



# Body composition

Assessing body composition using a stable isotope technique to monitor healthy growth and recovery from malnutrition

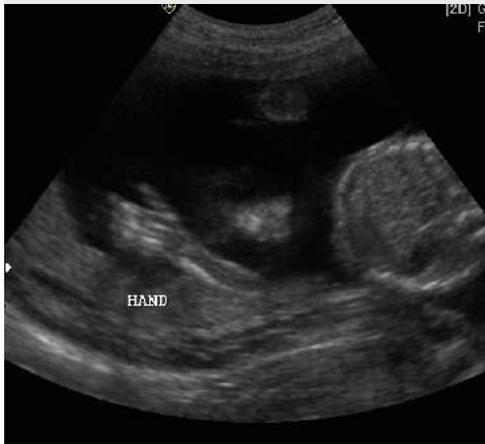
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Cornelia Loechl,  
Head of the Nutritional and  
Health-Related Environmental  
Studies Section,  
International Atomic Energy  
Agency (IAEA)

# IAEA 'Nutrition for Improved Health'

Enhance Member State capabilities to combat malnutrition in all its forms and to address environment related nutrition issues for better health throughout the life course:

- Maternal, infant and young child nutrition;
- Prevention and control of obesity and non-communicable diseases;
- Health effects of the environment.



# IAEA's Contribution to the Global Efforts in Nutrition

The IAEA's work complements the work of other players in nutrition through encouraging the use of stable isotope techniques (safe and non radioactive) in design and evaluation of nutrition interventions

## Stable isotope techniques are reference methods for assessment of:

- Body composition;
- Exclusive breastfeeding;
- Total daily energy expenditure;
- Micronutrient absorption;
- Vitamin A status;
- Protein and amino acid bioavailability and metabolism.



# Support Mechanisms of IAEA

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graph TD; A[Support Mechanisms of IAEA] --> B[Coordinated Research Projects]; A --> C[Technical Cooperation Programme]; B --> D[• Call for research proposals]; B --> E[• Respond to research questions]; B --> F[• Small group of research institutes]; B --> G[• 4-5 years]; B --> H[• Small annual grants]; B --> I[• Regular coordination meetings]; C --> J[• Project submission from Member States]; C --> K[• Building and strengthening capacity to use stable isotope techniques]; C --> L[• Biannual planning and implementation cycle]; C --> M[• Training, expert advice, equipment, sample analysis, data management/analysis];
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## Coordinated Research Projects

- Call for research proposals
- Respond to research questions
- Small group of research institutes
- 4-5 years
- Small annual grants
- Regular coordination meetings

## Technical Cooperation Programme

- Project submission from Member States
- Building and strengthening capacity to use stable isotope techniques
- Biannual planning and implementation cycle
- Training, expert advice, equipment, sample analysis, data management/analysis

# IAEA's Human Health Publications



**IAEA HUMAN HEALTH SERIES**

**No. 3**

Assessment of  
Body Composition and Total  
Energy Expenditure  
in Humans Using  
Stable Isotope Techniques



**IAEA HUMAN HEALTH SERIES**

**No. 12**

Introduction to Body  
Composition Assessment  
Using the Deuterium Dilution  
Technique with Analysis  
of Saliva Samples by  
Fourier Transform Infrared  
Spectrometry



**IAEA HUMAN HEALTH SERIES**

**No. 13**

Introduction to Body  
Composition Assessment  
Using the Deuterium Dilution  
Technique with Analysis of  
Urine Samples by Isotope Ratio  
Mass Spectrometry



**Also available in French and Spanish**

<http://humanhealth.iaea.org>

# More information: Human Health Campus

The screenshot displays the IAEA Human Health Campus website. At the top, there is a blue header with the IAEA logo and the text "IAEA Human Health Campus". A search bar is located on the right side of the header. Below the header, a navigation menu includes "Home", "Nuclear Medicine", "Radiopharmacy", "Radiation Oncology", "Medical Physics", "Technologists", and "Nutrition". The "Nutrition" section is highlighted. On the left side, there is a "Nutrition" sidebar with links to "Body Composition", "Bone Mineral Density", "Total Energy Expenditure", "MAM Symposium 2014", and "Human Milk Intake". The main content area is titled "Nuclear Techniques in Nutrition" and features several articles with images and titles: "Body Composition", "Bone Mineral Density", "Total Energy Expenditure", "Vitamin A Body Pool Size", "Peer-reviewed publications & useful links", "Environmental Enteric Dysfunction", "Brochures & Multimedia Material", "Carbon-13 Breath Tests", "Writing Skills", and "Environmental Enteric Dysfunction". At the bottom, there is a "NEW!" announcement: "Assessing Vitamin A Safety in Large-Scale Nutrition Intervention Programmes: Setting the Research Agenda" and a "FOOD AND NUTRITION BULLETIN" banner.



Also on LinkedIn:  
**IAEA Human Health Campus**  
Send a request to join the group!

Check out:

<https://nucleus.iaea.org/HHW/Nutrition/>

# Implications of body composition

## **Undernutrition**

- The effect of feeding lipid nutrient supplements (LNS) or ready-to-use therapeutic food on body fat accretion

## **Overnutrition**

- Fatness and adiposity – overweight/obesity/diabetes
- Obesity may be programmed by events early in life

## **Healthy growth – quality of growth**

- Association between greater weight gain (rate of weight gain) in early infancy and later fat mass and central fat distribution

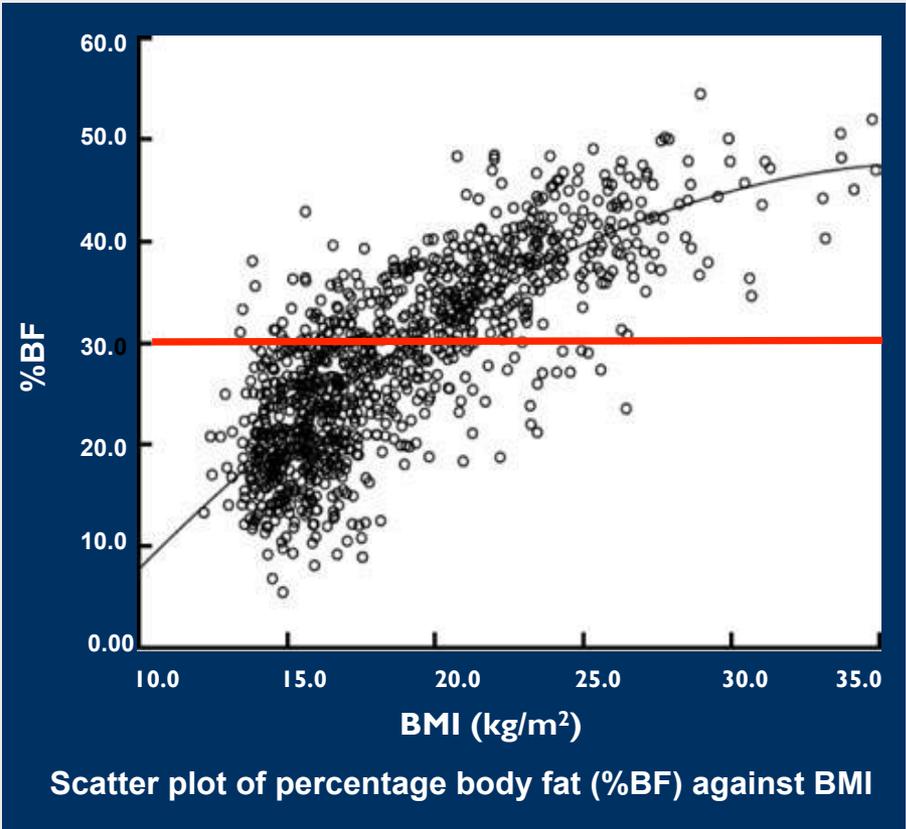
# Childhood Obesity And Related Health Risks In Asia And The Pacific (IAEA regional project)

**Countries:** China, Lebanon, Malaysia, Philippines and Thailand

**Participants:** 1039 children age 8-10 years

**Technique:** Body composition using deuterium dilution technique

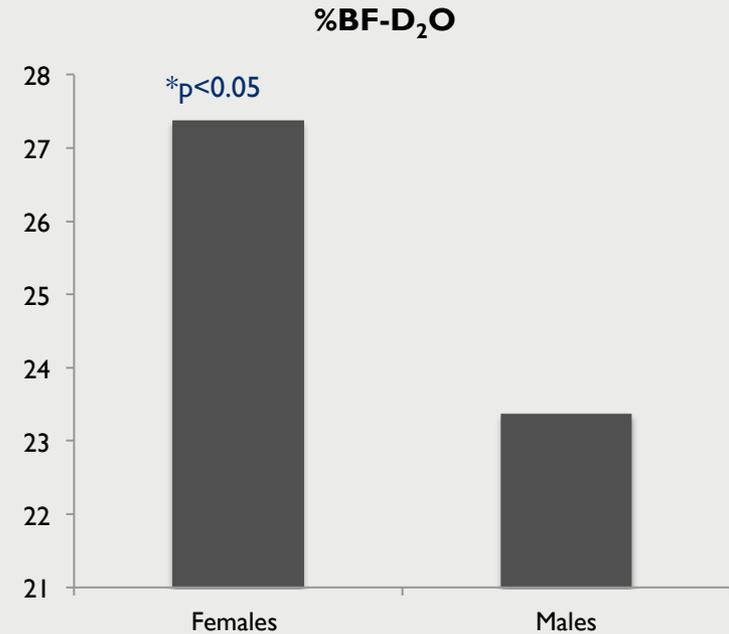
**Conclusion:** Necessity to consider ethnic differences in body composition when developing body mass index (BMI) cut-off points and other obesity criteria in Asian children



BMI cut-offs for Asian children should be lowered when BMI is used as screening tool for overweight and obesity

# Assessment of adiposity and association with risk factors for NCDs in Latin American children (IAEA regional project)

- Body composition using deuterium dilution technique in 1,205 children age 6-12 years, 12 countries in Latin America and the Caribbean
- **Significant association of %BF with: blood pressure, blood lipids (TC, HDL, LDL), insulin and immune factors (CRP, IL-6)**



# Symposium recommendation

- Go beyond weight change as measure of success, need to assess body composition and metabolic indicators

The poster features a blue background with white and purple text. At the top left, the title 'International Symposium on Understanding Moderate Malnutrition in Children for Effective Interventions' is written in a large, bold font. To the right of the title is a purple logo consisting of three stylized 'M' shapes, with the text 'Managing Moderate Malnutrition' below it. Further right, the dates '26-29 May 2014' and location 'Vienna, Austria' are listed. In the center, there are five circular images: a woman feeding a child, a group of children, a woman holding a child, a group of children, and a child eating. At the bottom, logos for the organizing and cooperating organizations are displayed: IAEA (International Atomic Energy Agency), VALID (Valid International), WFP (World Food Programme), and MI (Micronutrient Initiative).

**International Symposium on  
Understanding Moderate  
Malnutrition in Children  
for Effective Interventions**

**Managing Moderate  
Malnutrition**

26-29 May 2014  
Vienna, Austria

Organized by the  
**IAEA**  
International Atomic Energy Agency

In cooperation with the  
**VALID** Valid International

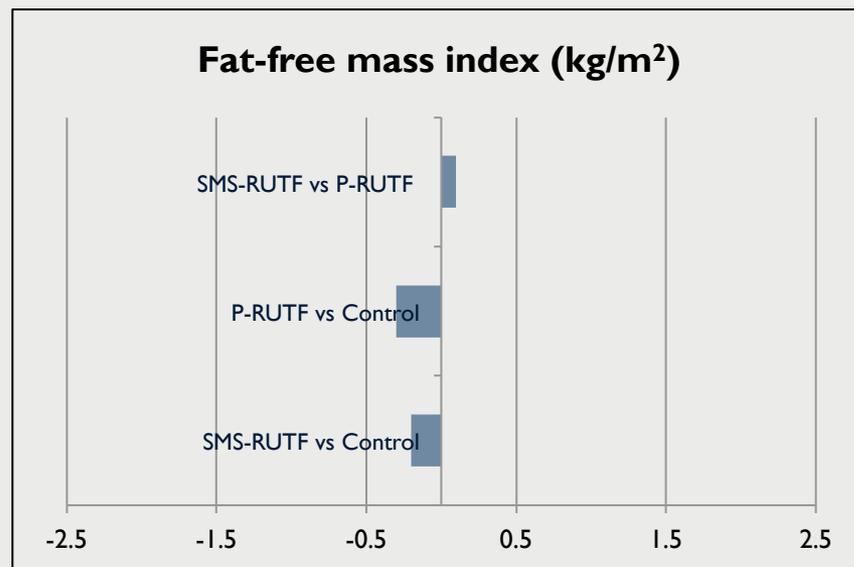
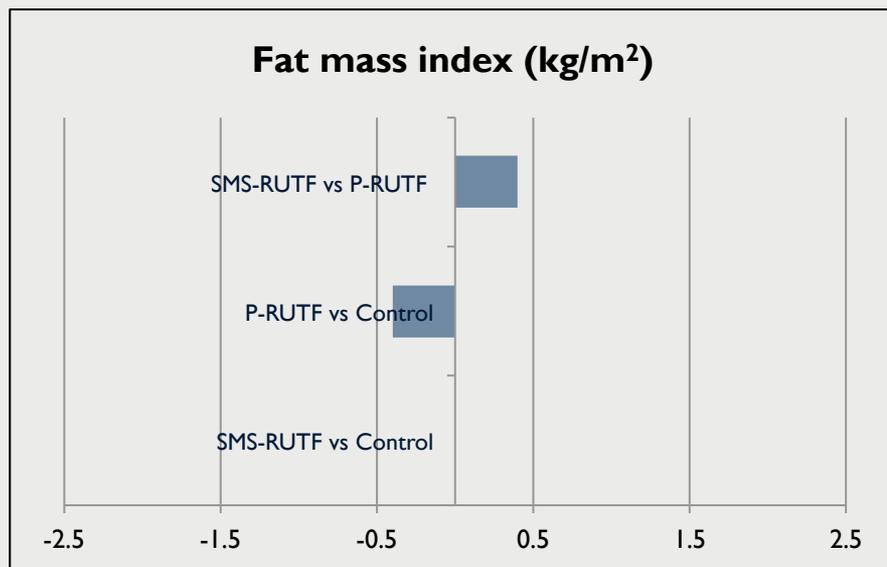
**WFP**  
World Food Programme

**MI** Micronutrient Initiative

# Recovery from malnutrition

## Example from Democratic Republic of Congo

- **Comparison of the efficacy** of soya-maize-sorghum RUTF (SMS-RUTF) with that of standard peanut paste based RUTF (P-RUTF) in children **24-59 months old** with SAM
- **Differences in body composition** attributable to the 2 products measured at discharge/recovery; comparison with non-malnourished community control
- No significant differences in FM/FMI - both RUTFs not associated with an excess of fat deposition
- Recovery was the same for both products in children >24 months



Control: n=47

SMS-RUTF: n=29

P-RUTF: n=26

adapted from: Bahwere *et al*, *Am J Clin Nutr* 2016;103:1145-61

# Effectiveness of food supplements in increasing fat-free tissue accretion in children with moderate acute malnutrition: A randomised 2 × 2 × 3 factorial trial in Burkina Faso

Christian Fabiansen, Charles W. Yaméogo, Ann-Sophie Luel-Brockdorf, Bernardette Cichon, Maren J. H. Rytter, Anura Kurpad, Jonathan C. Wells, Christian Ritz, Per Ashorn, Suzanne Filteau, André Briend, Susan Shepherd, Vibeke B. Christensen, Kim F. Michaelsen, Henrik Friis 

Published: September 11, 2017 • <https://doi.org/10.1371/journal.pmed.1002387>



Photo: K Michaelsen

## Why was the study done?

- Are lipid based (LNS) and corn-soy based (CSB) supplements equally effective?
- Are milk and soy based supplements equally effective?
- **Do MAM children who receive LNS accumulate too much fat while gaining weight?**

## What did the study do?

- 6-23 old children with MAM, n=1609, Burkina Faso
- Effectiveness of:
  - Feeding LNS vs CSB on weight gain and FFM
  - Feed composition: soy (and its quality) vs dry skimmed milk (and its quantity)
- Main outcome: **Body composition by deuterated water (FFM gain)** in addition to weight
- Measured at enrolment and after 12 weeks

## What did the study find?

- Overall, with all supplements, mean weight gain = 0.90 kg (95% CI 0.88, 0.93;  $p < 0.01$ )
- Higher recovery rate for LNS vs CSB
- **Mean FFM composition of this weight gain = 93.5% (95% CI 89.5, 97.3)**
- **FFMI accretion was slightly higher with LNS feeding: no excess fat gain**

# New IAEA regional project: Follow-up of MAM and SAM children (2016-2019)

- **Objective:**  
Evaluate impact of MAM and SAM treatment programmes on health outcomes to improve understanding of relative success of current approaches
- **Measurements:**
  - 1) Body composition - sensitive measure of nutritional status (body fat and lean body tissue)
  - 2) Markers of metabolic syndrome
- **Countries** with existing cohort of children: Burkina Faso, Kenya, Ethiopia, Malawi, Uganda, Tanzania, Zambia, DRC



# Applying Nuclear Techniques to Understand the Link between Early Life Nutrition and Later Childhood Health (new IAEA research project)

- To investigate the relationship between the first 1000 days and later childhood body composition
- To explore whether interventions during the first 1000 days can influence childhood body composition and associated NCD risk factors



**Cohort A – mother received intervention from preconception and child from birth**



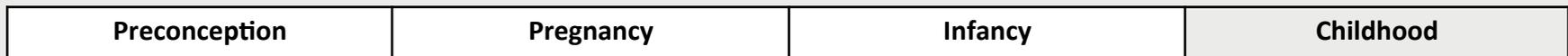
**Cohort B – mother received intervention in pregnancy**



**Cohort C – Child received previous intervention in infancy**

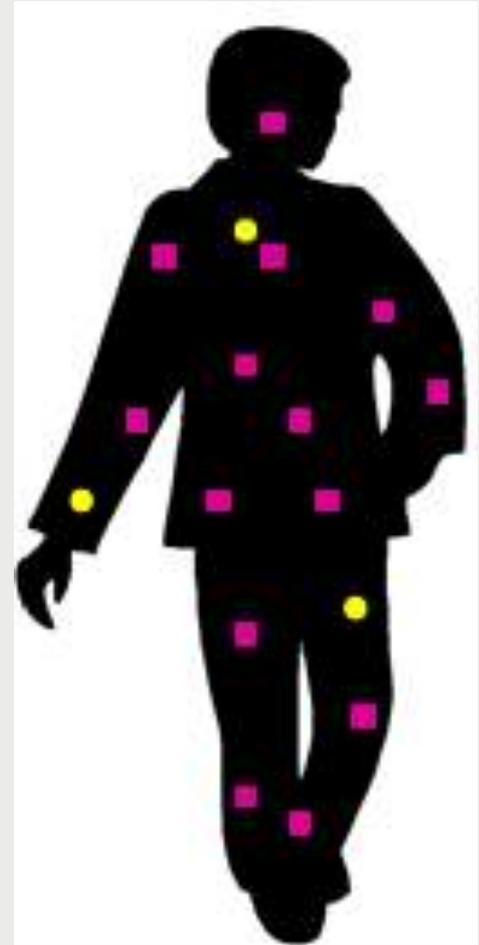


**Cohort D – No intervention received**



# Body composition by deuterium dilution – how does it work?

1. Collect baseline sample before drinking accurately weighed dose of deuterium that mixes with body water evenly within a few hours; collect 2 post-dose samples (3-4 h in saliva; 5-6 h in urine)
2. Measure deuterium abundance before and after equilibration of the dose
3. Calculate total body water and fat-free mass using appropriate hydration factor
4. Determine amount of fat mass as difference between body weight and fat-free mass (2-compartment model)



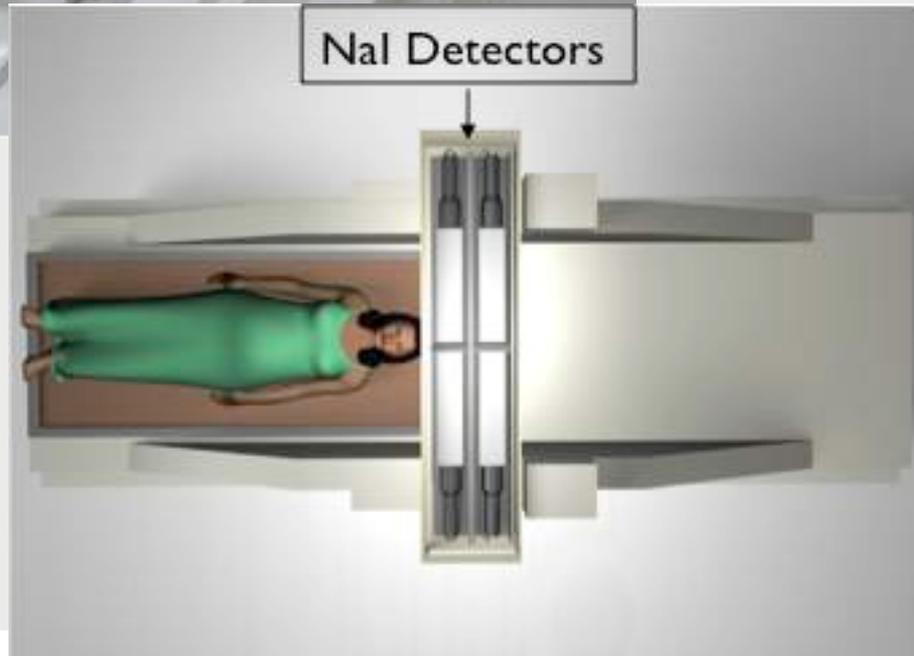
## CHALLENGES

- **Hydration factor**
  - Varies with growth and physiological states
- **Reference data**
  - Will it be possible across different ethnic groups?

## SOLUTIONS

- Body Cell Mass
- Muscle Mass
  
- IAEA Coordinated Research Project to produce reference charts from birth to 2 years of age

Shadow Shield-Whole body potassium counter  
Counting natural  $^{40}\text{K}$  in the body as an index of body cell mass



Cellular  
4C

Fat

K  
(BCM)

ECF

ECS

# Deuterated Creatine – Muscle mass



American  
Physiological  
Society

Journal of  
Applied Physiology

PUBLISHED ARTICLE  
ARCHIVES  
SUBSCRIPTIONS  
SUBMISSIONS  
CONTACT US

*J Appl Physiol* (1985). 2014 Jun 15; 116(12): 1605–1613.

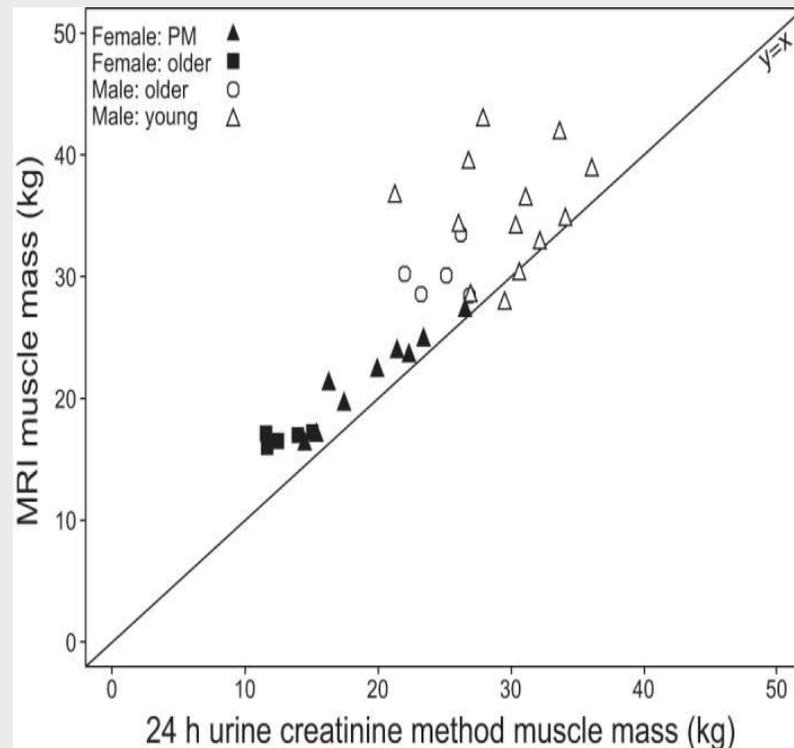
Published online 2014 Apr 24. doi: [10.1152/jappphysiol.00045.2014](https://doi.org/10.1152/jappphysiol.00045.2014)

PMCID: PMC4064374

## Total body skeletal muscle mass: estimation by creatine (*methyl-d<sub>3</sub>*) dilution in humans

Richard V. Clark,<sup>1</sup> Ann C. Walker,<sup>1</sup> Robin L. O'Connor-Semmes,<sup>1</sup> Michael S. Leonard,<sup>1</sup> Ram R. Miller,<sup>1</sup> Stephen A. Stimpson,<sup>1</sup> Scott M. Turner,<sup>2</sup> Eric Ravussin,<sup>3</sup> William T. Cefalu,<sup>3</sup> Marc K. Hellerstein,<sup>4</sup> and William J. Evans<sup>2</sup>

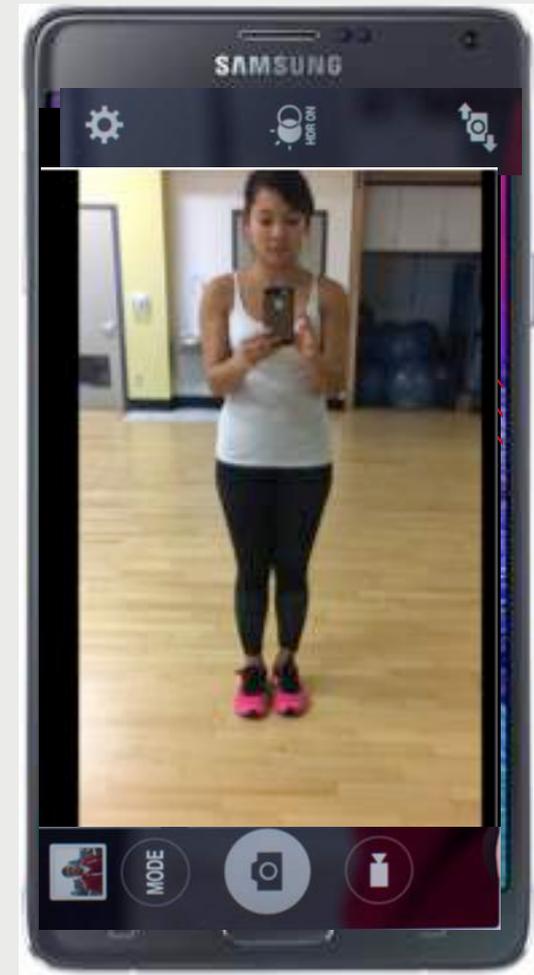
- Deuterated creatine measure not affected by hydration
- D<sub>3</sub>-creatine (*methyl-d<sub>3</sub>*) used to trace the creatine pool size
- Assume 95% of body creatine is within muscle
- Conversion:  
Muscle mass = creatine pool size/4.3 g/kg
- Correlates well with MRI estimates of muscle mass in adults



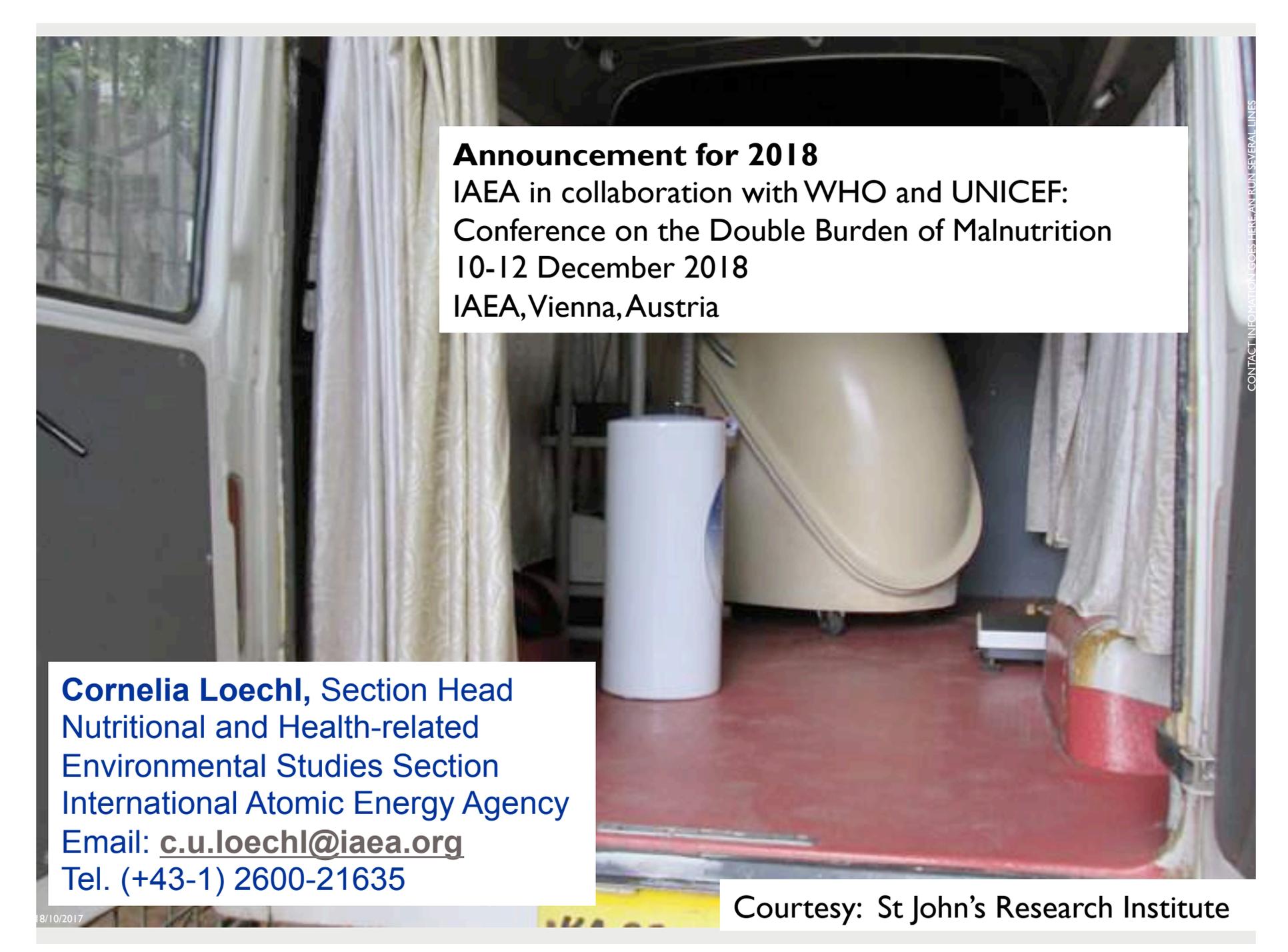
# Accessible technology – 2D Cell Phone Apps

The Selfie body composition demonstration app makes monitoring body composition accessible!

IAEA partners with University of California, San Francisco



Selfie Cell Phone



**Announcement for 2018**

IAEA in collaboration with WHO and UNICEF:  
Conference on the Double Burden of Malnutrition  
10-12 December 2018  
IAEA, Vienna, Austria

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Courtesy: St John's Research Institute