Emerging technologies in measuring body composition in low-resource settings across the life course

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Nuclear Techniques in Human Health

Prevention, Diagnosis, Treatment

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Why is measuring body composition important?

- Dramatic lifestyle changes have altered eating habits and activity levels worldwide, driving an increase in obesity for many low- or middle-income countries (LMIC).
- Protein-calorie malnutrition is still prevalent in some LMICs and can occur in combination with excess adiposity
- There is a critical need for accurate quantitative markers of nutritional status appropriate for low-resource settings for both public health research and diagnostic and monitoring purposes.

Role of Body Composition Measurements in Population Studies

Outcomes in descriptive and interventional studies

- Effects of aging, disease, pregnancy, malnutrition, infection on body composition
- Effects of diet, exercise, other lifestyle changes

Assessable technologies make these objectives possible on LMIC environments!

- Changes in fat or muscle may affect exercise capacity, insulin sensitivity, lipids
- Gender differences may be explained by differences in body composition
- Regional fat has different metabolic properties

Nuclear methods for validating accessible BC technologies

D_2O TBW
Deuterated Total Body Water

Dual-energy
X-ray Absorptiometry (DXA)

Total Body Potassium

Challenges in measuring BC in low resource settings

Nuclear techniques are the most true and precise but costly

TABLE 2 Special considerations for measuring body composition with specific technologies

	DXA	BIA	Subq thick	Wt and ht indices	Anthropometry	Dilution	TBK	Body density
Cost	--	+	++	++	±	--	--	-
Compliance	±	±	++	++	++	++	++	+
Infrastructure		++	++	++	++			-
Precision	++	++	+	++	++	++	++	++
Quality control	++	-	+	+	+	++	++	++
Training		++	-	++	++			-
Trueness	++	+	-	+	±	++	++	++
Safety	-	++	++	++	++	++	++	++

+, advantagous; ++, more advantageous; -, limitations; −, more limitations than comparative technology.
DXA, dual-energy X-ray absorptiometry; BIA, bioimpendance; subq, subcutaneous; wt, weight; ht, height; TBK, total body potassium.

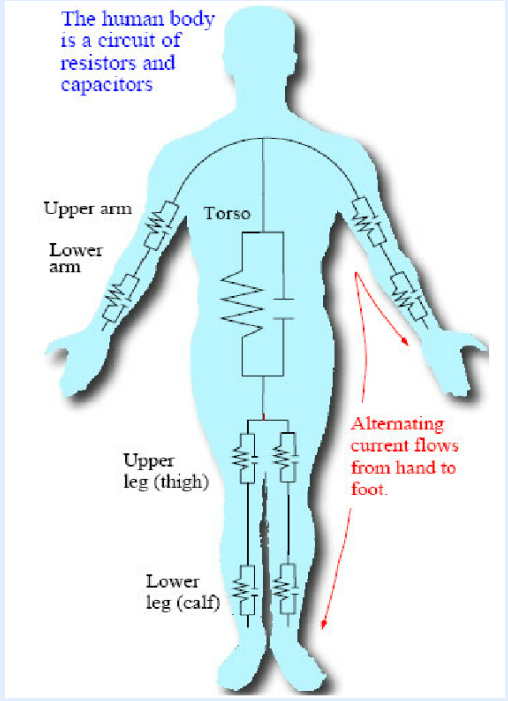
Shepherd 2016 *Obesity* 24(5): 985-988.

Using nuclear methods to validate more accessible technologies

- Bioimpedance
- Anthropometry/Volumes
- Muscle Measures
- 3D Optical Body Scans

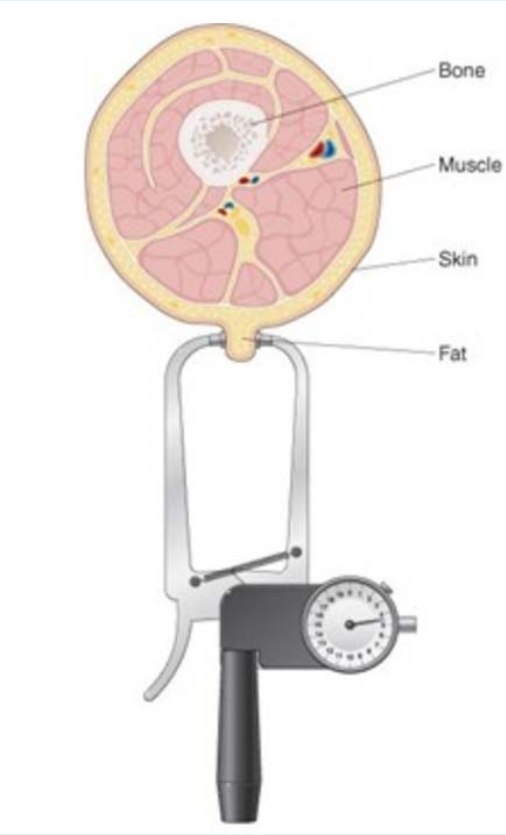
Using nuclear methods to validate more accessible technologies

- Bioimpedance
- Can be inexpensive but accuracy must be validated



Using nuclear methods to validate more accessible technologies

- Forms of anthropometry – tissue dimensions



Classical Skin Fold


Near-Infrared Interactance

A-mode Ultrasound

- Provide reasonable accuracy of local tissue thicknesses
- Can be validated against DXA and TBW
- Generally poor accuracy in predicting overall body composition
- Best accuracy in the young, fit, healthy!

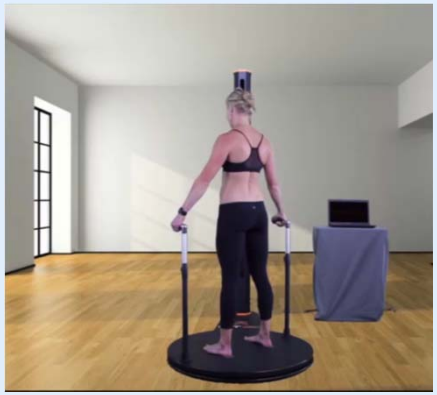
Using nuclear methods to validate more accessible technologies

- Deuterated Creatine – Muscle mass

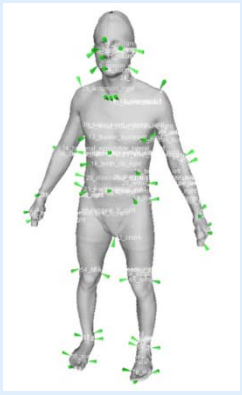
- Water status can affect accuracy of muscle measures using DXA, BIA
- Deuterated creatine measure not affected by hydration
- 95% of creatine stored in muscle
- Muscle mass = creatine pool size / 4.3 g/kg

Using nuclear methods to validate more accessible technologies

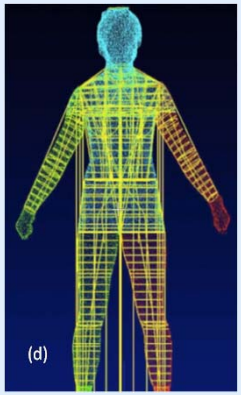
- 3D Optical Body Scans
- 2D Cell Phone Apps



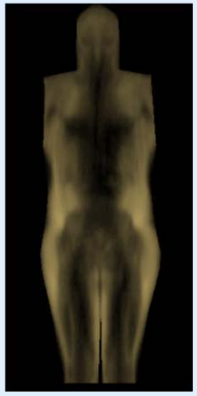
3D optical acquisition



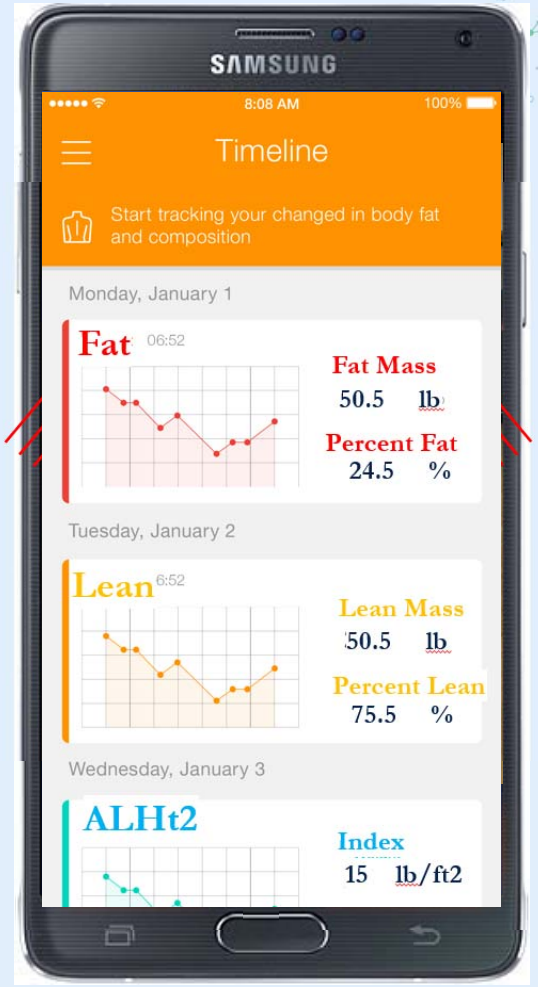
Registration



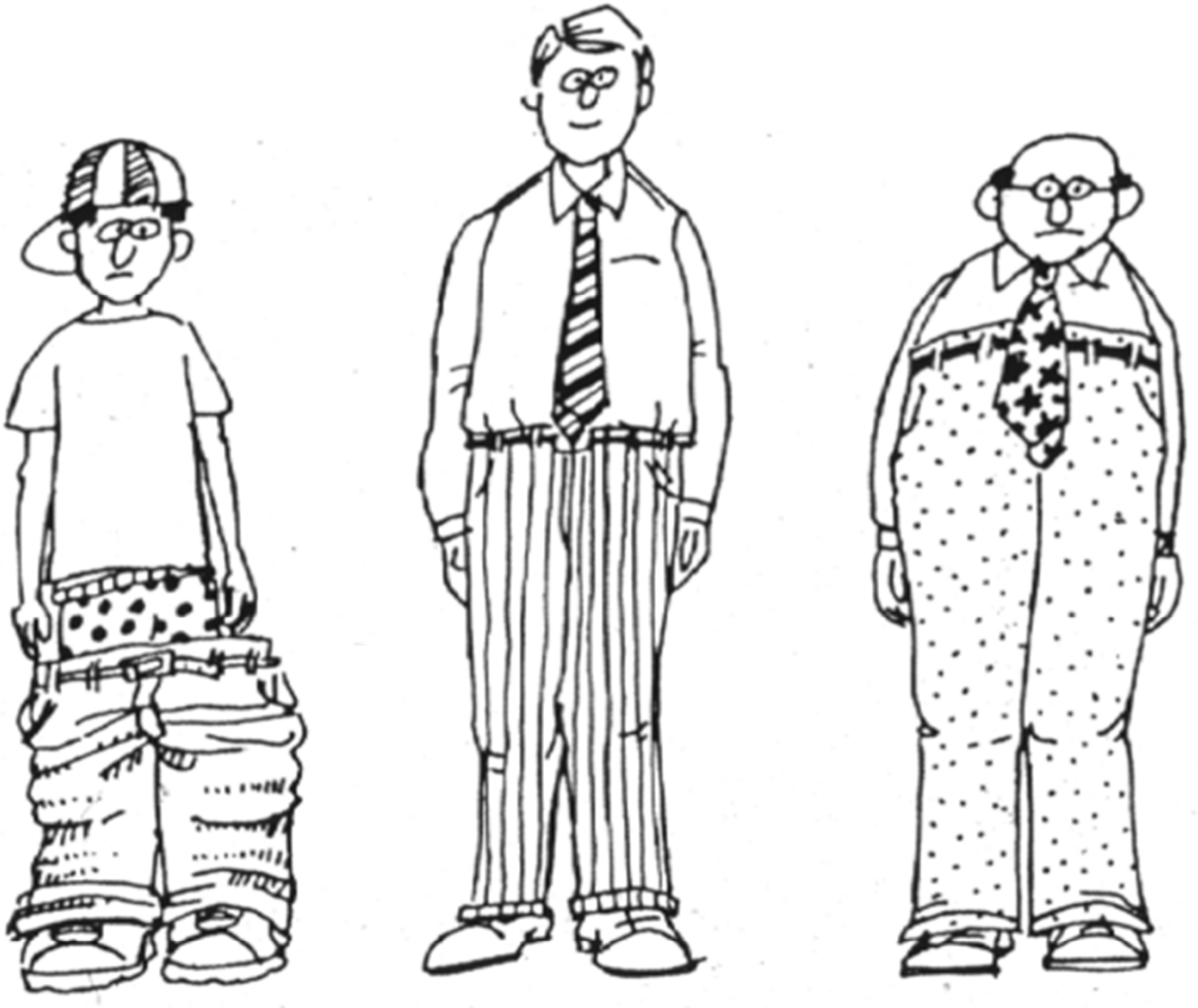
Automated Anthropometry



Predicted DXA Fat

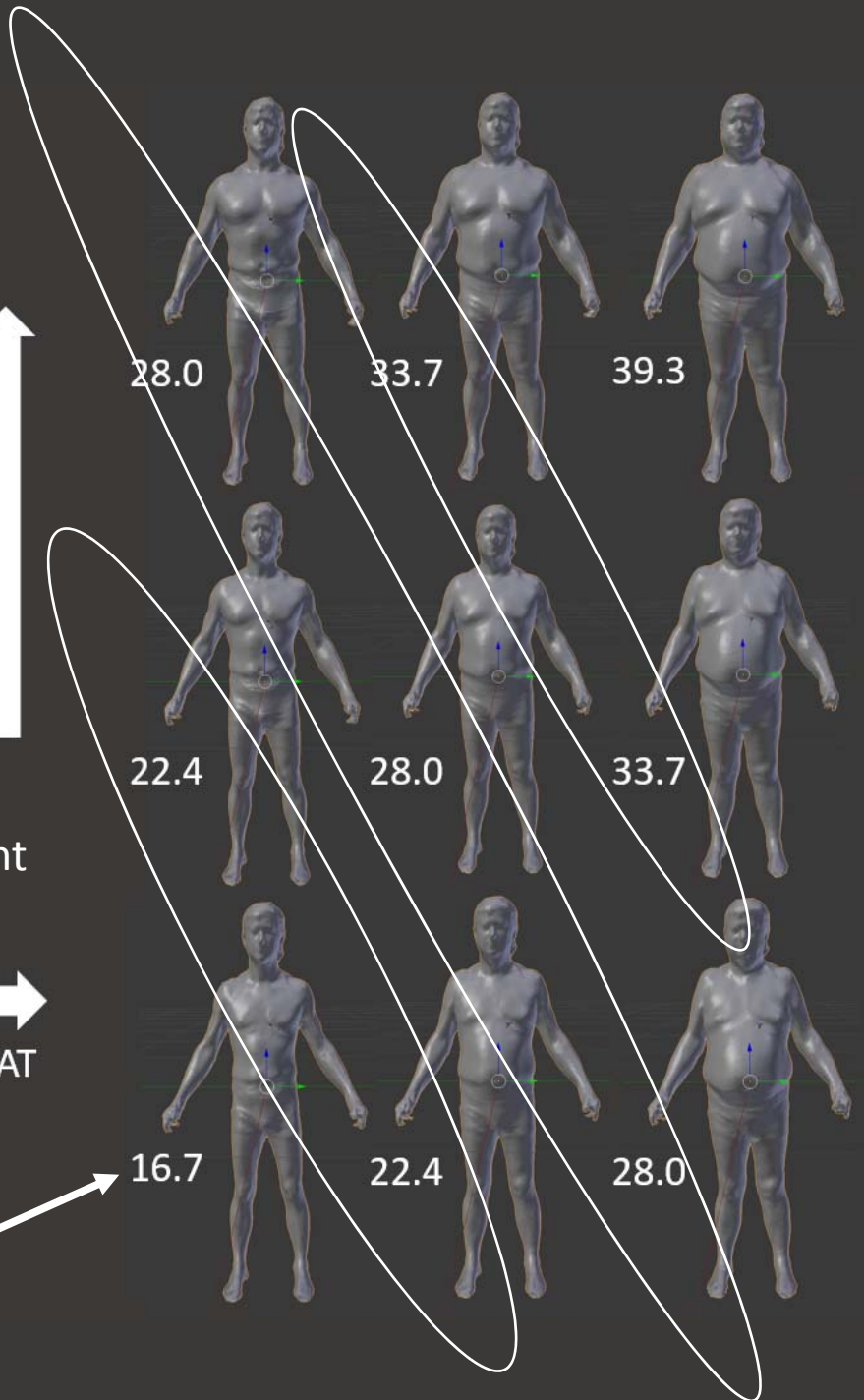


Selfie Body Composition measures



THE THREE STAGES OF MAN

Body Shape Prediction models based on changes in fat and muscle mass



Changes by 20 kg in Lean

BMI can be the same for dramatically different body compositions

Changes by 20 kg in FAT

BMI

Case examples and interactive session on body composition.

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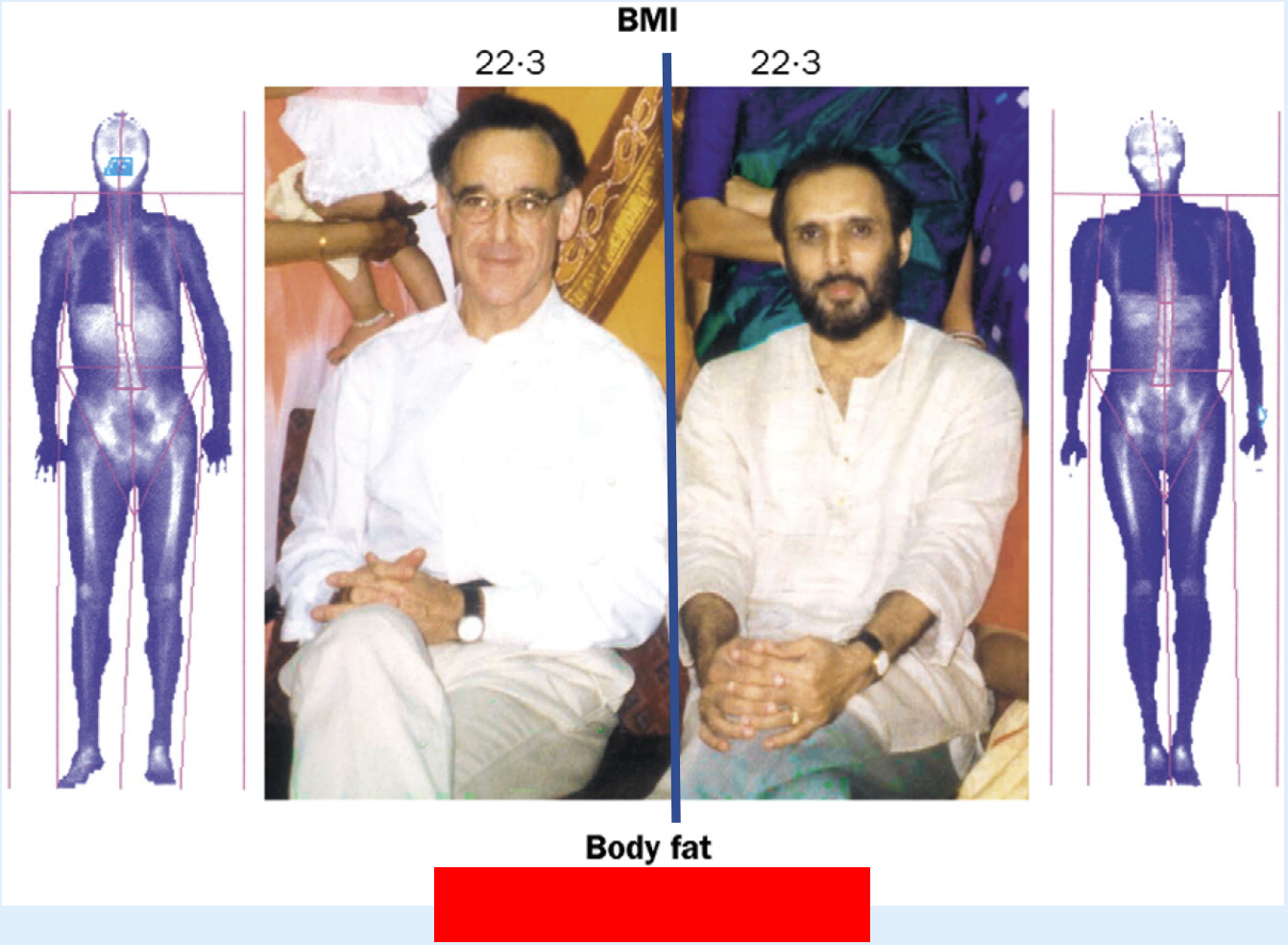


The Lancet 2004 363, DOI: (10.1016/S0140-6736(03)15269-5)

The Y-Y paradox
Chittaranjan S Yajnik, MD, John S Yudkin, FRCP
The Lancet, Vol 363 (9403), January 2003

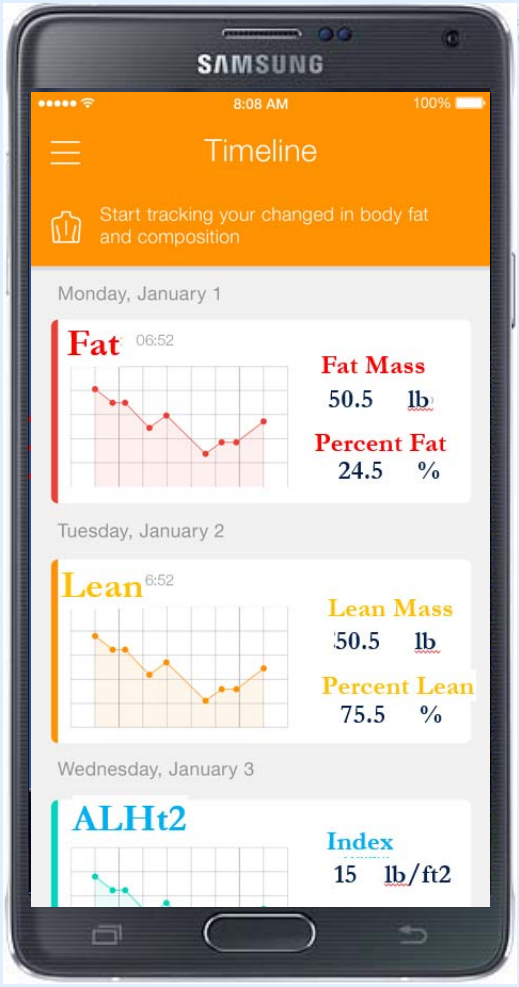
Questions:

- Is BMI enough for monitoring health in individuals?
- How could you better identify *individuals* that would benefit from a dietary or lifestyle intervention?
- How could you better monitor *individuals* on an intervention?

The Selfie body composition demonstration app make monitoring body composition assessable!

How would you use the selfie app?

Look for the Selfie Body Composition App this Fall on Google Play!

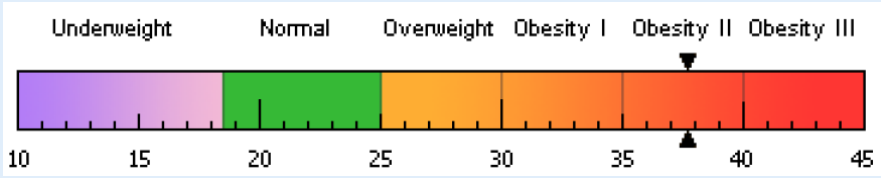


Case Examples

Obesity - Male

Selfie Cell Phone

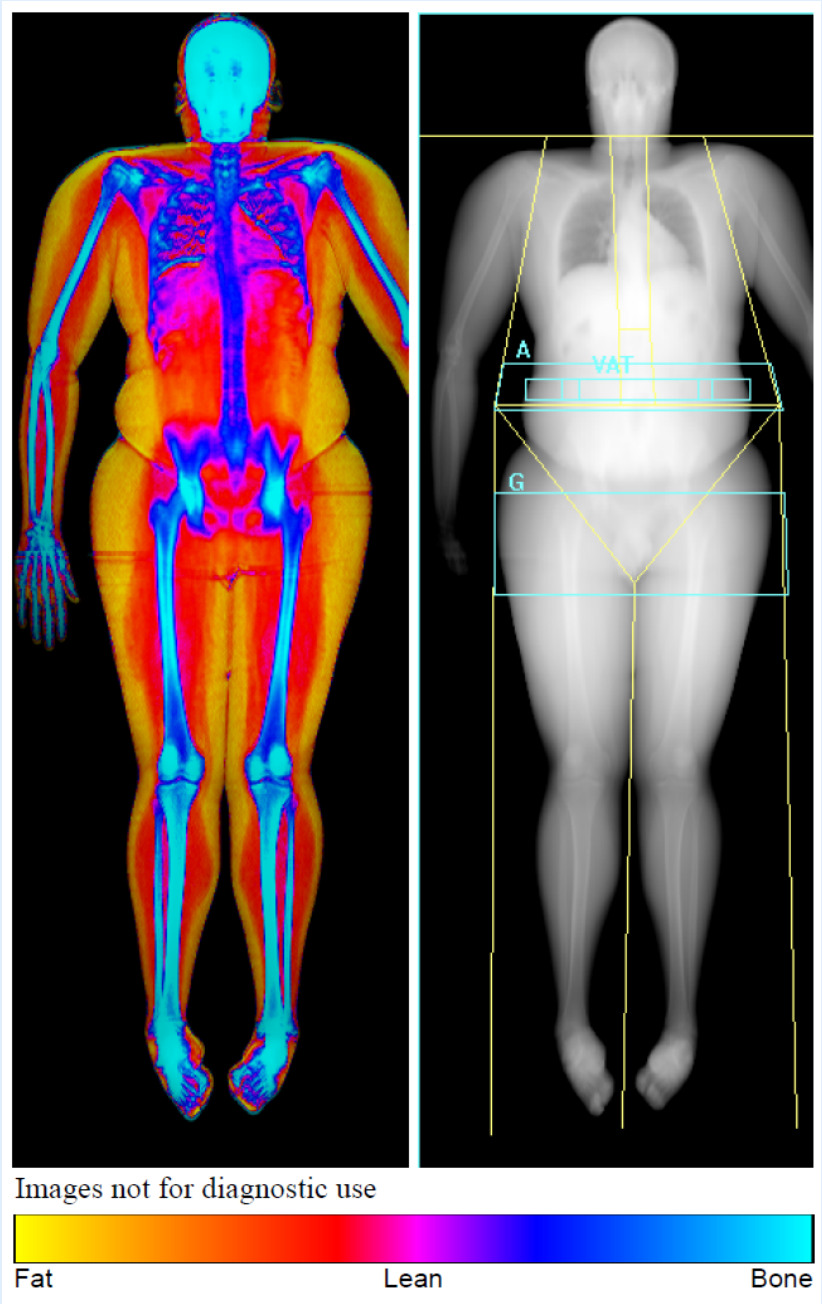
22 year old
African-American
Male
Weight = 117 kg
Height = 176 cm
BMI = 38



Is this enough information for a targeted intervention?

DXA Body Composition

Obesity - Male



BMI = FMI + LMI

Fat mass Index (FMI)
= 14.5 kg/m2 (Obese Class I – should reduce)

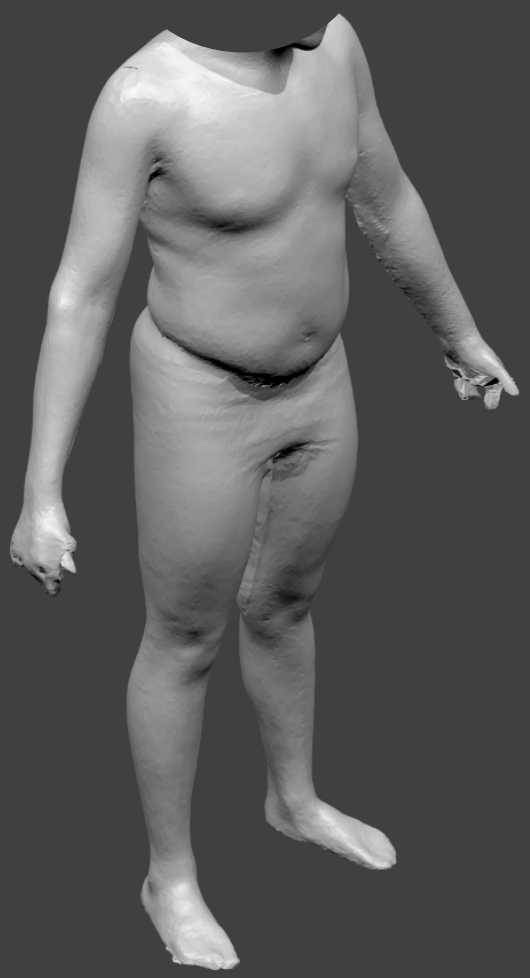
Lean Mass Index (LMI)
= 23.1 kg/m2 (High – OK)

Recommendation:
Reduce Fat Mass Index (down to 6.0 kg/m2)
Keep Lean Mass Index in healthy range (above 16 kg/m2)

Do you think targeting fat and lean interventions is more useful than weight alone?

3D Optical

Obesity - Male



BMI = 26, Weight = 80.5 kg
FMI = 6.0 , LMI = 20.0

In the intervention,

He lost

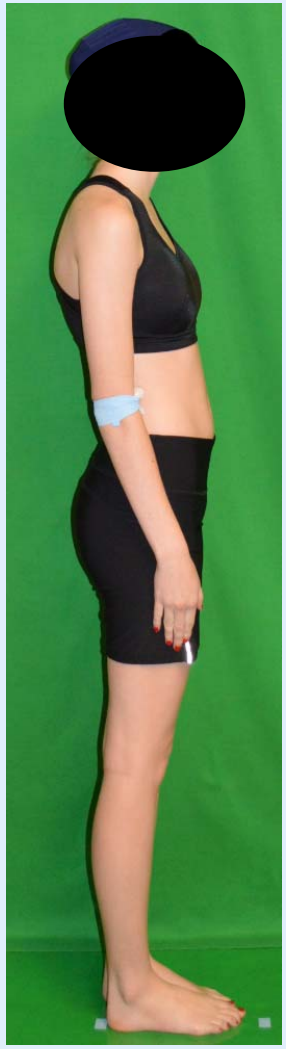
37 kg weight

26.5 kg Fat

10 kg Lean

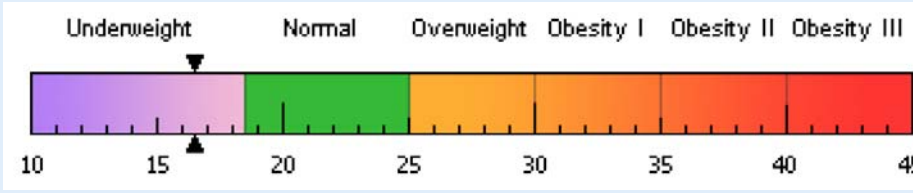
BMI was 37, and is now 26 kg/m2

Underweight/Low Lean - Female



Selfie Cell Phone

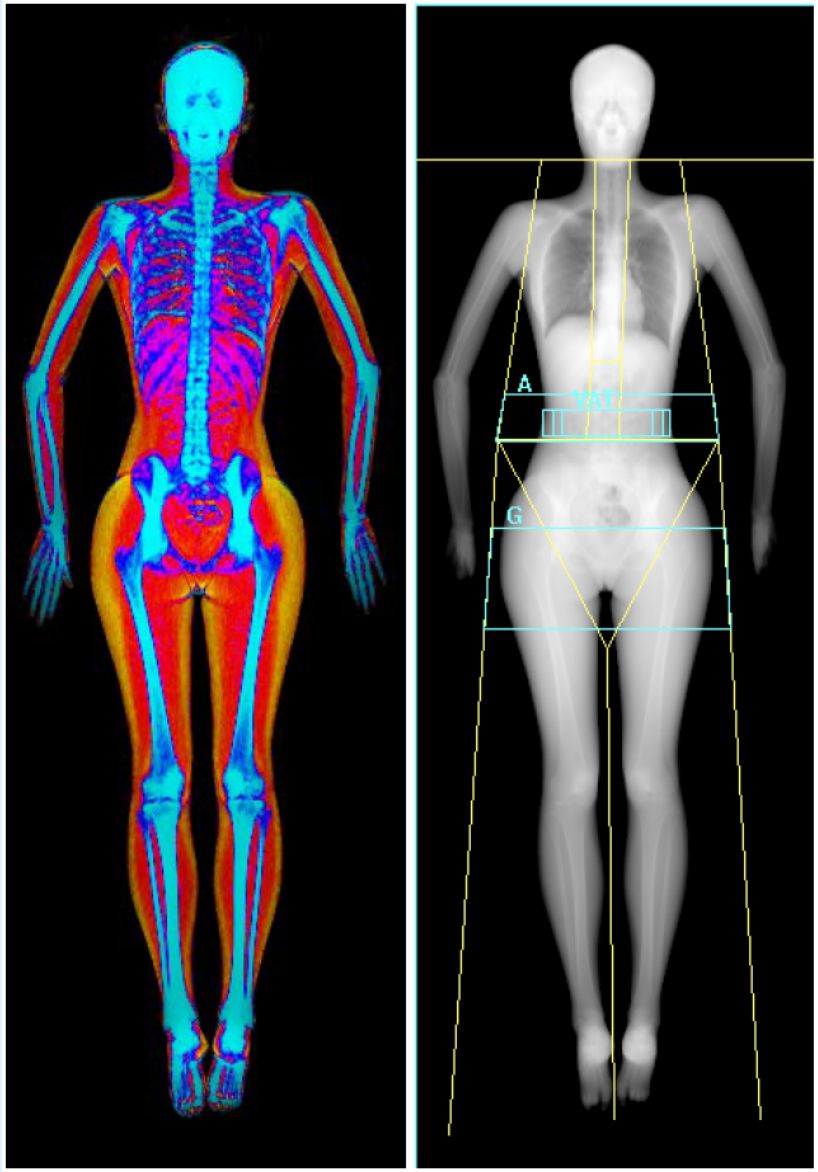
22 year old
Caucasian
Female
Weight = 47 kg
Height = 168 cm
BMI = 16.5



Is this enough information for a targeted intervention?

DXA Body Composition

Underweight Female



Fat mass Index (FMI)
= 4.1 kg/m2 (Low, less than 5)

Lean Mass Index (LMI)
= 12.2 kg/m2 (Low, less than 15)

Appendicular Lean Mass Index (ALMI)
= 4.6 kg/m2 (Low, less than 5.4)

Recommendation:
Increase Fat Mass Index (up to 6.0 kg/m2)
Increase Lean Mass Index (up to 16 kg/m2)

Do you think targeting fat and lean interventions is more useful than weight alone?

3D Optical
Underweight Female

BMI = 21, Weight = 60 kg
FMI = 6.0, LMI=15.0

In the intervention,

She gained

16 kg weight

5 kg Fat

10 kg Lean

BMI was 16.5, and is now 21 kg/m2

Summary

- Nuclear techniques can successfully be used to calibrate assessable technologies like 3D optical for identifying who and how to intervene for improved health

THANK YOU!