. Ann Intern Med 1995; 122: 481-6

Distribution of BMI as a function of % body fat in men and women (UK, age 18-99)

Meeuwsen, Horgan & Elia. *Clin Nutr* (2010)

% Body Fat
(BIA, Bodystat)

Legend:
- Male — n= 11,582
- Female — n= 12,044

women

Men

Y-axis: Body fat percentage (bioimpedance)
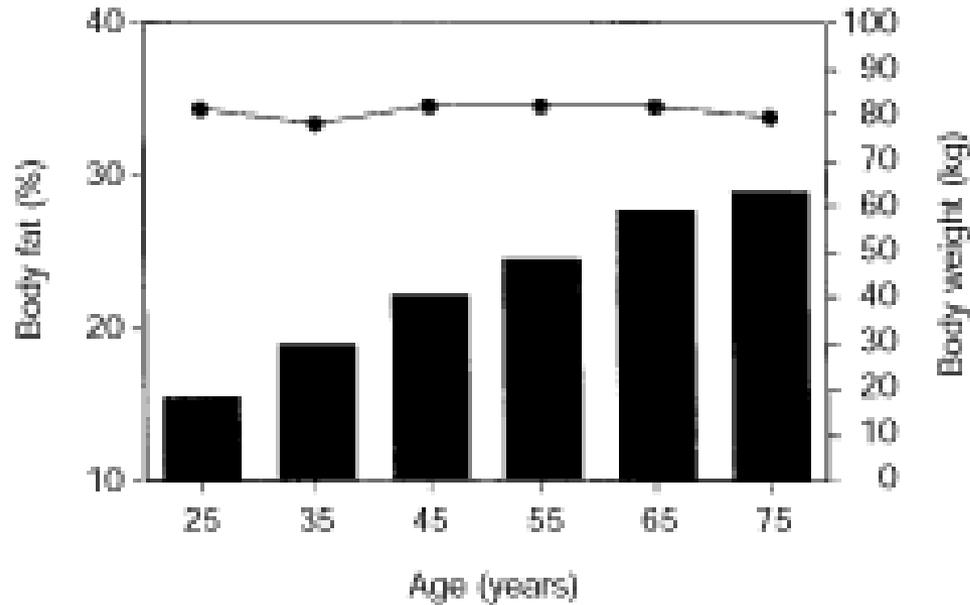X-axis: Body Mass Index (kg/m²) — BMI

Conclusion of authors
The association between BMI and % body fat is not strong, particularly in the desirable BMI range.
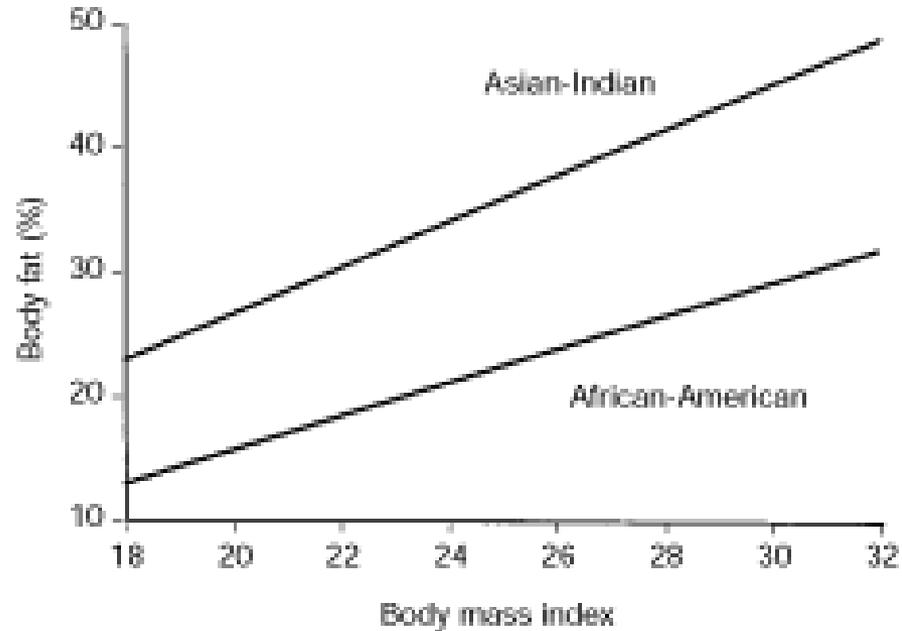
Beyond body mass index.

Prentice AM, Jebb SA.
Obes Rev. 2001;2:141-7.

**Age-related increase in body fat
for normal males at constant BMI**

**Racial differences in the relationship
between BMI and body fat.**

Establishing **Deuterium dilution technique** as Reference for Body Composition assessment in healthy young healthy adults in **Mauritius** *(n=160)* (BMI range: 15–41)

I
Relationships:
Fat%–BMI
Trunkfat%–WC
Gender & Ethnicity

II
Validation of field techniques

BIA8, SKF

III
Cardiometabolic signatures vs
Body composition

UNI
FR

Sadna Hunma, PhD Thesis 2015
University of Fribourg, Switzerland

Derived BMI cut-offs for overweight and obese in Mauritians compared with the WHO BMI cut-offs (Caucasian-based).

Hunma et al. *Int J Obesity* (2016, *in press*)
doi: 10.1038/ijo.2016.176
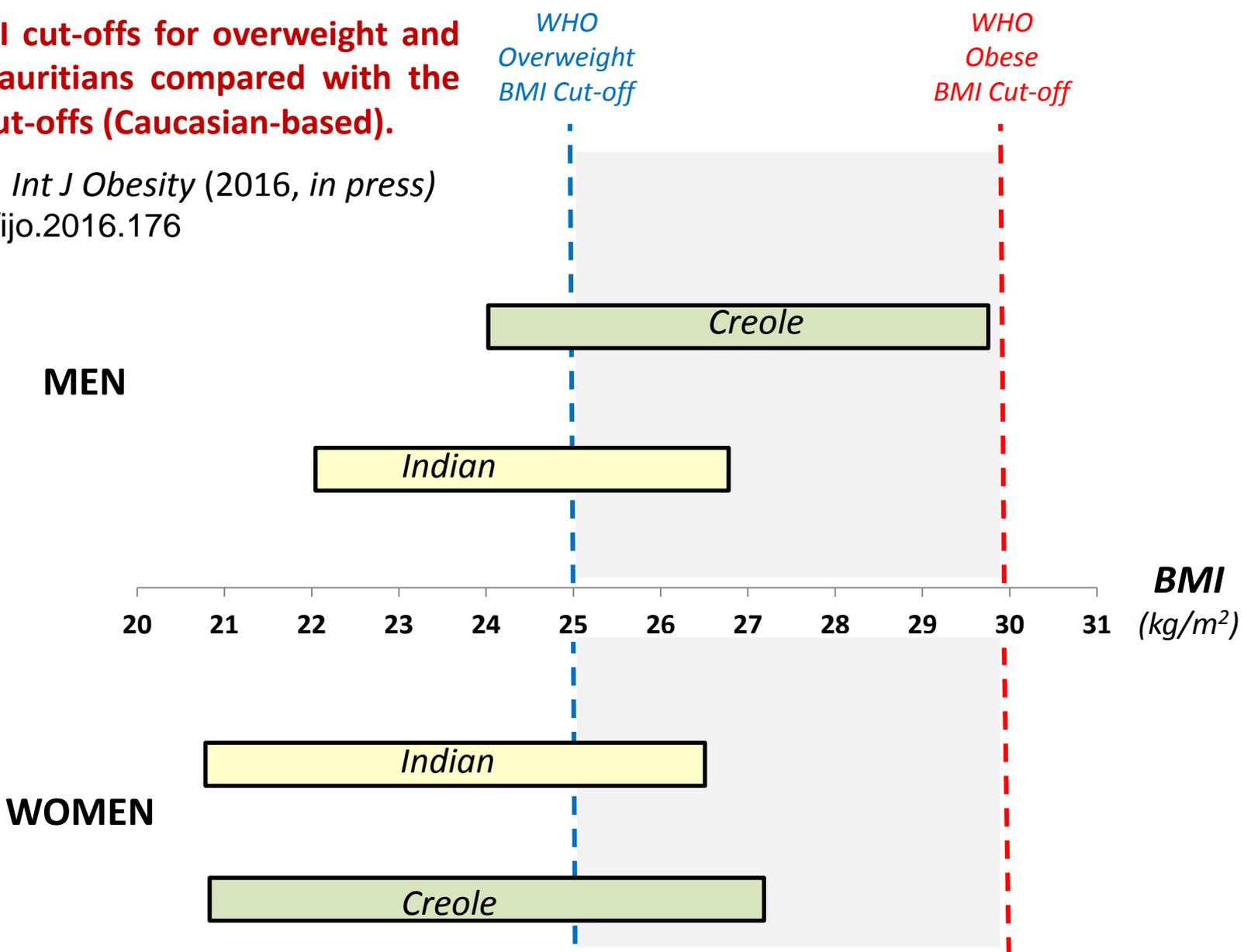
Proportions of Overweight (OW) & Obese (OB) based upon WHO (Caucasian-based) cut-offs *vs* Mauritian cut-offs

WHO cut-offs   **Mauritian cut-offs**

Indian Men

OB
OW   NW

Creole Men
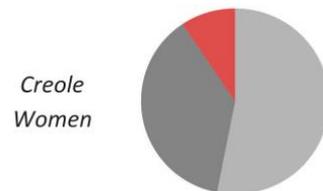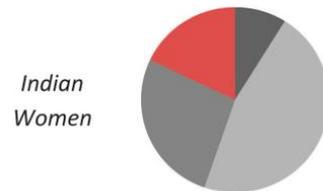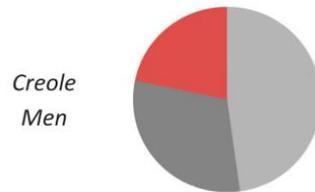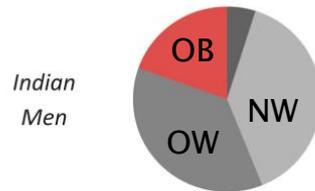
Indian Women
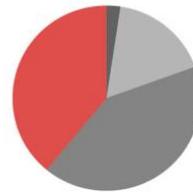
Creole Women

Based upon measured body fat% and derived cut-offs in young Mauritian men and women :

- The proportion of Indian men as well as Indian and Creole women who are obese are 2-3 times greater than predicted by WHO cut-offs for OW or OB..

- In this age-group, typically sedentary, 60-75% are overweight or obese.

Hunma et al. *Int J Obesity* (2016, *in press*)
doi: 10.1038/ijo.2016.176

Beyond body mass index.
Prentice AM, Jebb SA. *Obes Rev*. **2001**;2:141-7.

- Obesity is defined as an excess accumulation of body fat, and it is the amount of this excess fat that correlates with ill-health.

- BMI is only a surrogate measure of body fatness.

- It often provides misleading information about body fat content
  including: infancy and childhood; ageing; racial differences; athletes; military and civil forces personnel; weight loss with and without exercise; physical training; and special clinical circumstances.

- The time is now right to initiate a gradual evolution **beyond BMI towards standards based on <u>actual measurements of body fat mass</u>**.

15 years later: where are we now?

Is body fat a superior predictor of ill-health than BMI?

Beyond BMI - Phenotyping the Obesities

Blundell JE, Dulloo AG, Salvador J, Frühbeck G;

European Association for Study of Obesity (EASO) SAB Working Group on BMI

& Collaborators Farpour-Lambert N, Fogelholm M, Micic D, Oppert JM, Toplak H, Vidal-Puig T, Visscher T, Yumuk V.

'' The categorisation of obesity by BMI is crude and clearly lacks scientific precision. However, it is clear that <u>even using a direct measure of body fat</u> (rather than BMI) does <u>not</u> remove all ambiguity.''

Why body fat may not be better than BMI?

'' Body fat is measured with <u>much greater error</u> than body weight and height (the components of BMI). Consequently, this would weaken the relationship between the two variables and explain why any potential superiority of body composition measurements in predicting health risks may sometimes be difficult to demonstrate.''

There are also other potential reasons !

Beyond BMI - Phenotyping the Obesities

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- Neither BMI nor total body fat unambiguously reflects the risk to health.

- Other anthropometric indices easy to obtain and related to abdominal fat content such as *waist circumference (WC), saggital depth (abdominal height), WHR, waist-to-height ratio (WTHR)* may offer better predictors of mortality and morbidity than BMI.

- Emerging evidence suggests that the accuracy of discriminating health risk based on anthropometry is improved when WC are stratified by BMI, sex and race/ethnicity.

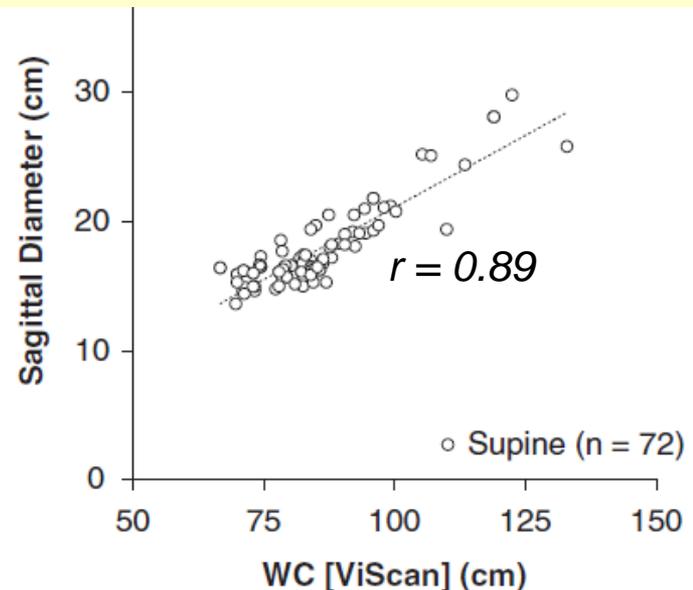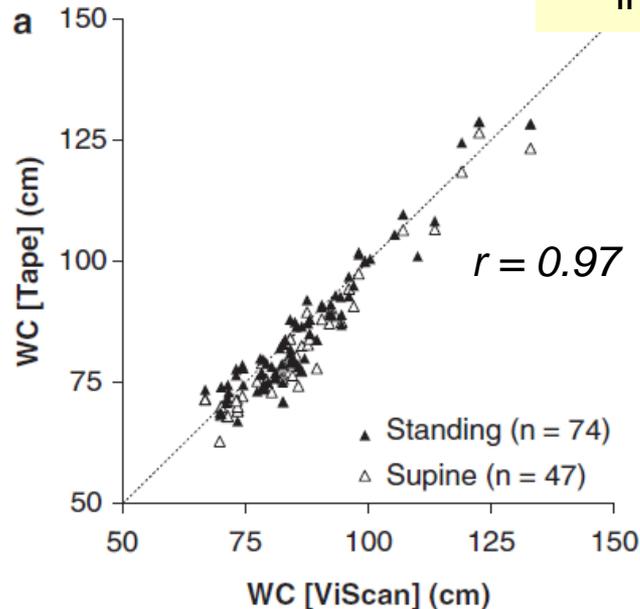# Non-contact assessment of waist circumference: will tape measurements become progressively obsolete?

Schutz Y, Sarafian D, Miles JL, Montani JP, Dulloo AG.
Eur J Clin Nutr. 2012; 66:269-72

Investigator-independent

- Provides a precise & objective measurement of WC but its cost (~3,500 $) precludes its wide utilization.

- Such type of device would permit a sound comparison of WC at international level, provided the device is further validated in different ethnic groups and at different BMI in different gender.

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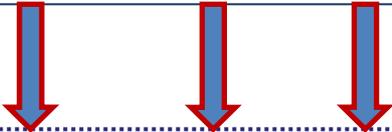**There are also other potential reasons !**

Commentary: The paradox of body mass index in obesity assessment: not a good index of adiposity, but not a bad index of cardio-metabolic risk

Jonathan CK Wells

BMI is a composite index of risk

$$BMI = BW / H^2$$

$$= (FM + FFM) / H^2$$

Cardiometabolic risk

Özaltin E. Int J Epidemiol. 2012;41:1434-5.
Commentary: …….. **why taller people are healthier and live longer**.

Beyond BMI-Fat% relationship

In the relationship between BMI & Adiposity (Fat%),
the importance of FFM is masked

FFM, (like FM),

also plays crucial roles

in weight homeostasis and health risks indicators

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Cardiometabolic
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Sadna Hunma, PhD Thesis 2015
University of Fribourg, Switzerland

The Future:
body composition & health risks indicators

Beyond BMI

⬇

Beyond fat mass and FFM

⬇

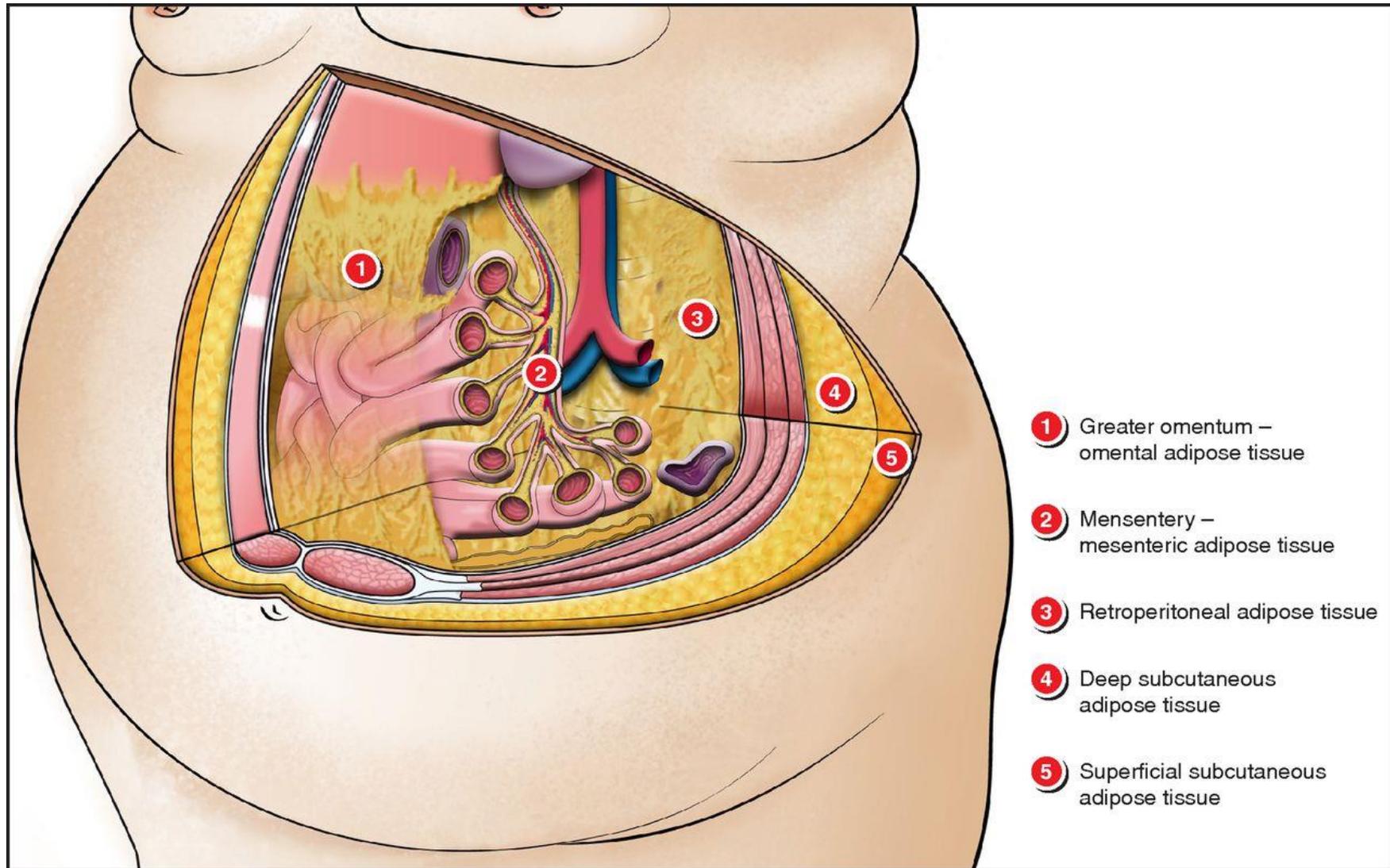**Deep** body composition phenotyping

Capability of different body fat measurements to estimate total body fat and fat distribution

Snijder et al. Int J Epidemiol. 2006 Feb;35(1):83-92.

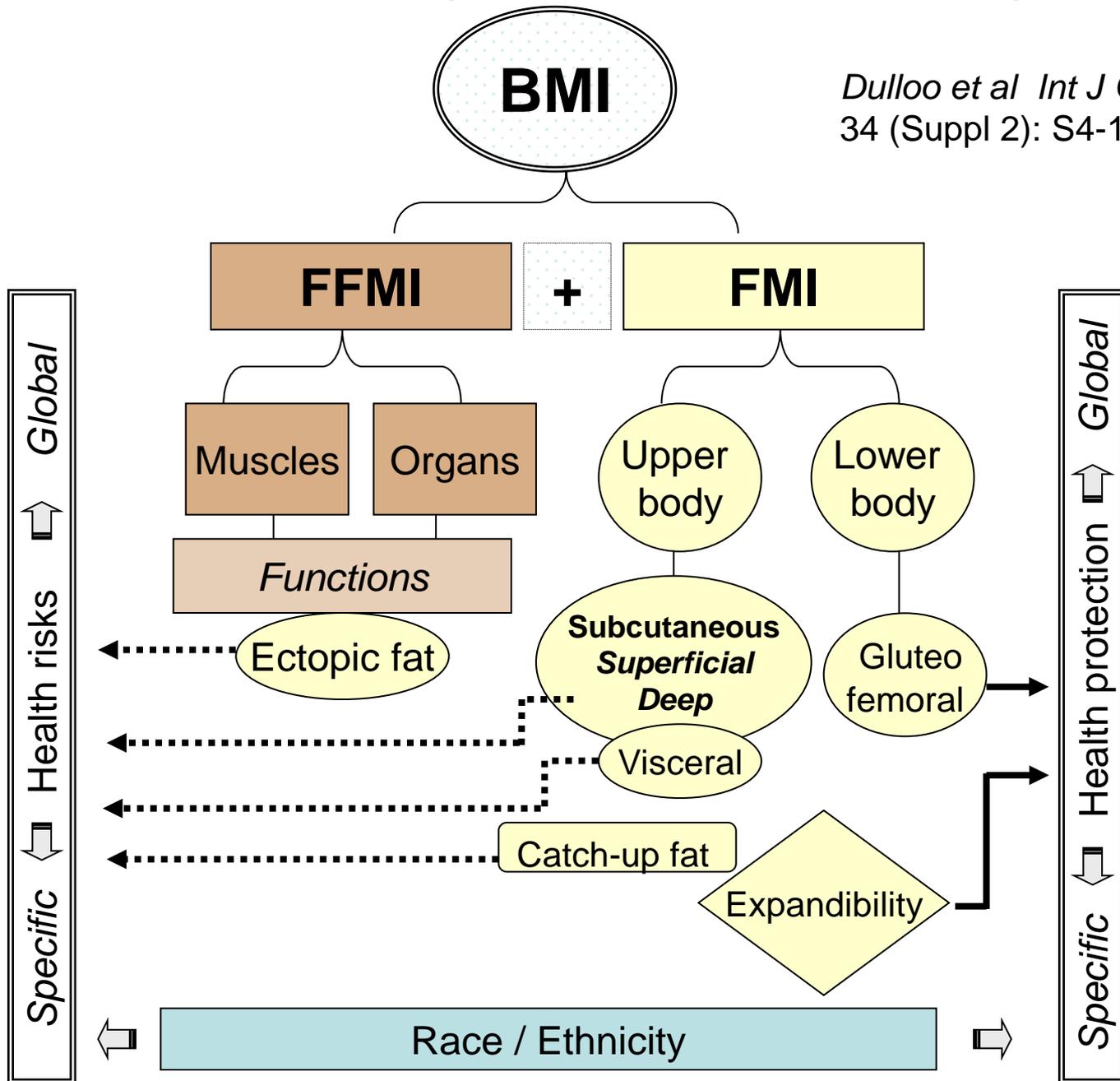| Method	Capability measuring total body fat	Capability measuring fat distribution	Applicability in large population studies
CT	Moderate	Very high	Low
MRI	High	Very high	Low
DXA	Very high	High	Moderate
Densitometry	Very high	Very low	Low
Dilution techniques	High	Very low	Moderate
BIA	Moderate	Low /moderate	High
BMI	Moderate	Very low	Very high
WC, HC, WHR, SAD	Low	High	Very high
Skinfolds	Moderate	Moderate	High

Ideal measure(s) for monitoring body composition and obesity should be simple to use, relatively cheap, accurate and precise.

Anatomical localization of the main abdominal adipose tissue depots

1. Greater omentum – omental adipose tissue
2. Mensentery – mesenteric adipose tissue
3. Retroperitoneal adipose tissue
4. Deep subcutaneous adipose tissue
5. Superficial subcutaneous adipose tissue

Concepts of body composition phenotypes

BMI

Dulloo et al Int J Obes (2010); 34 (Suppl 2): S4-17

FFMI + FMI

Global ↑ Health risks ⇩ *Specific*

Global ⇧ Health protection ⇩ *Specific*

Muscles | Organs

Upper body | Lower body

Functions

Ectopic fat

Subcutaneous *Superficial* **Deep**

Gluteo femoral

Visceral

Catch-up fat

Expandibility

Race / Ethnicity

http://fr.slideshare.net/PeterJaniszewski/weight-loss-among-metabolically-healthy-obese-men-and-women-harmful-or-beneficial?related=1

Deep body composition (BC) phenotyping in men of different race/ethnicity

	Asian Indian *vs Caucasians*	African American *vs Caucasians*
Type 2 diabetes & CV risks	↑	↑
Fat-free mass Index (FFMI)	↓	↑
Muscle mass	↓	↑
Bone mass	↓	↑
Organ mass (OM)	?	↓
Fat mass Index (FMI)		
Upper body		
Superficial SAT	↑	↑
Deep SAT	↑	-
VAT	↑	↓
Hepatic lipids	?	↓
Lower body		
Gluteofemoral SAT	↓	↑
IMAT	↑	↑
Intramyocellular lipids *(from leg muscle)*	?	↓
Resting EE (FFM-adjusted)	?	↓
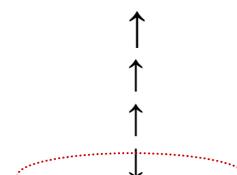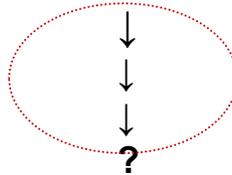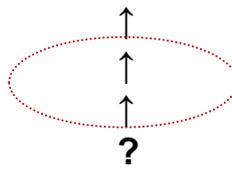
DIfferent BC Clusters for cardiometabolic risks

Dulloo et al. Int J Obes (2010) 34 (Suppl 2): S4-17
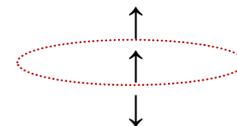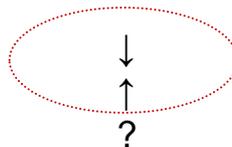
Body Composition Methods

Capability of different body fat measurements to estimate total body fat and fat distribution

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Method	Capability measuring total body fat	Capability measuring fat distribution	Applicability in large population studies
CT	Moderate	Very high	Low
MRI	High	Very high	Low
DXA	Very high	High	Moderate
Densitometry	Very high	Very low	Low
Dilution D2O **techniques**	High	Very low	Moderate
BIA (whole body)	Moderate	Very low	High
BIA-Abdo(*ViScan*)	Low	High	High
BMI	Moderate	Very low	Very high
WC, HC, WHR, SAD	Low	High	Very high
Skinfolds	Moderate	Moderate	High

- CT, computed tomography; MRI, magnetic resonance imaging; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; SAD, sagittal abdominal diameter.

Body Composition DXA

DXA Results Summary:

Region	BMC (g)	M
L Arm	142.88	
R Arm	162.16	
Trunk	576.13	
L Leg	407.72	
R Leg	397.16	
Subtotal	1686.05	
Head	444.22	
Total	**2130.27**	

TBAR303 - NHANES BCA calibration

Adipose Indices

Measure	Result	Percentile YN	Percentile AM
Total Body % Fat	8.97	2	1
Fat Mass/Height (kg/m)	**2.47**	**6**	**3**
Android/Gynoid Ratio	0.88		
% Fat Trunk/% Fat Legs	0.54	2	1
Trunk/Limb Fat Mass Ratio	0.60	2	1
Est. VAT Mass (g)	263		
Est. VAT Volume (cm)	284		
Est. VAT Area (cm)	54.5		

Concepts of body composition phenotypes

Dulloo et al Int J Obes (2010); 34 (Suppl 2): S4-17
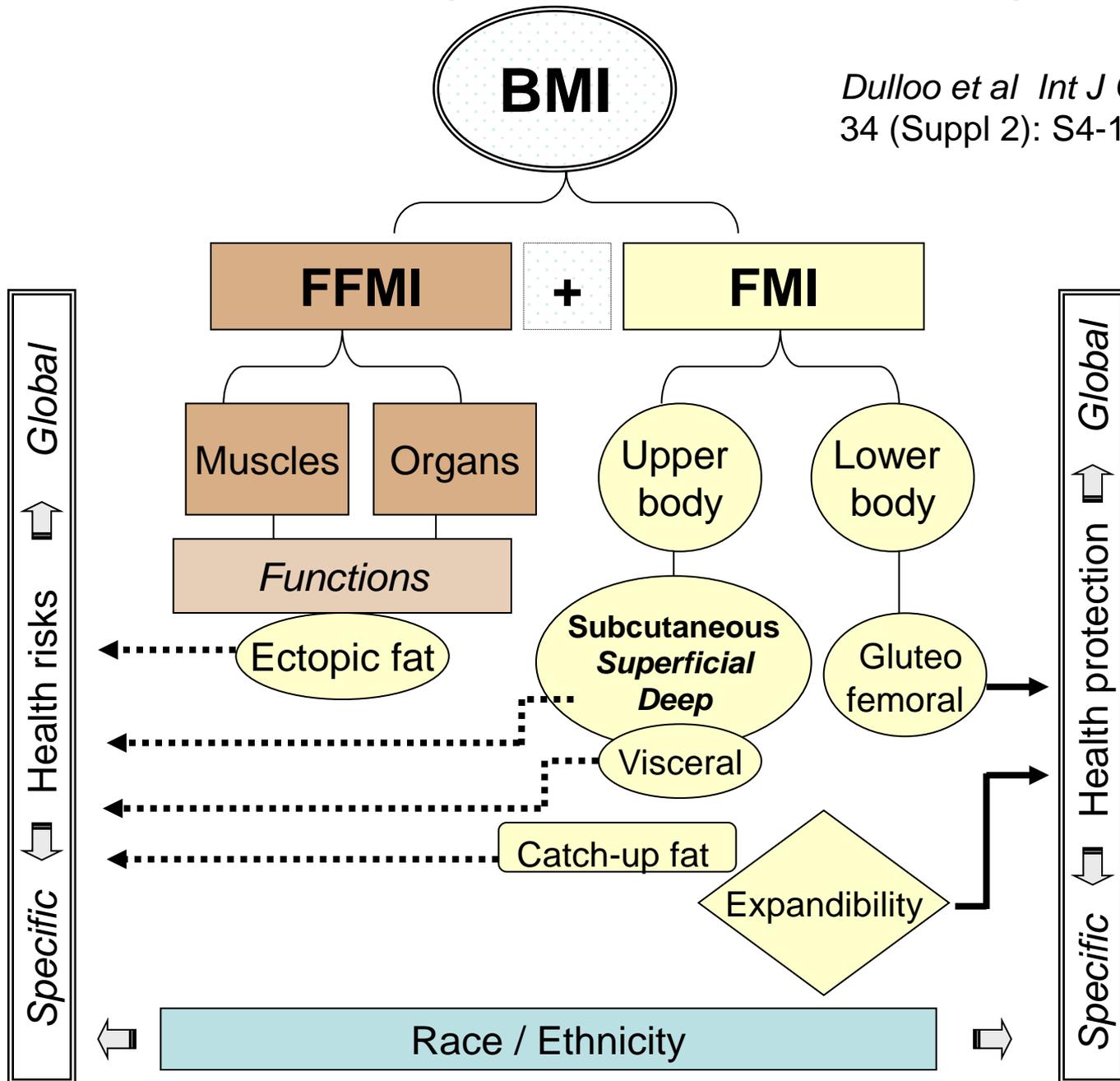
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Blundell JE, Dulloo AG, Salvador J, Frühbeck, and
EASO SAB Working Group on BMI

" Given the stagnation in dealing with the 'obesity epidemic', some <u>radical thinking (and action)</u> is called for.

This action should begin with some clear vision and agreement about the fundamental nature of obesity and its diagnostic characterization."

IAEA sponsored projects in Mauritius

Central Health Laboratory MOHQL, Candos

Dr N. Joonas / Dr S.S. Manraj

Towards a sustainable project

Predisposition to cardiometabolic risks in young adults
(Longitudinal study)

Predisposition to Child obesity & cardiometabolic risks

Predisposition to cancer in women
(breast, endometrial)

Sadna Hunma

Harris Ramuth

Vinay Ramessur

External Doctoral (PhD) students at University of Fribourg, Switzerland