The size, shape, density of human bodies and how they change in form and function from conception to older age varies by **sex, age, ethnicity, activity and heritage/genes and environment**. All the molecules that the body is composed of are determined by the foods that are consumed: quantity and quality. The most simple anthropometric measures of body composition are **body mass, height and waist**. The most widely used determinant of relative body size is **body mass index**. The concept of the quadruple burden of malnutrition and the relationship to BMI will be discussed. With more sophisticated measures such as bioimpedance, plethysmography, isotope dilution and dual xray absorptiometry the body mass can be divided into two compartments; **fat free mass (FFM) and fat mass (FM) and hence % body fat**. If FFM and FM are divided by height squared then **FFMI and FMI** are determined. Of practical interest is how body composition changes with growth, particularly in the critical periods of growth: in utero, baby and toddlerhood and adolescence. Metabolic rate, dietary and energy requirements, physical activity levels all impact on body composition and function. Practical examples of the importance of measures of body composition and function will be discussed.

https://drive.google.com/file/d/1hWMyO86CqIyMWZvYWDbXyhg4ICDDiRxY/view

Body Composition and Measurements: Pros and Cons "What Lies Underneath"

Elaine Rush MNZM, PhD

Auckland University of Technology

https://www.aut.ac.nz/profiles?id=erush&asset=263217

Outline of presentation

age/growth

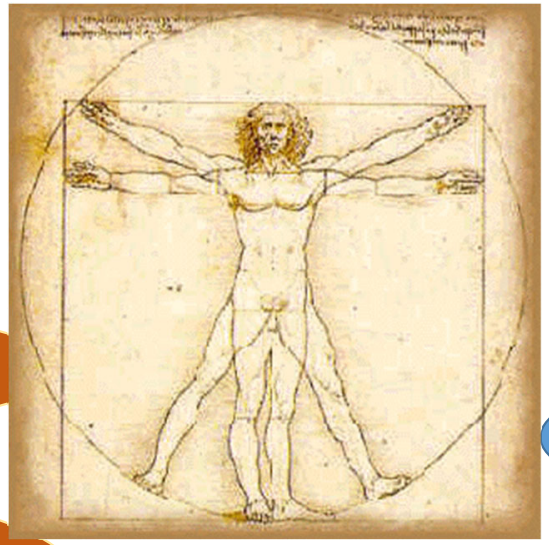
gender/sex

ethnicity

foods/dietary patterns

metabolism/ physical activity/climate

Food security



relationships

elemental

molecular

weight, height, waist, skinfolds,

electrical, BIA

two compartment

Regional, skeletal muscle

fat compartments

Our bodies are what we eat and do!

All the molecules that the body is composed of are determined by the foods that are consumed: quantity and quality.

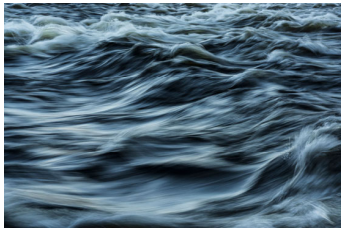
foods/dietary patterns

metabolism/ physical activity/climate

Where does food come from- the food ecosystem?

To grow healthy plants and animals you need

Water

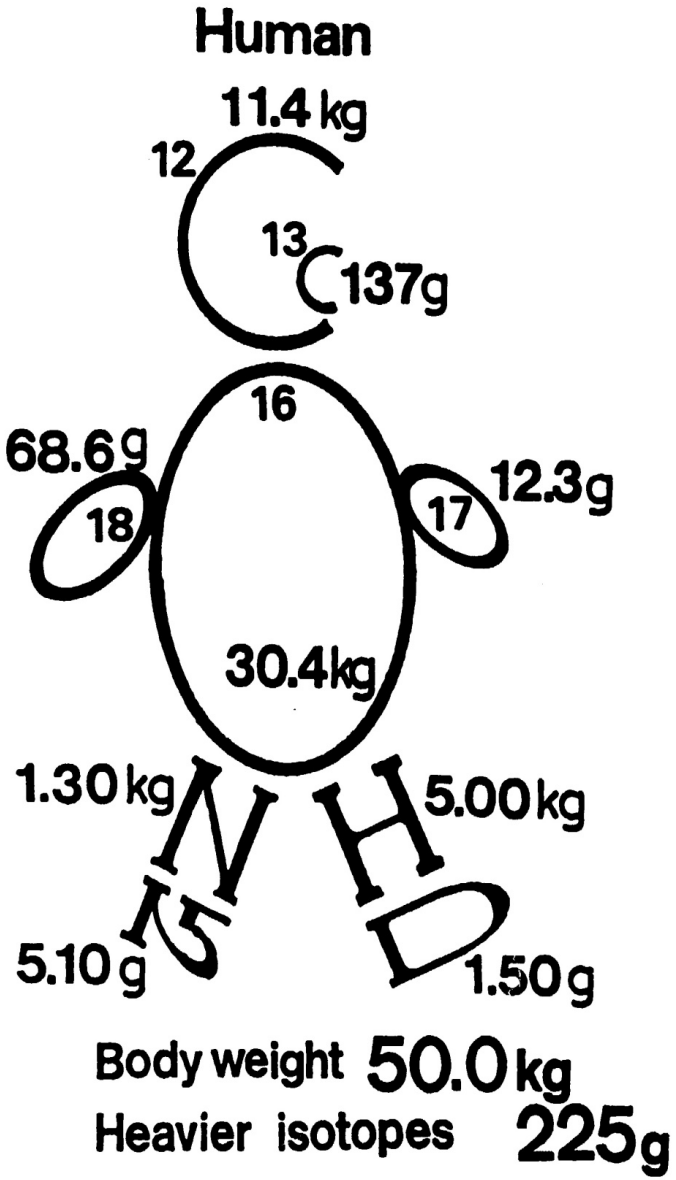


Soil/minerals

Carbon dioxide, nitrogen, oxygen

Sun/warmth/light

Healthy seeds



elemental

Isotopic Composition of 50 kg Human

To grow healthy humans you need

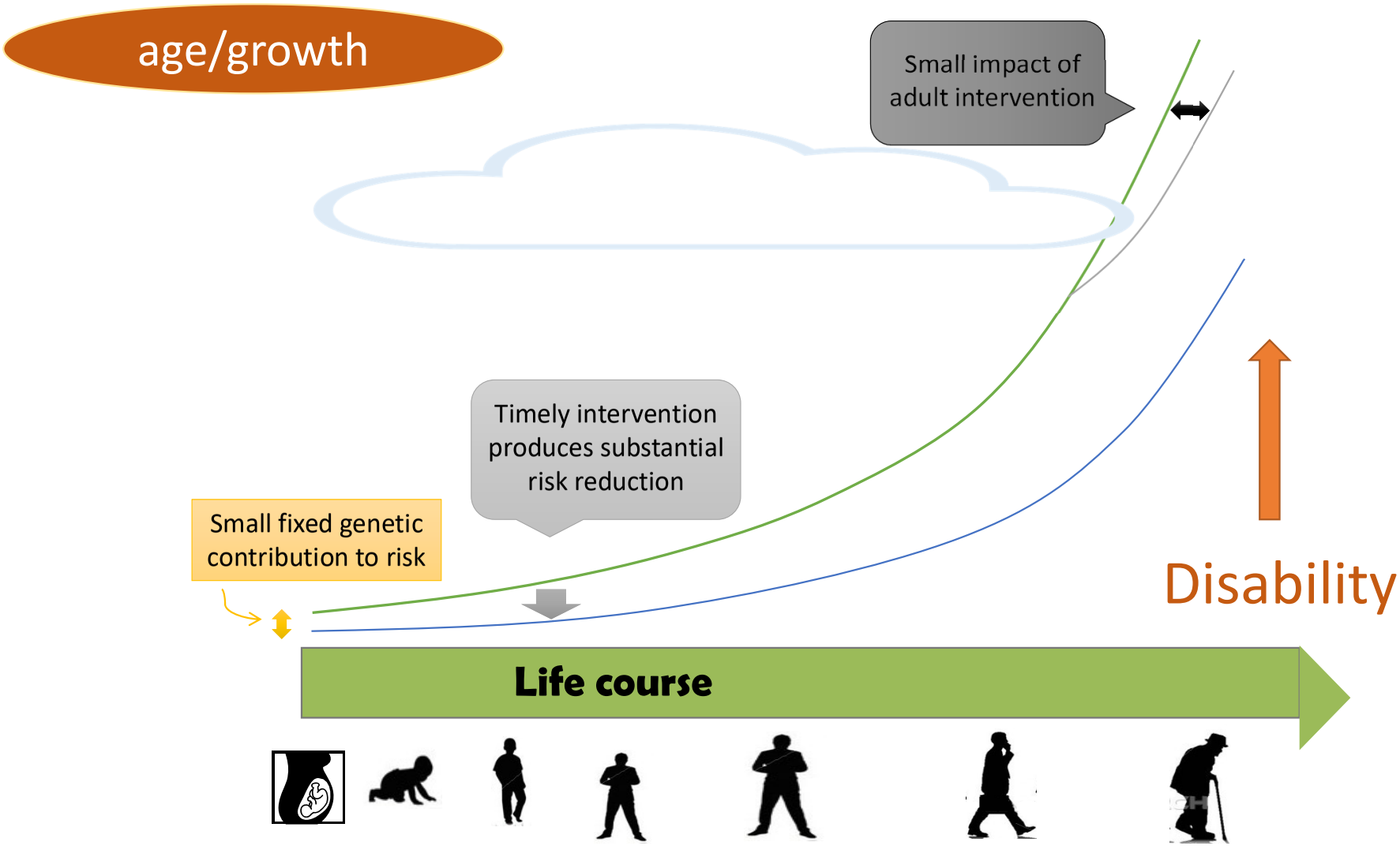
Foods not nutrients

Wholesome foods in sensible combinations

Four Fs!

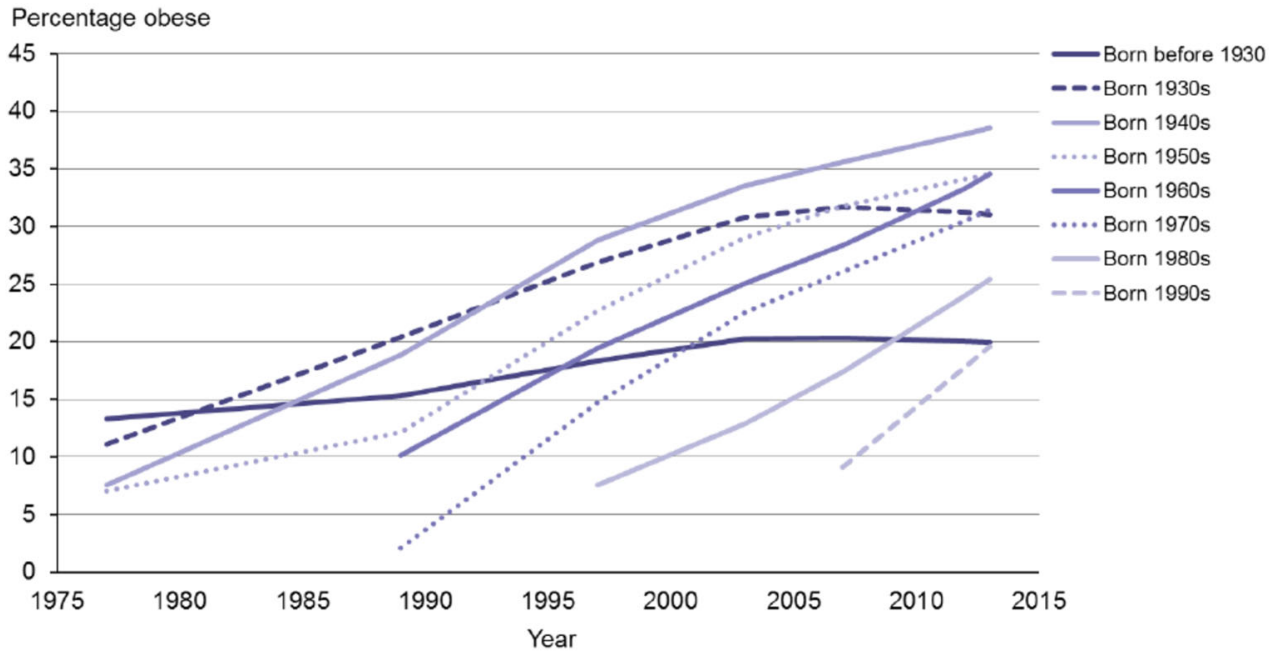
food, feet, fingers, and fellowship

foods/dietary patterns


age/growth
Small impact of adult intervention
Timely intervention produces substantial risk reduction
Small fixed genetic contribution to risk
Disability
Life course

Weight relative to height, BMI >30 kg.m^{-2}

Figure 10: Adult obesity rate, by birth cohort, 1977–2012/13



Note: Years of survey were 1977, 1989, 1996/97, 2002/03, 2006/07, 2011/12 and 2012/13.

Ministry of Health. 2015. *Understanding Excess Body Weight: New Zealand Health Survey*. Wellington: Ministry of Health.

Obesity increases with aging - the older you are the more likely to be obese!

Quadruple Burden of **Malnutrition**

BMI

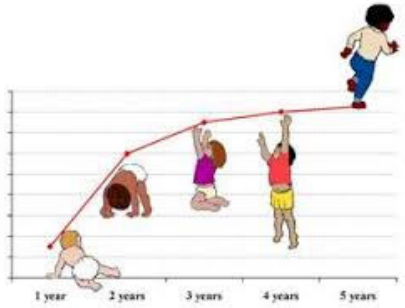
1. obesity and overweight,
2. underweight, stunting
3. food insecurity, and
4. hidden hunger

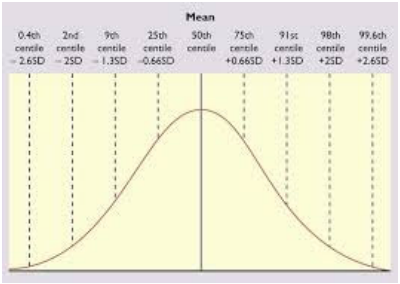
Fat, famished or starved?

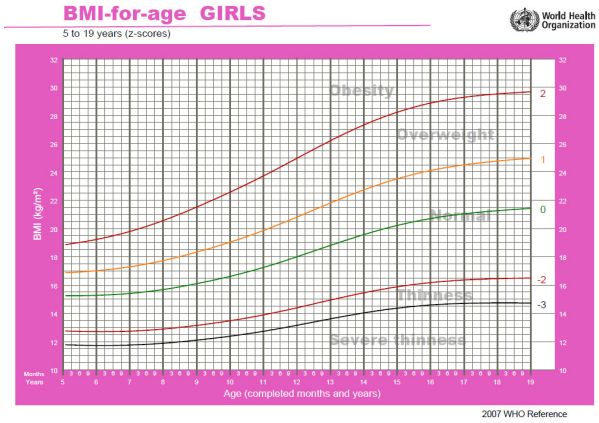
Food security

Ratios and relativity

- Waist to height <0.5
- Waist to hip
- Subscapular to triceps
- Stunting
- Z scores/percentiles







weight, height, waist, skinfolds,

Same age,
Same BMI
Same centile,
Same z score for BMI

Weight 50 kg
Height 156 cm
BMI 20.5 kg/m^2

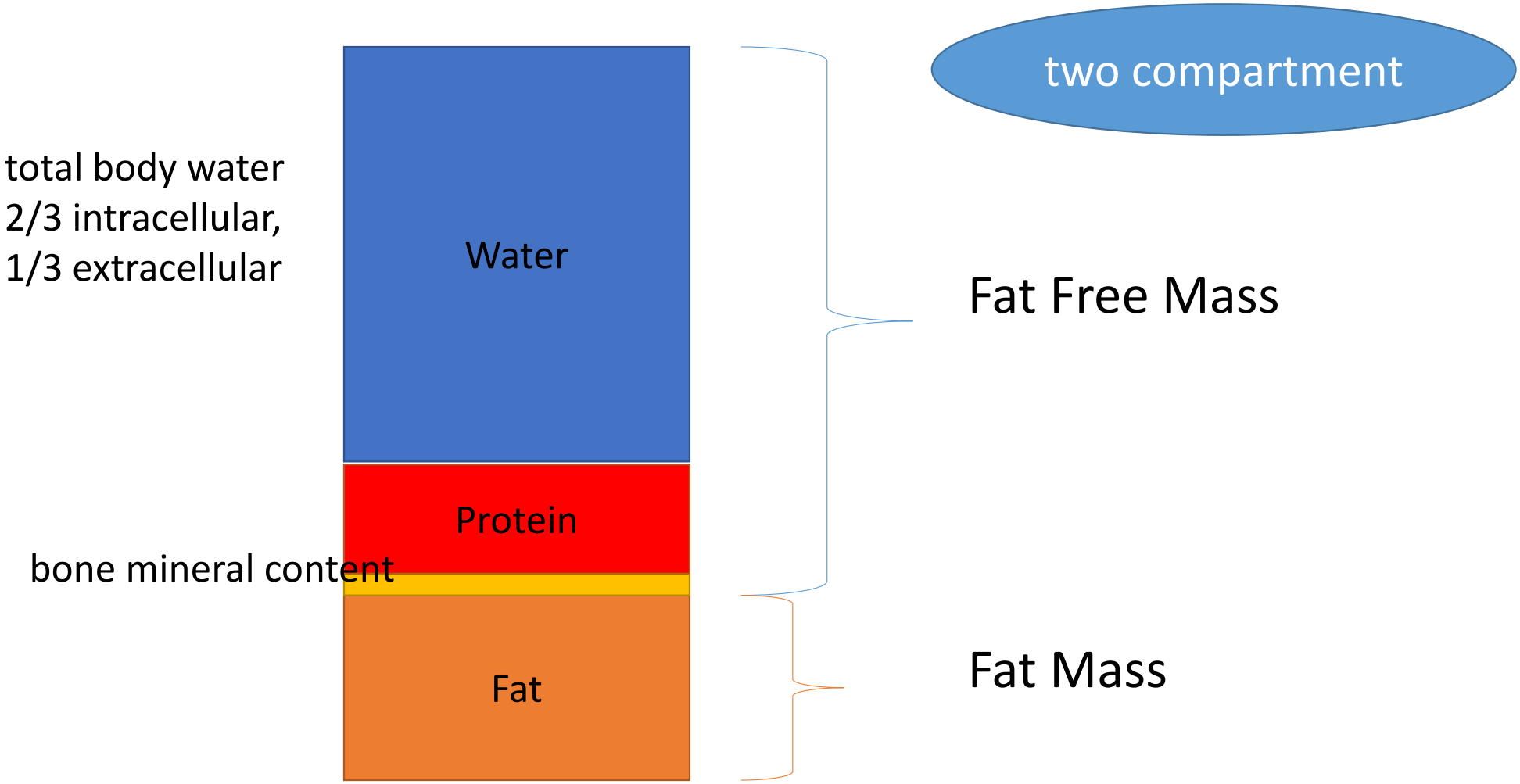
Weight 25 kg
Height 110 cm
BMI 20.6 kg/m^2

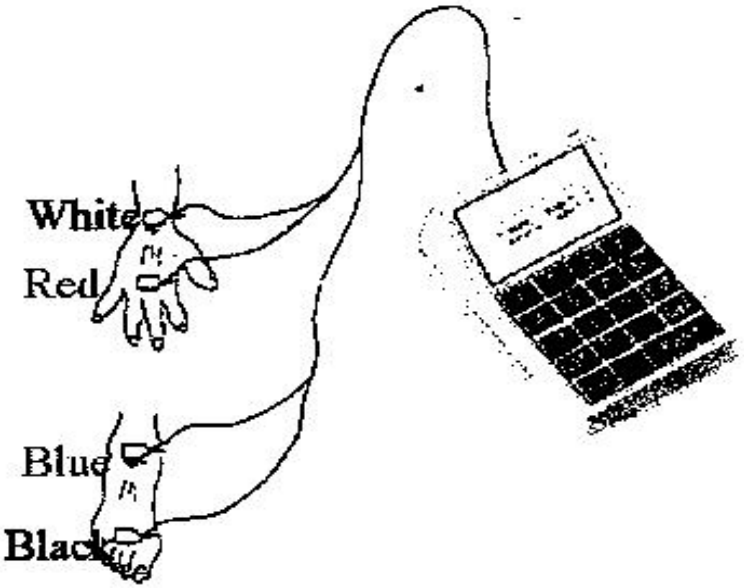
Methods of Measurement

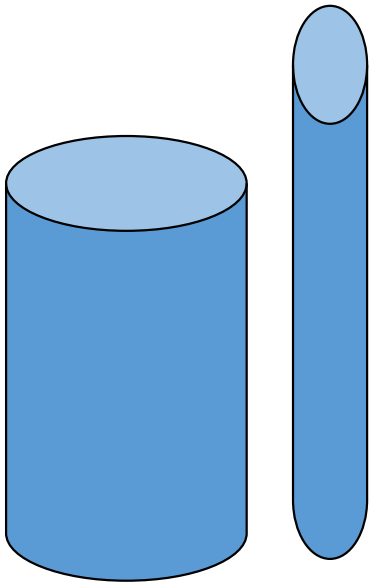
BMI –anthropometry

Bioimpedance analysis (BIA)

and two compartment model

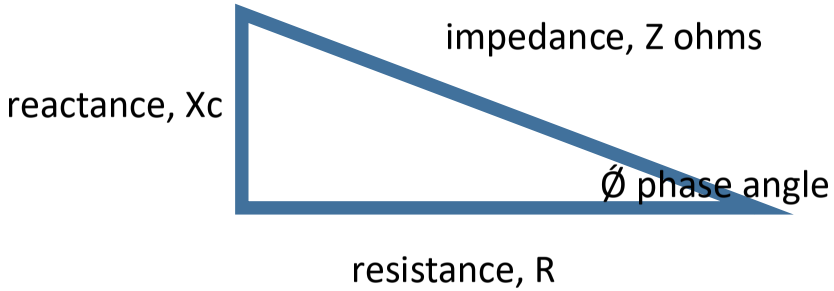

two compartment
total body water
2/3 intracellular,
1/3 extracellular
Water
Protein
bone mineral content
Fat
Fat Free Mass
Fat Mass





two compartment

Bioimpedance analysis 50kHZ for total body water



Electrical properties of the human body are related to the dimensions & the amount of water in the body. Total body water α (height of body)^2/resistance

Skinfolds

Prediction Eauations validated bv other methods.

Body water can be measured by deuterium dilution and from that body fat may be calculated given that the fat-free mass of the body has a known and constant hydration. ~73% in adults

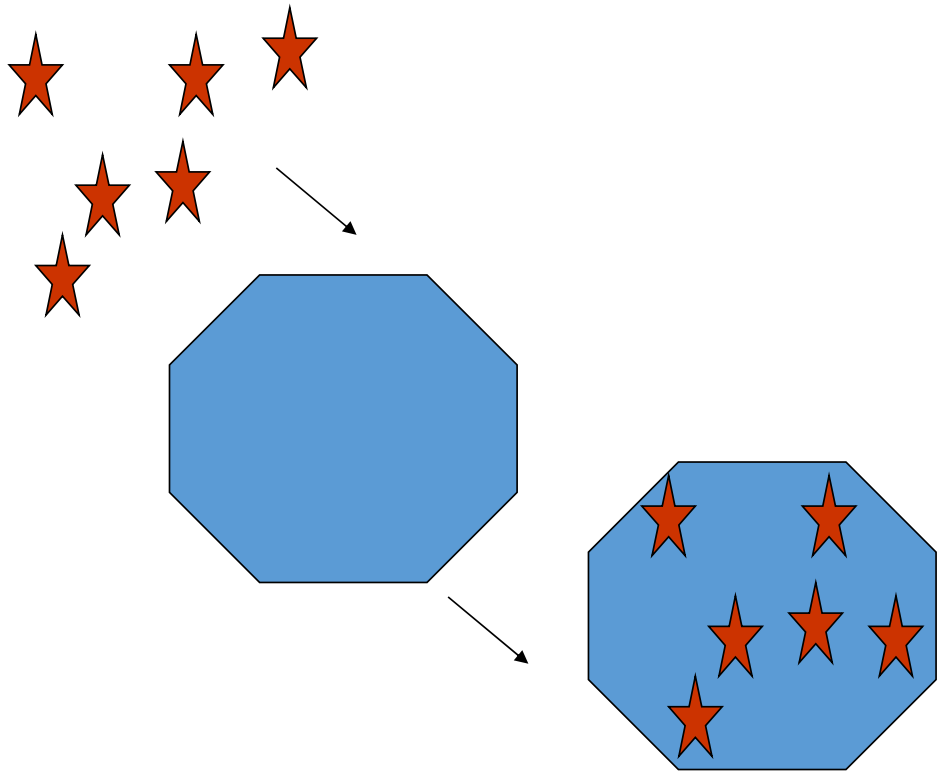
Measurement of unknown volume by dilution

- Add indicator such as isotopically labelled water
- Dose =6 stars

- Final concentration
- 6 stars /litre

- What is the volume?

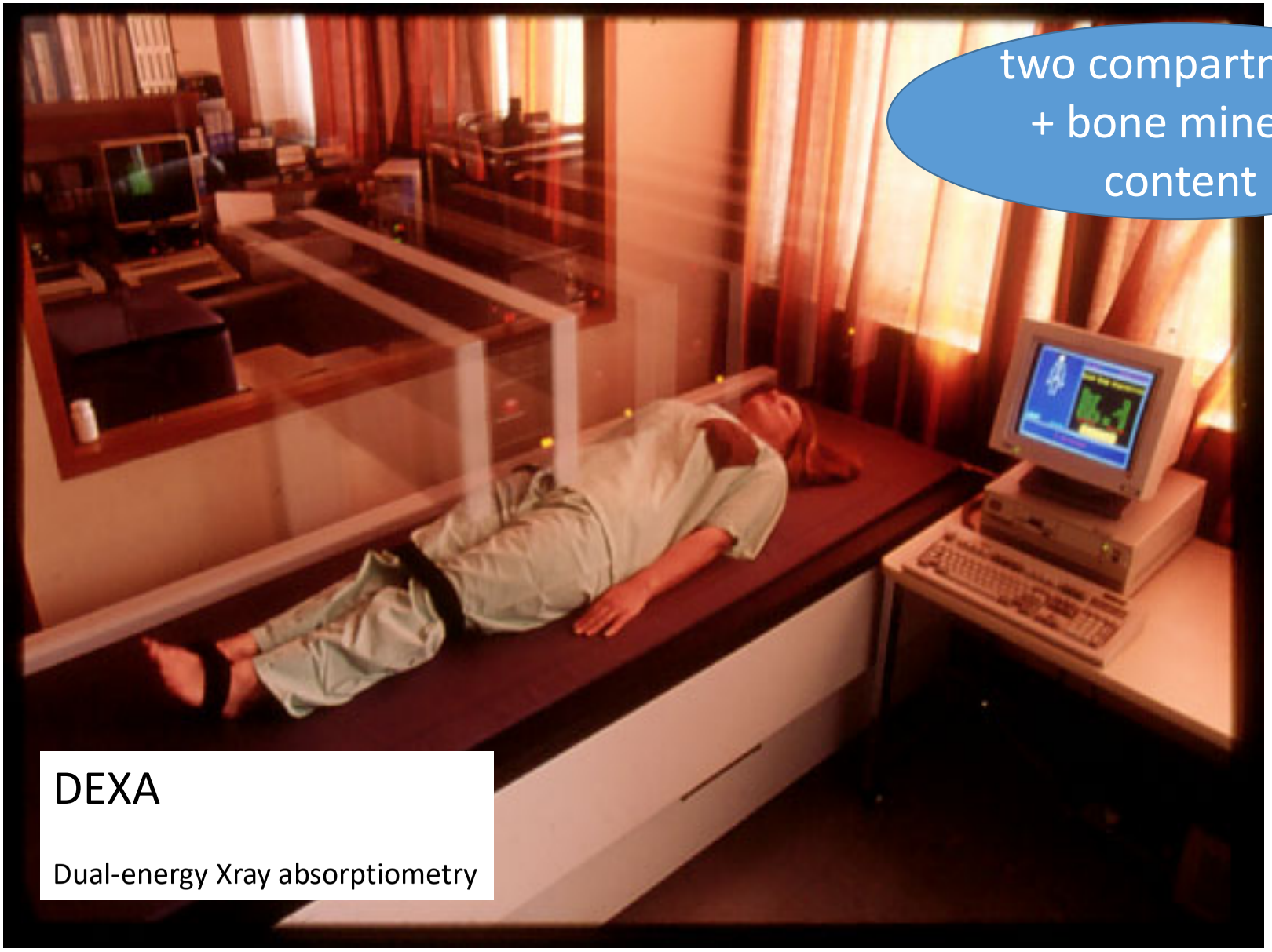
- Answer = 1 litre



Weight relative to volume – measure of body density related to body fat mass and fat free mass

Pea Pod, Bod Pod = air displacement plethysmography
underwater weighing

two compartment

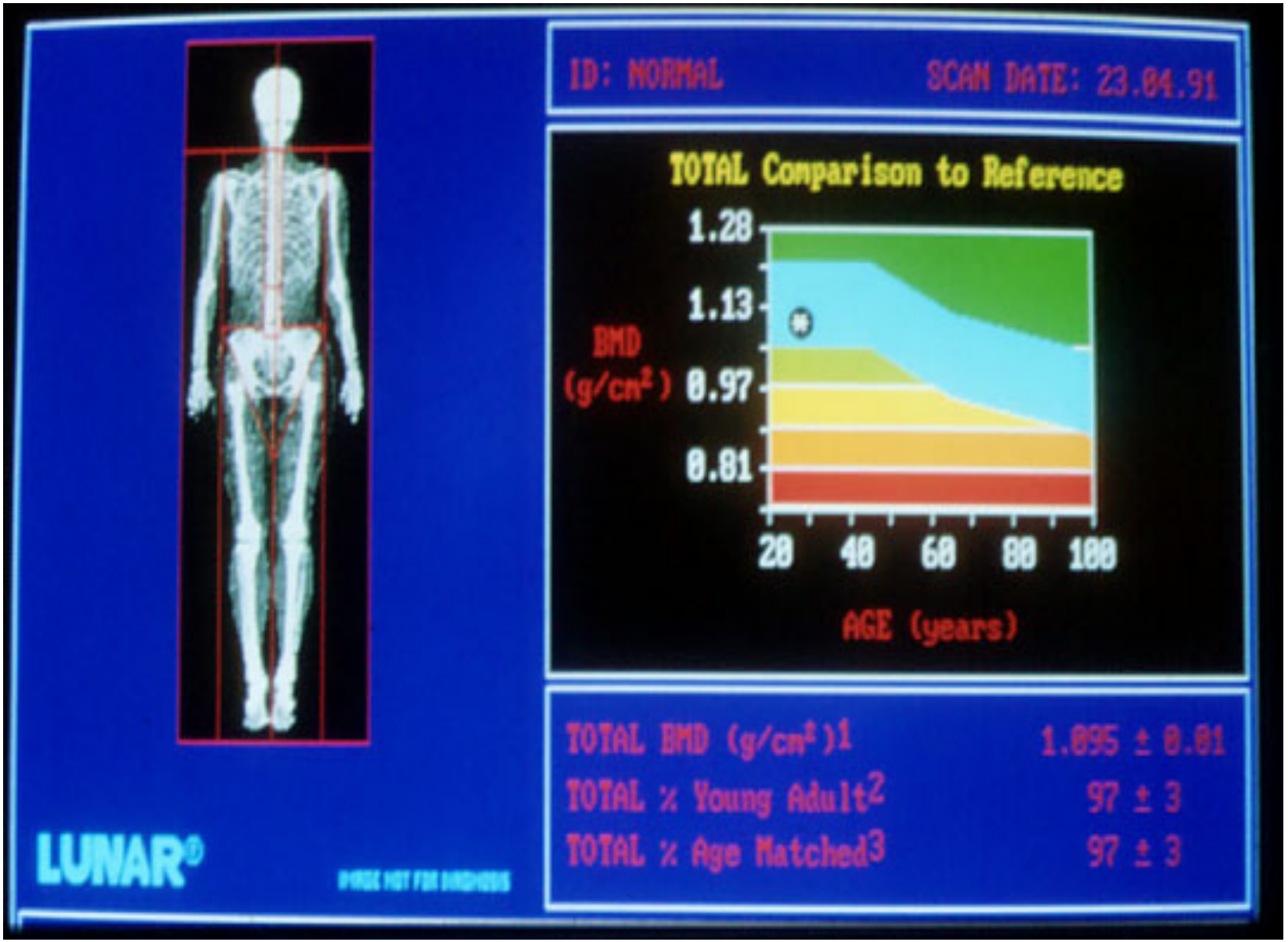

two compartment
+ bone mineral
content
DEXA
Dual-energy Xray absorptiometry

Dual energy Xray Absorptiometry

DEXA SCAN

fat, lean & bone mineral

two compartment + bone mineral content


ID: NORMAL
SCAN DATE: 23.04.91
TOTAL Comparison to Reference
1.28
1.13
0.97
0.81
BMD
(g/cm²)
20
40
60
80
100
AGE (years)
TOTAL BMD (g/cm²)1
1.095 ± 0.01
TOTAL % Young Adult2
97 ± 3
TOTAL % Age Matched3
97 ± 3
LUNAR®

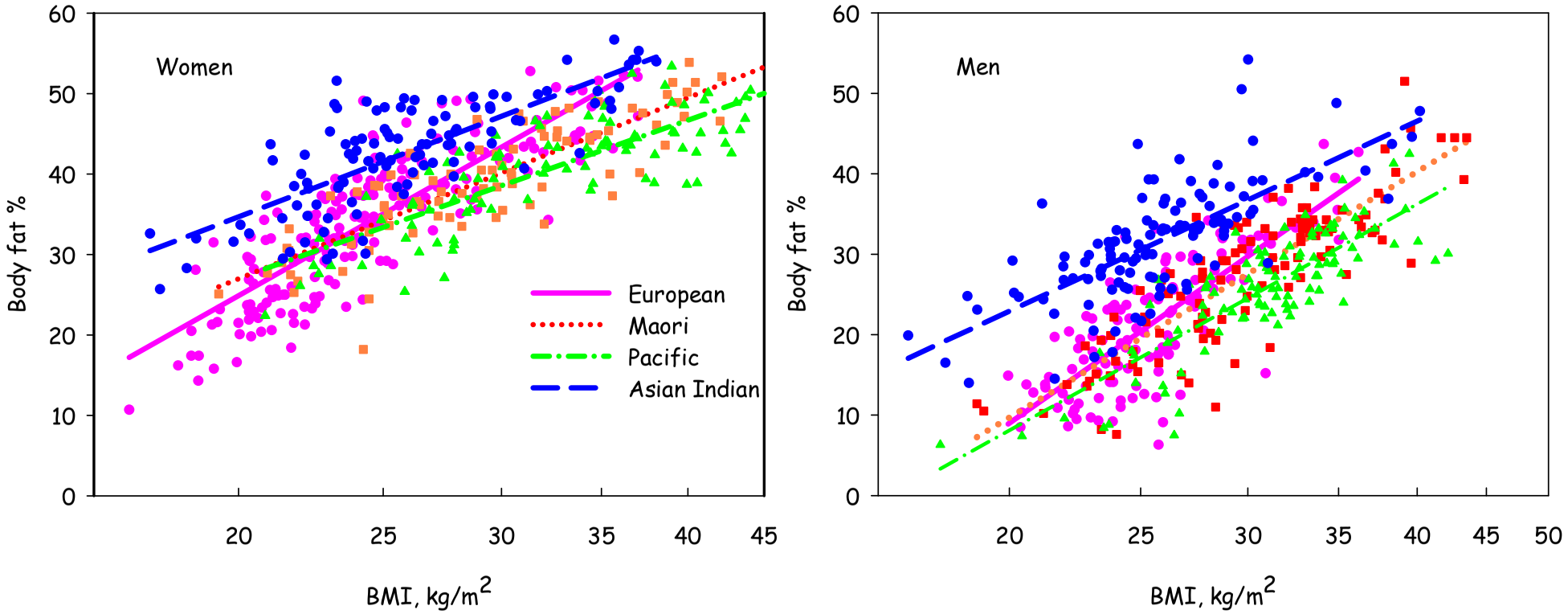
Central - head and torso

Peripheral - arms & legs

gender/sex

ethnicity

Adults of 4 ethnic groups

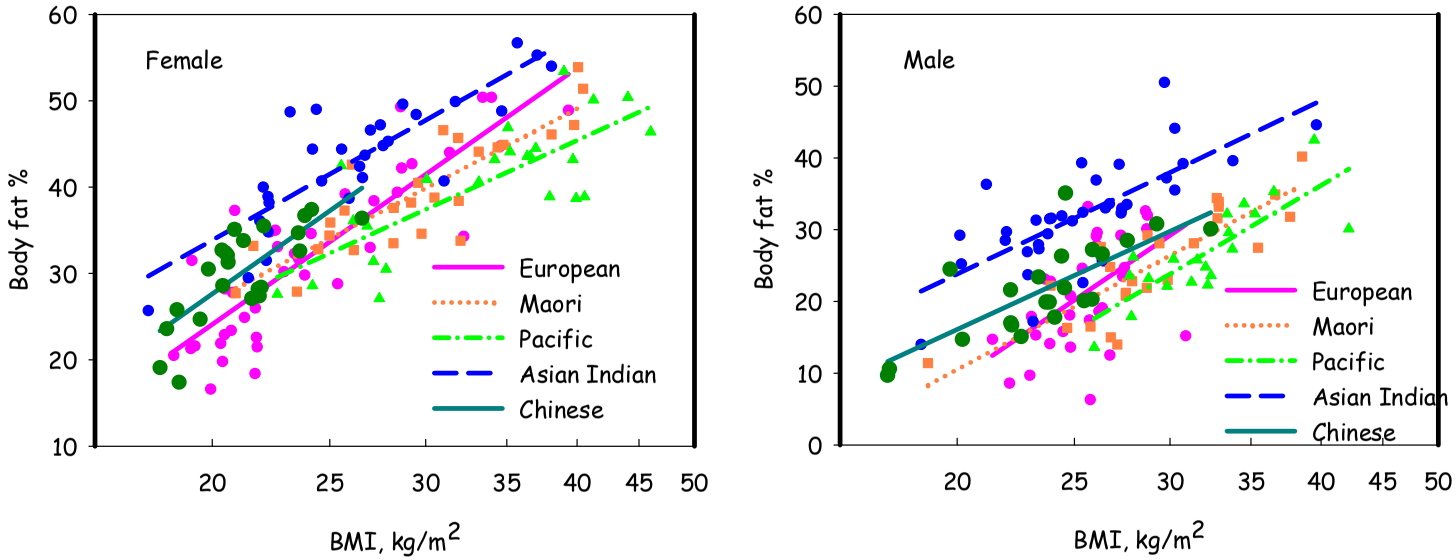


Rush et al Brit J Nutr 2009 *102*(4), 632-641.

30-39y Chinese adults added

gender/sex

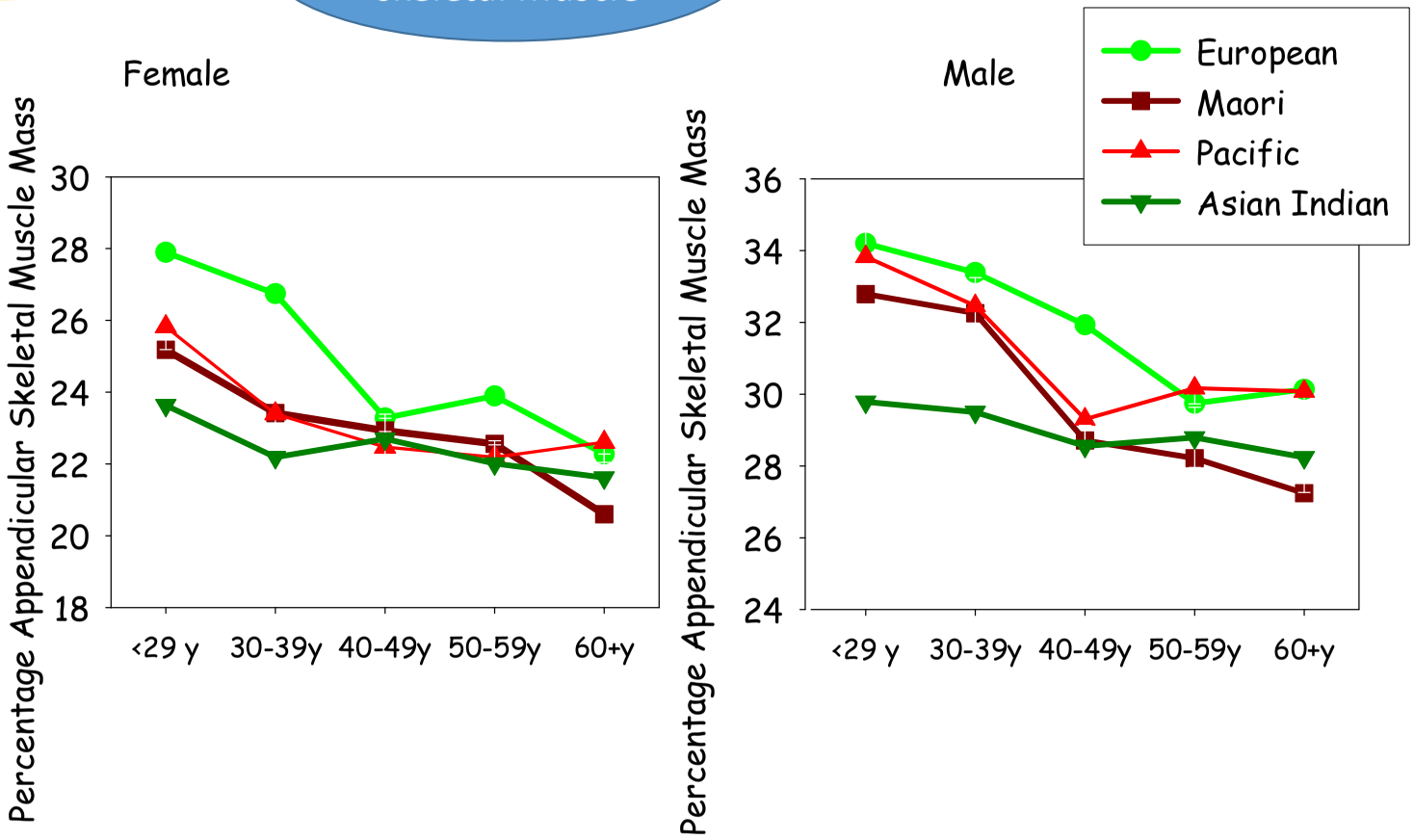
ethnicity



Wen et al NZMJ 2010 *123*(1327), 12.

age/growth

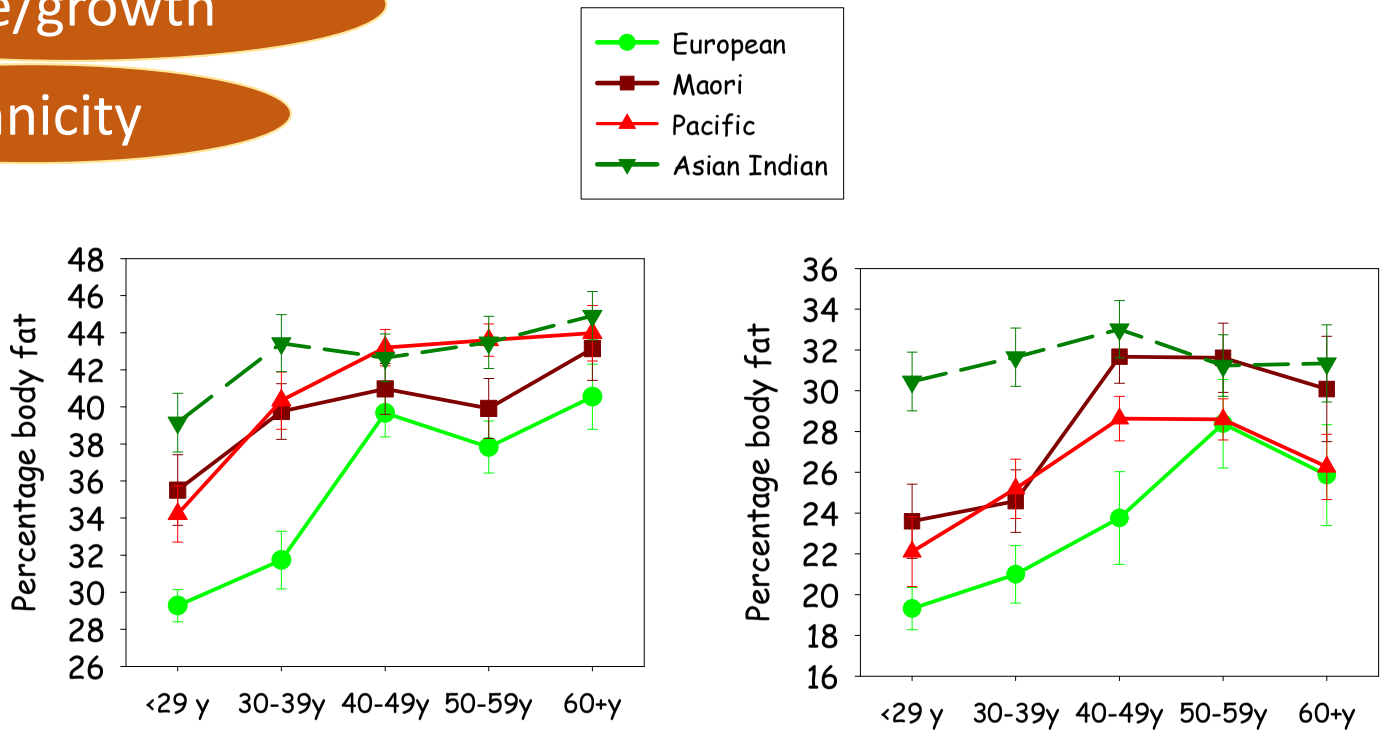
Regional, skeletal muscle



Rush et al Brit J Nutr 2009 *102*(4), 632-641.

age/growth

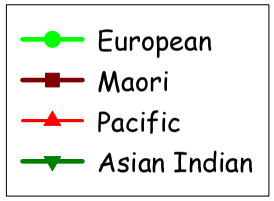
ethnicity

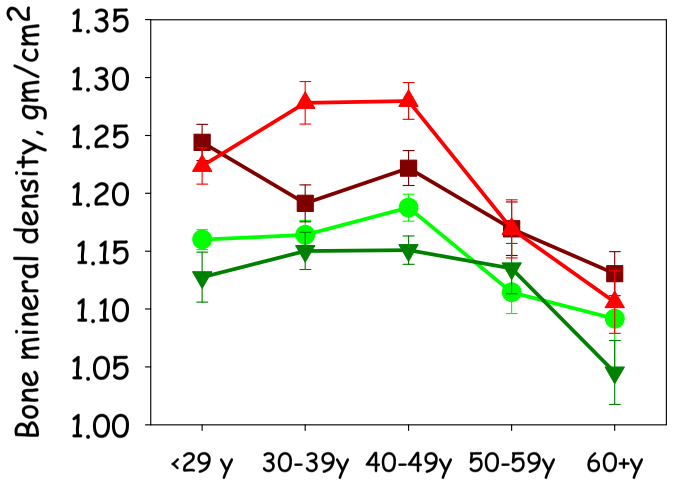


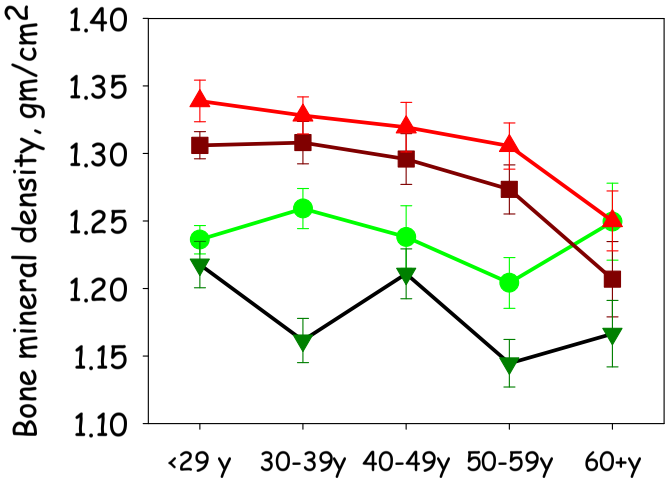
Rush et al Brit J Nutr 2009 *102*(4), 632-641.

age/growth

ethnicity

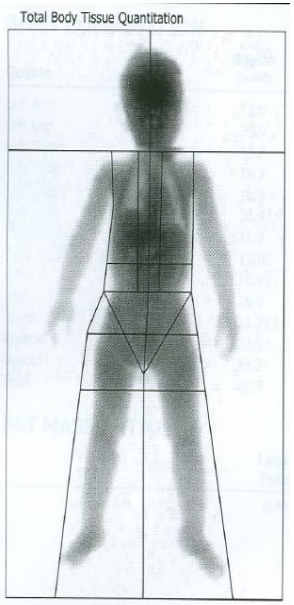


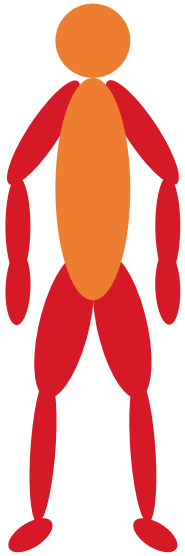


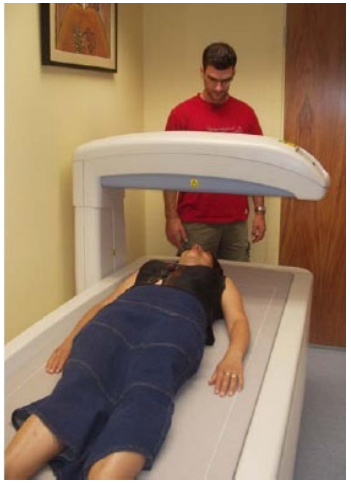


Rush et al Brit J Nutr 2009 *102*(4), 632-641.

MIGTOFU Study
aged 2.2y







Central

Appendicular

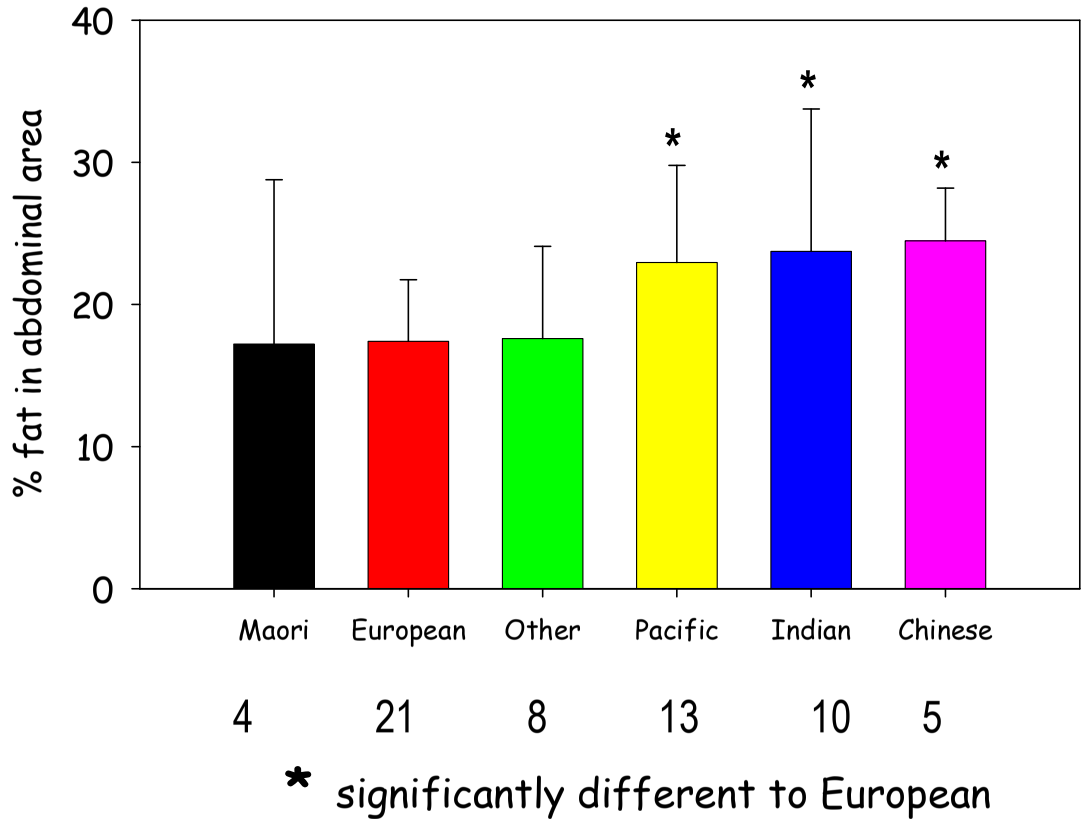
Region of interest analysis

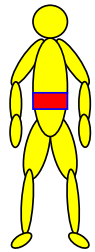
Abdominal area

Thigh area

Regional

MIGTOFU Ethnic differences at age two years
– abdominal fat percentage by DXA
(treatment, age and sex not significant)

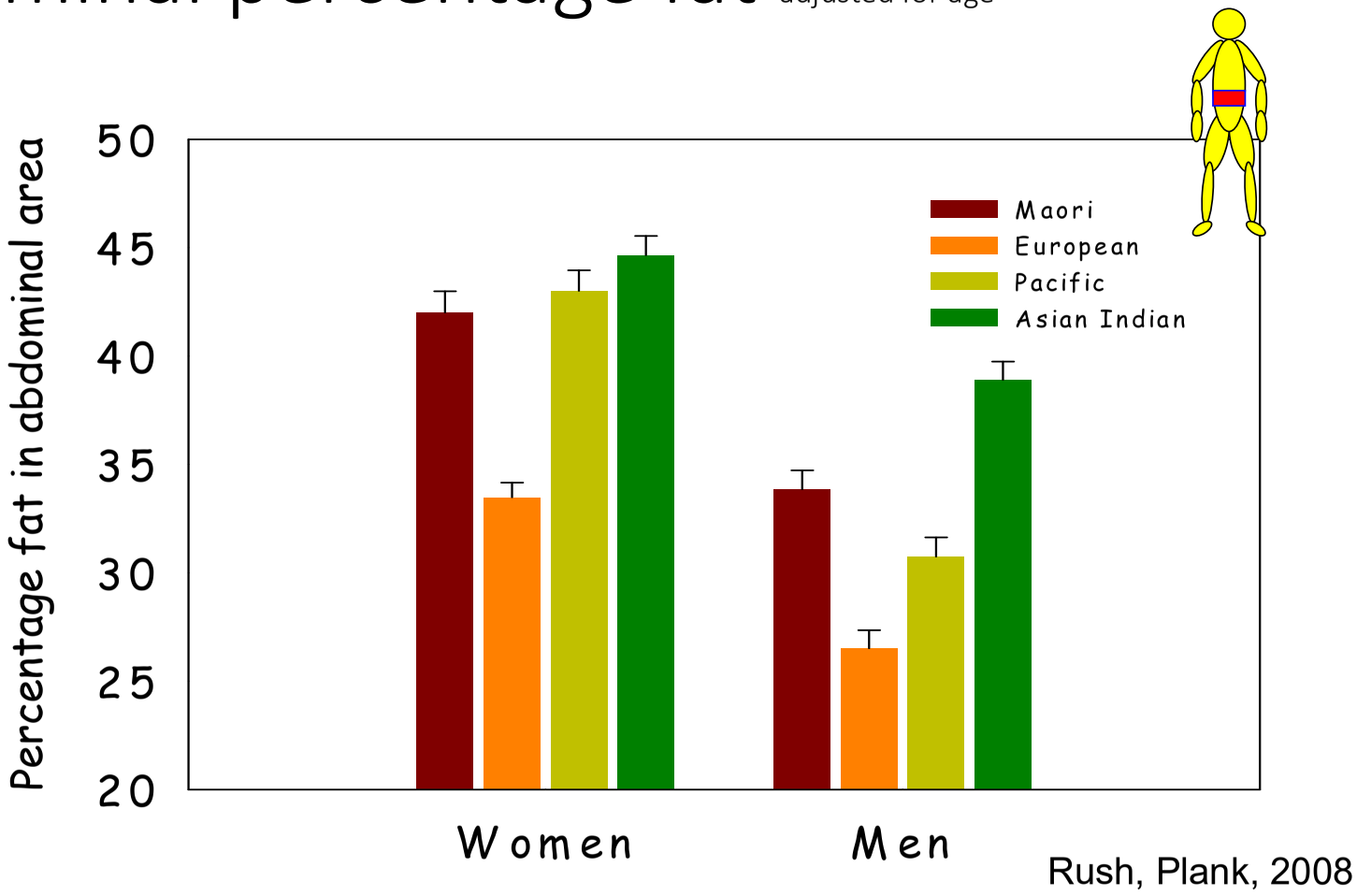




Regional

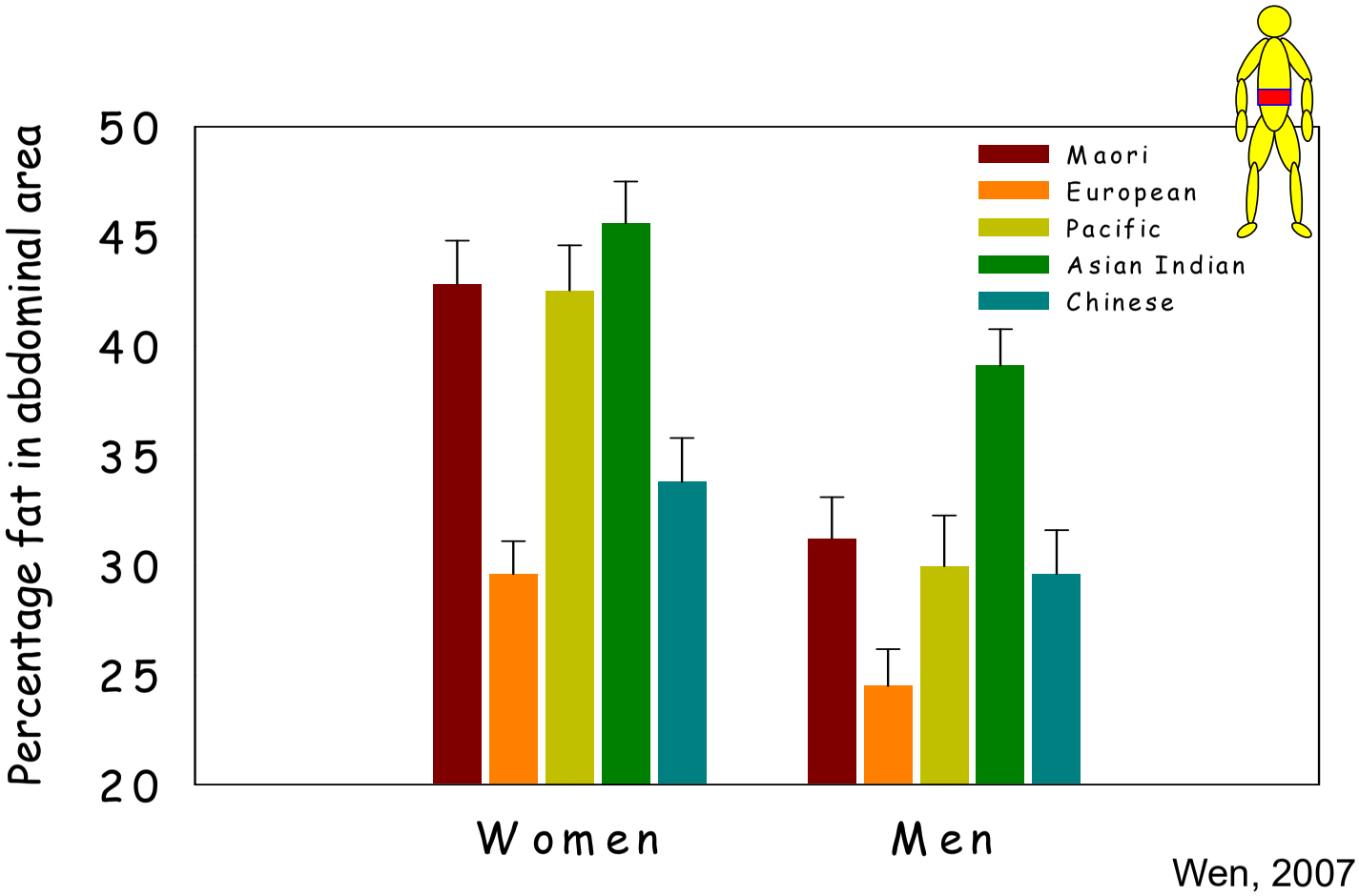
Rush, Rowan

Abdominal percentage fat adjusted for age



Rush, Plank, 2008

Abdominal percentage fat 30-39y



Wen, 2007

Hattori Chart

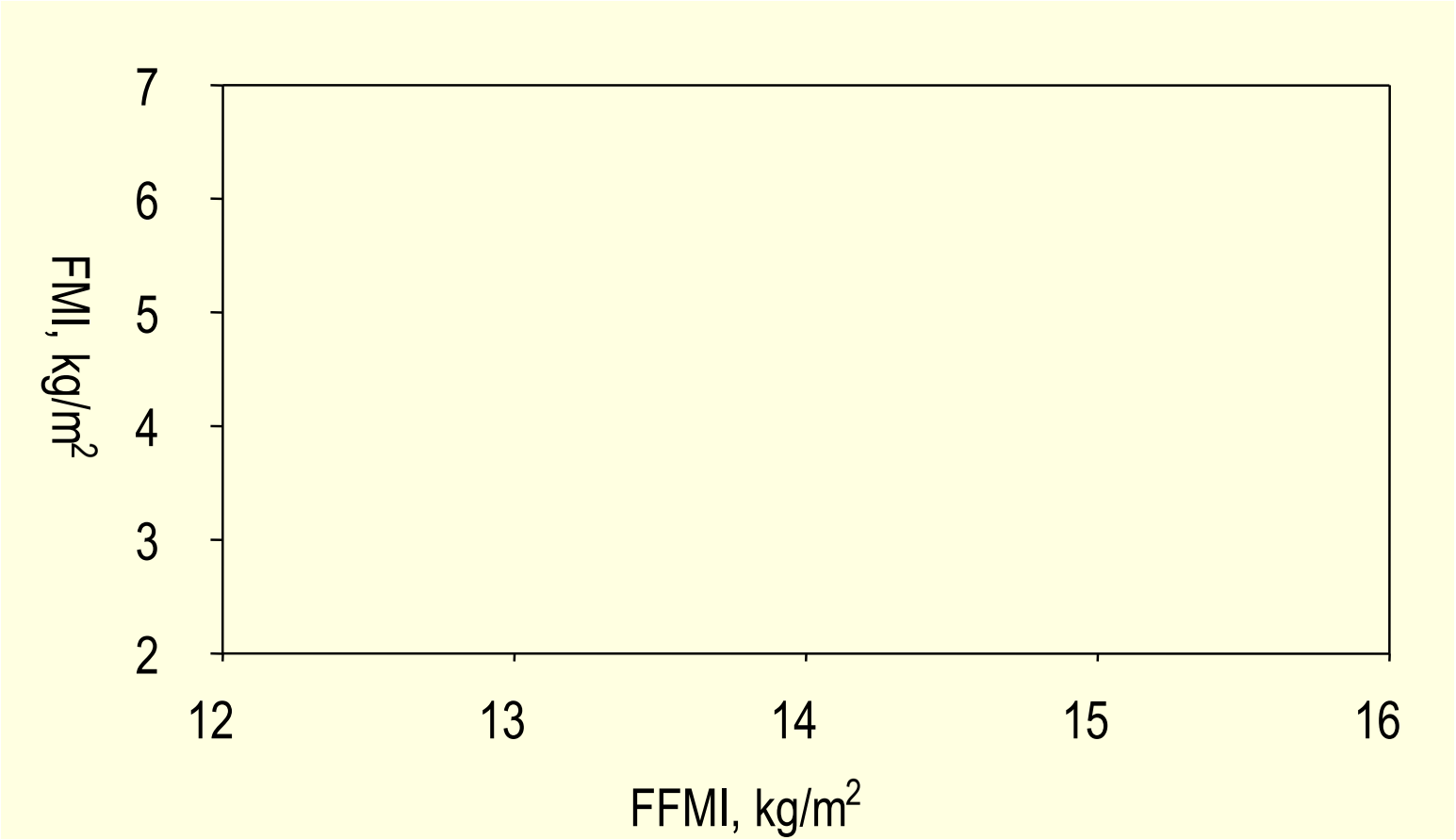
two compartment

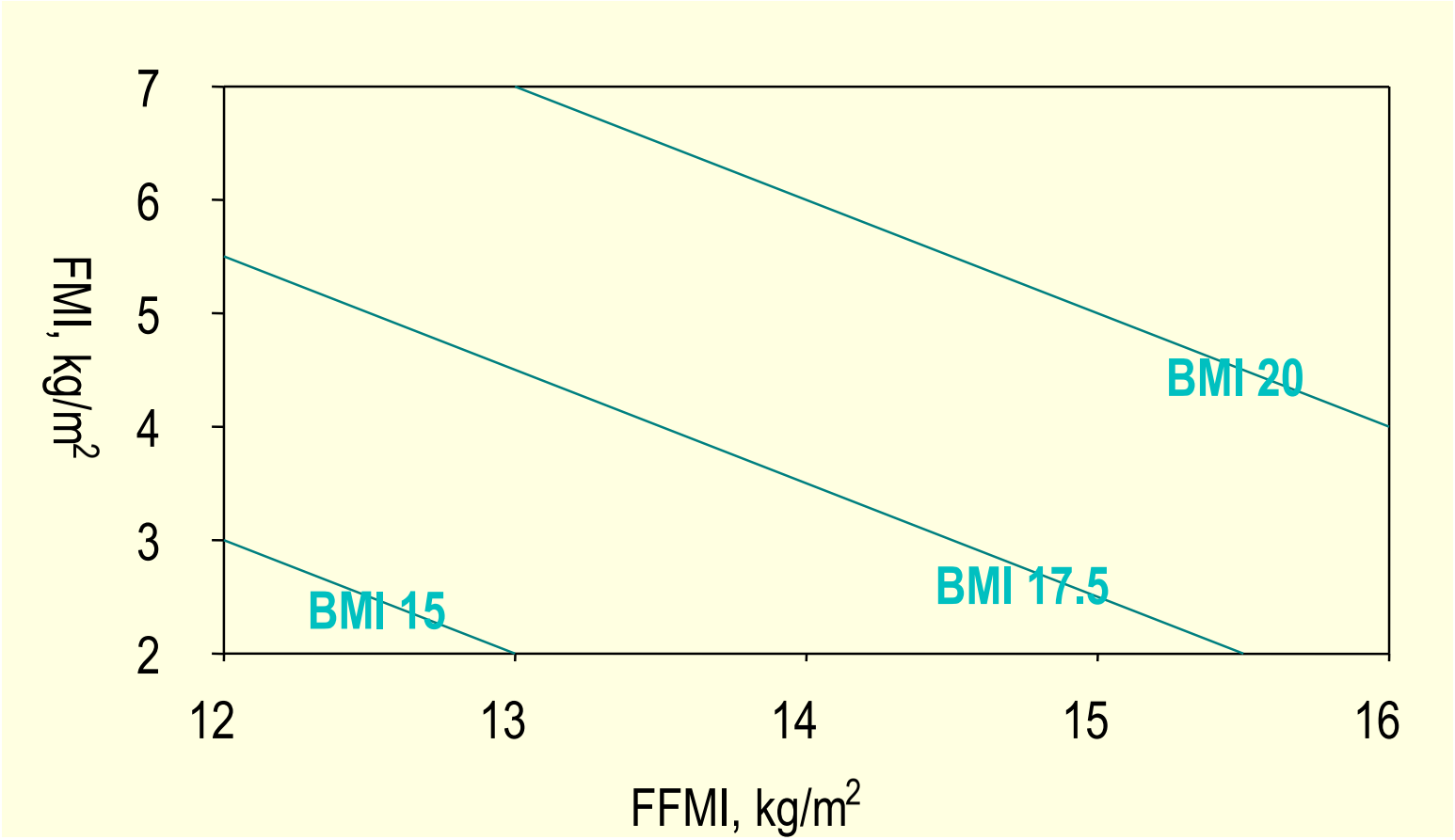
- Illustrates relationship between
  - Fat Mass Index
  - Fat Free Mass Index
  - BMI
  - % Body fat fat mass/body mass * 100

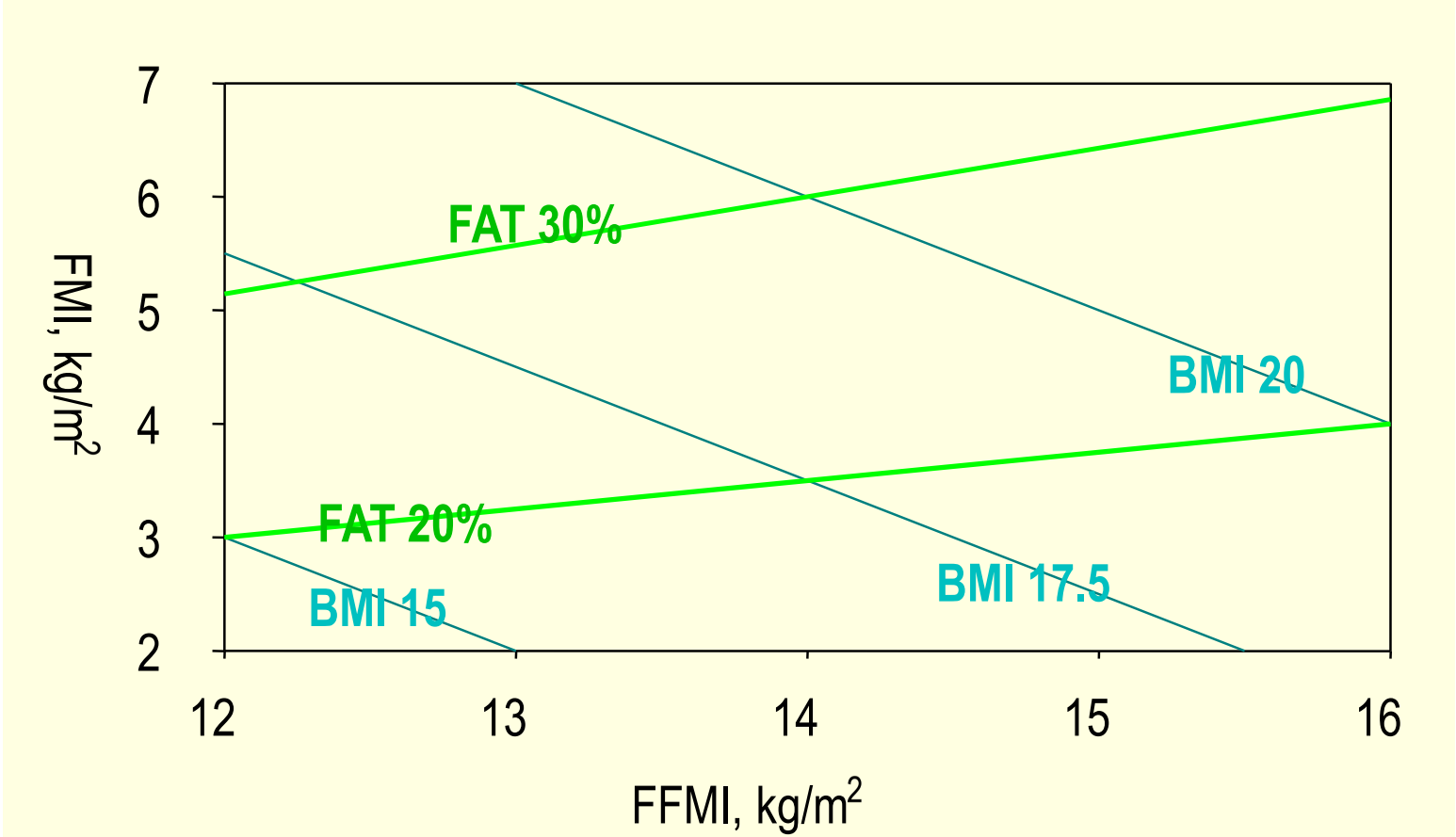
  - Fat mass plus fat free mass = Body mass(weight)

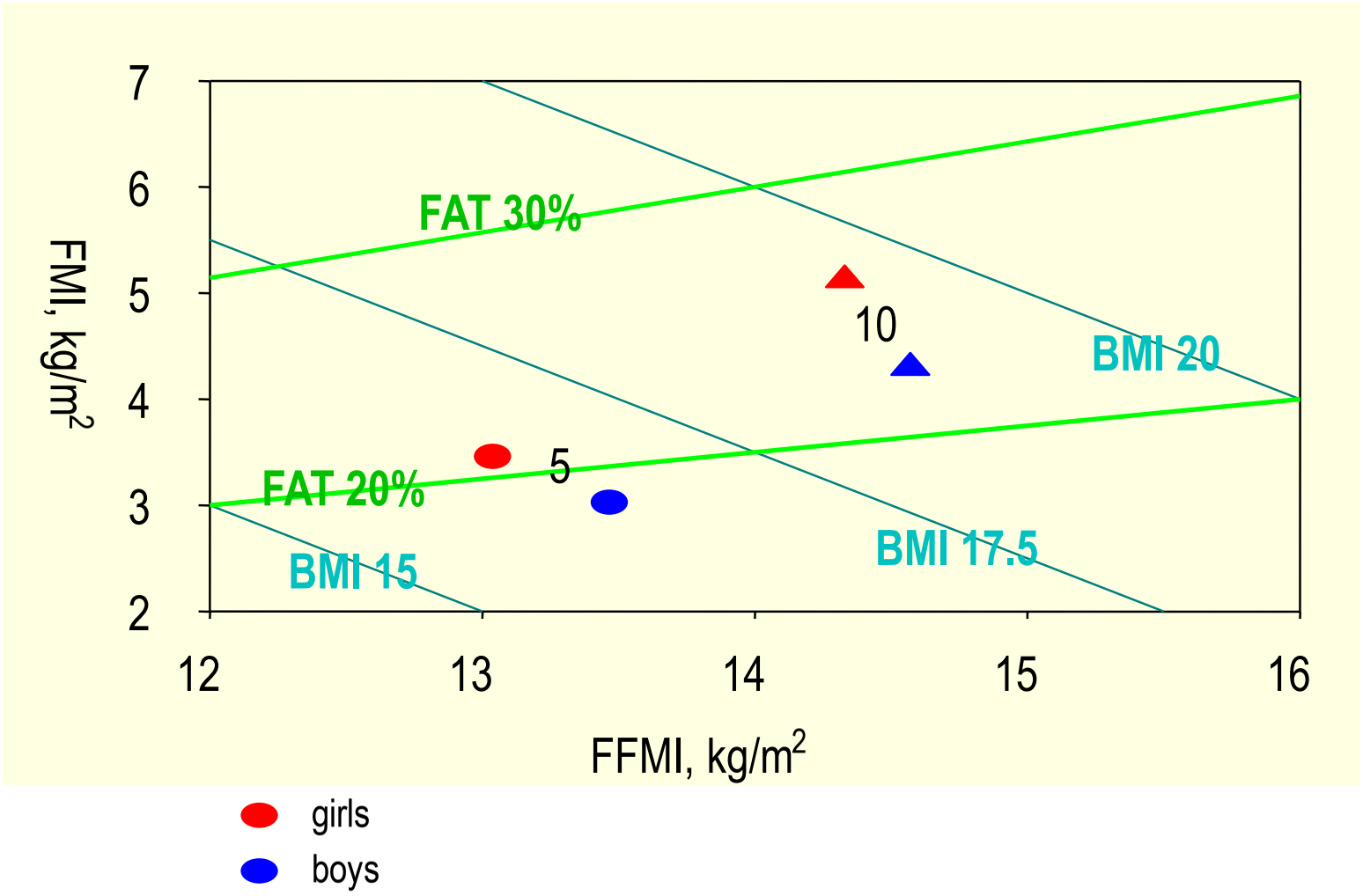
  - Fat mass/height m^2 plus fat free mass /height m^2 = body mass/height m^2 index
  - FMI + FFMI =BMI

Hattori et al, Am J Hum Biol *9*(5), 573-578

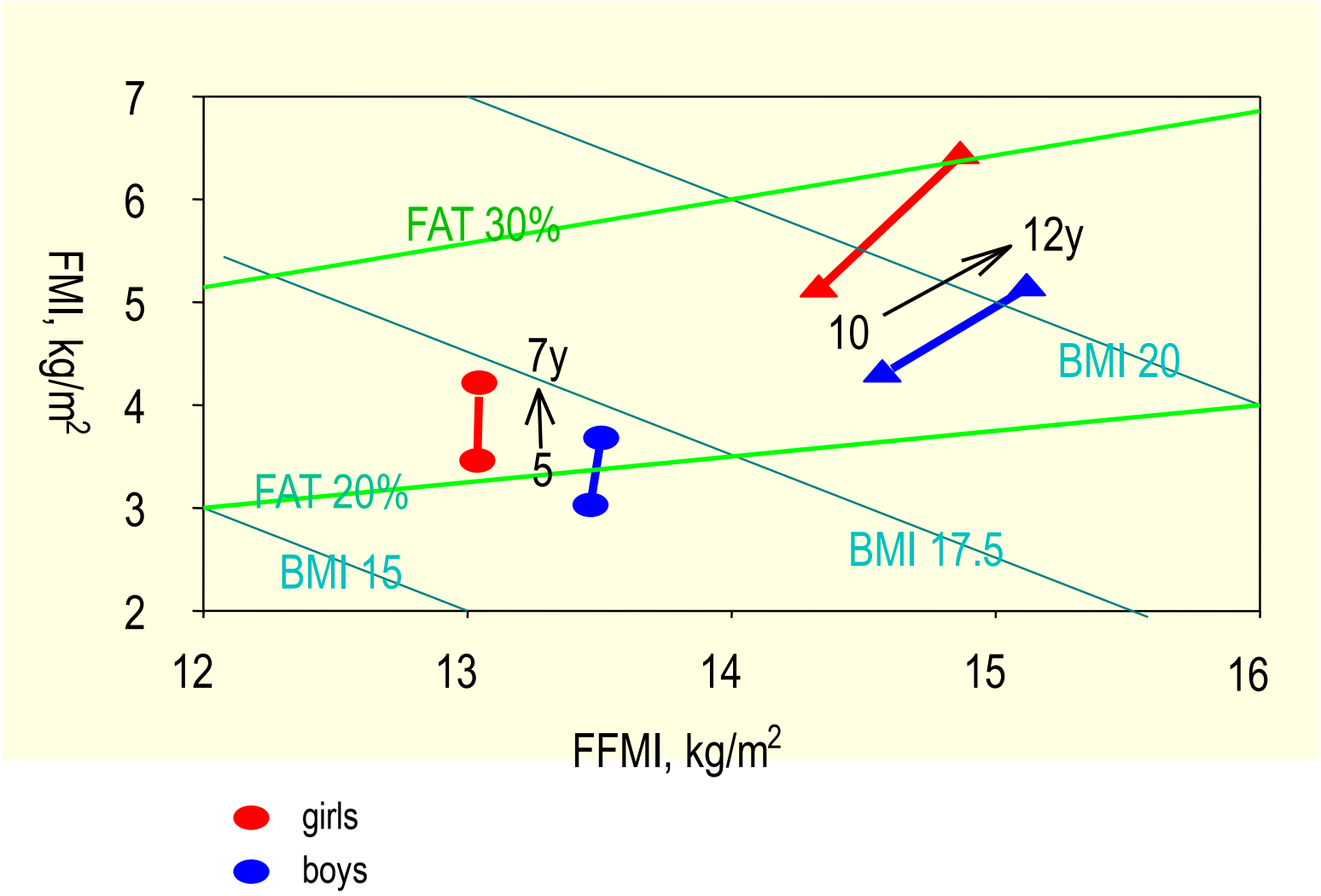

7
6
5
4
3
2
FMI, kg/m2
12
13
14
15
16
FFMI, kg/m2


7
6
5
4
3
2
FMI, kg/m2
BMI 20
BMI 17.5
BMI 15
12
13
14
15
16
FFMI, kg/m2

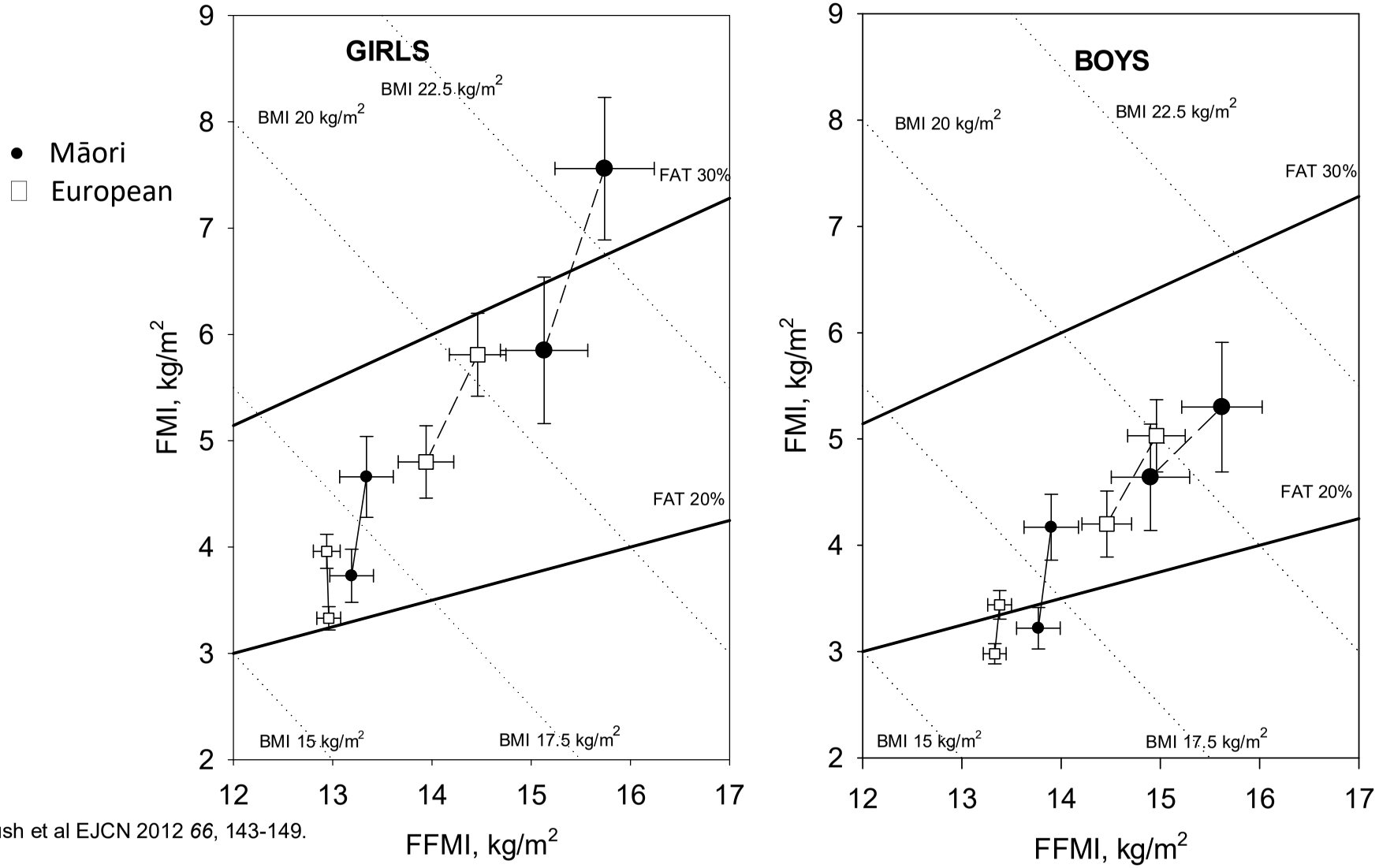

7
6
5
4
3
2
FMI, kg/m2
FAT 30%
FAT 20%
BMI 20
BMI 17.5
BMI 15
12
13
14
15
16
FFMI, kg/m2



Rush et al EJCN 2012 *66*, 143-149.

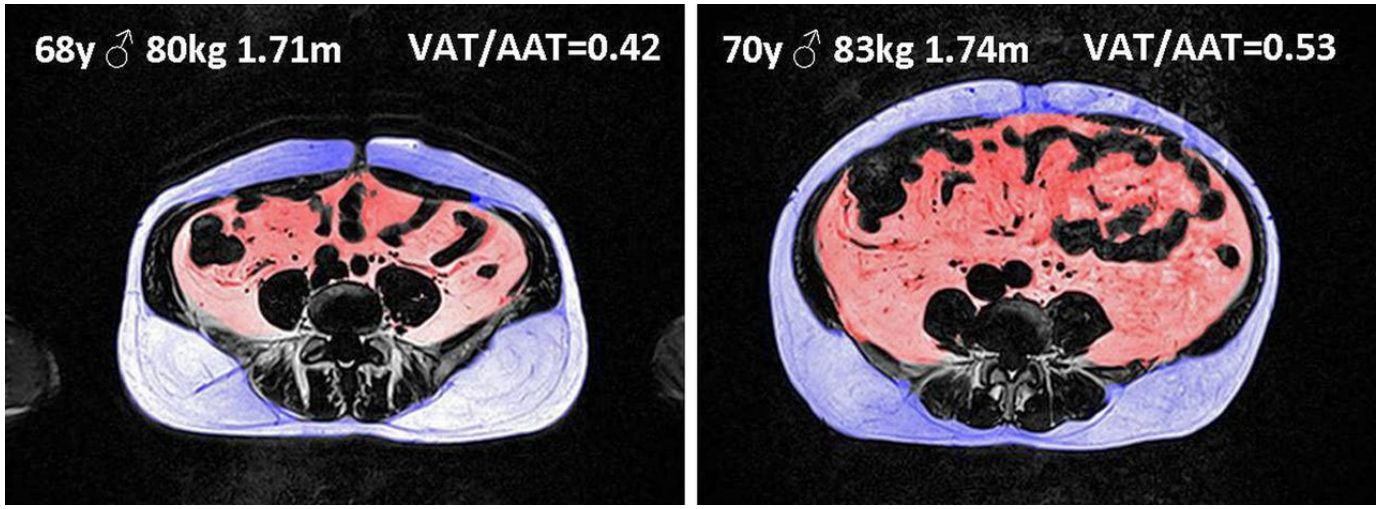


Rush et al EJCN 2012 *66*, 143-149.



Rush et al EJCN 2012 *66*, 143-149.

Example of abdominal fat segmentation. Magnetic Resonance Imaging

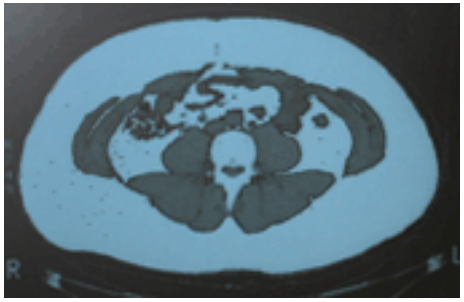


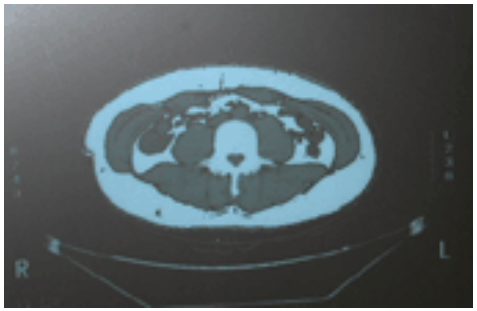
fat compartments

Matthias Raschpichler et al. BMJ Open 2013;3:e001915

BMJ Open

CT scan (computerised chromatography)





loss of 54 kg

fat compartments

Anatomical

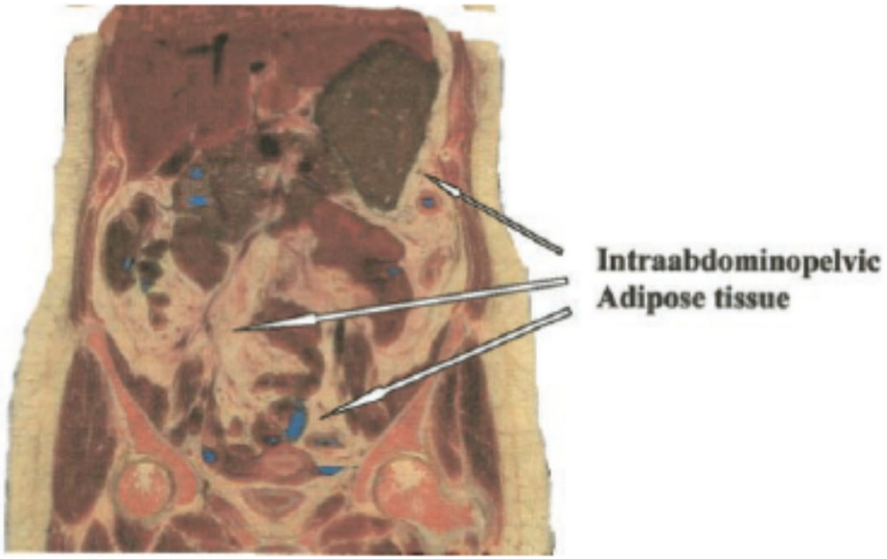


Figure 2.1 VAT compartment

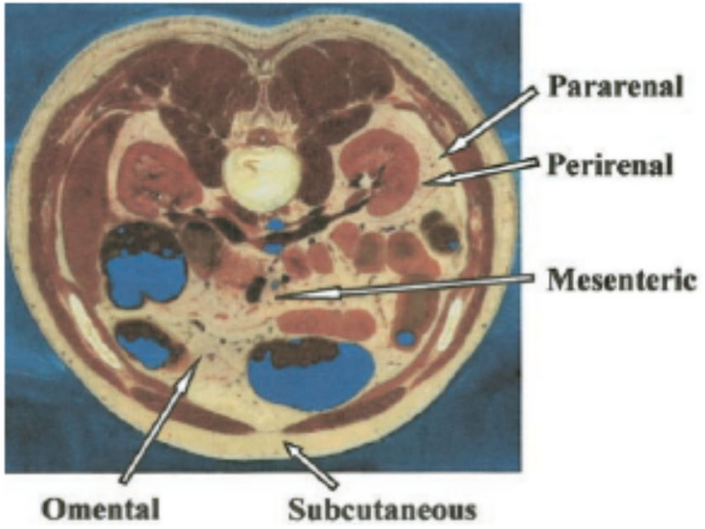
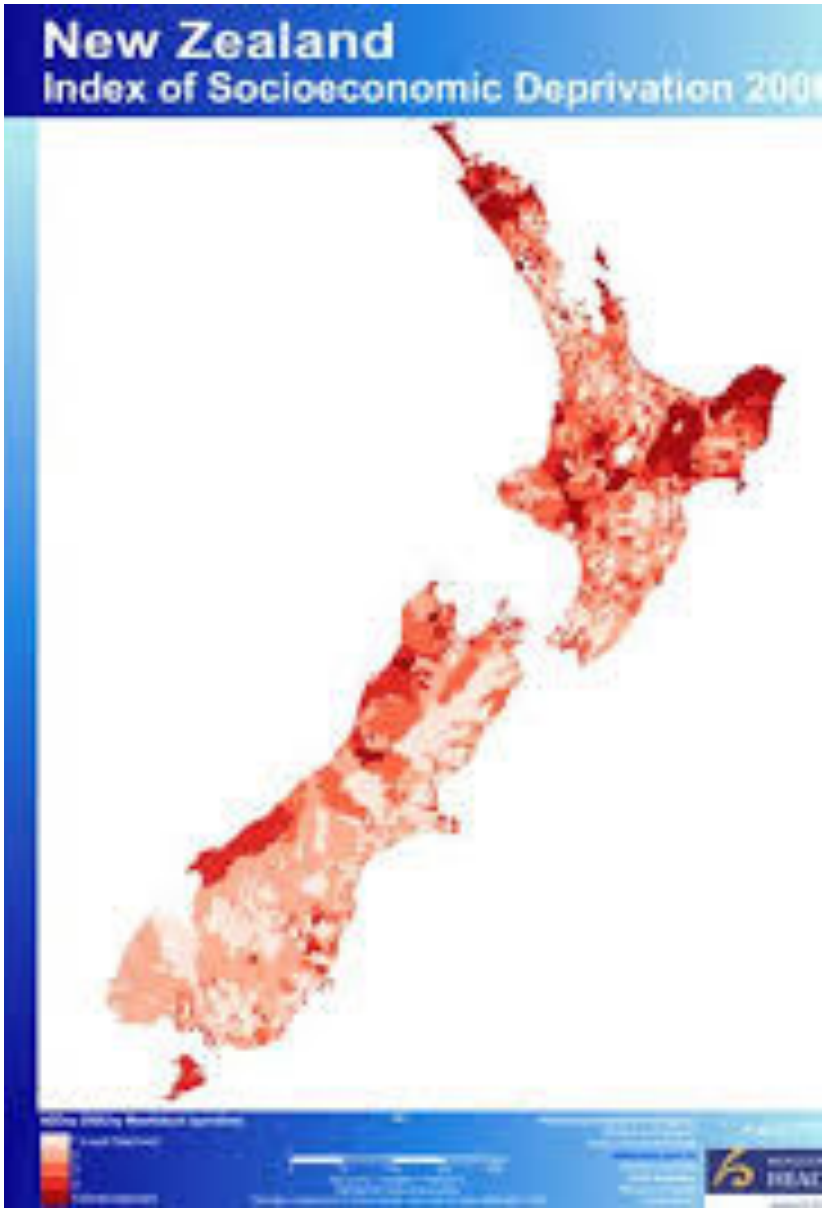


Figure 2.2 Main adipose tissue compartments

fat compartments



Population: 5M
Ethnically diverse
66% adults, 32% children overweight or obese
70% waist/height >0.5

Food security

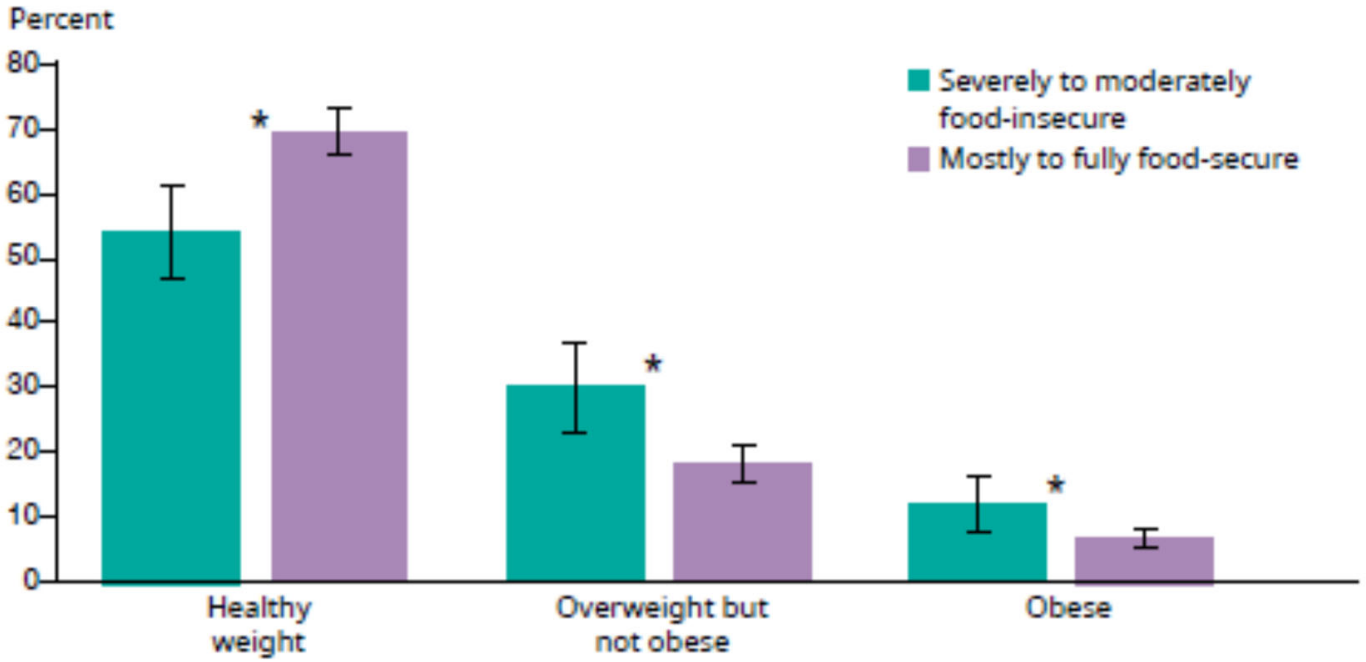
Households with food insecurity

	% children in households with food insecurity	95% CI
ALL	19	17.5–20.4
Least deprived 40%	9.5	7.0–12.1
Quintile 3	17.8	14.0–21.6
Quintile 4	19.5	16.2–22.9
Most deprived 20%	34.8	31.6–37.9

Based on questions such as – we eat less because of lack of money, variety of food limited
Household food Insecurity among children, New Zealand Health Survey 2014-2016

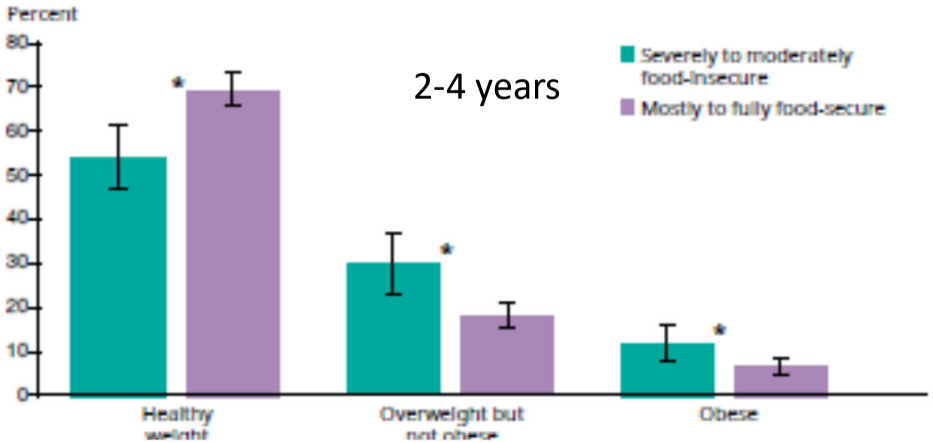
Food security

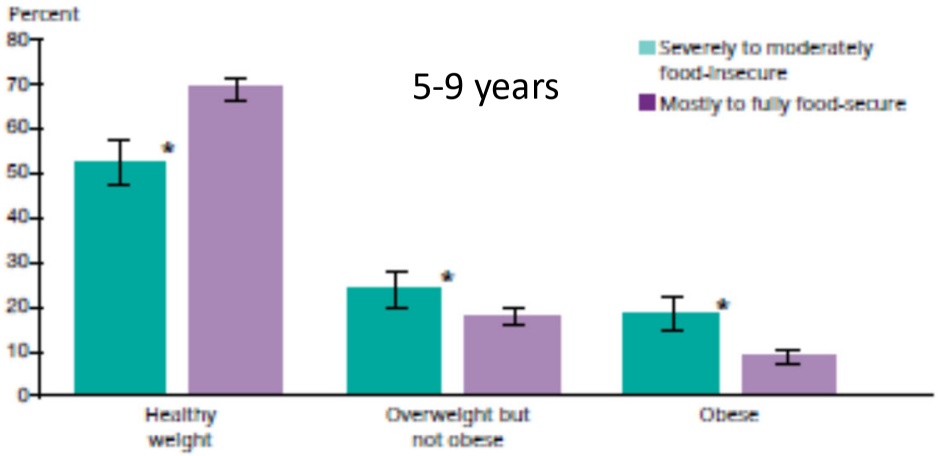
Figure 15A: Body size indicators by food security status for children aged 2–4 years, 2014/15 and 2015/16

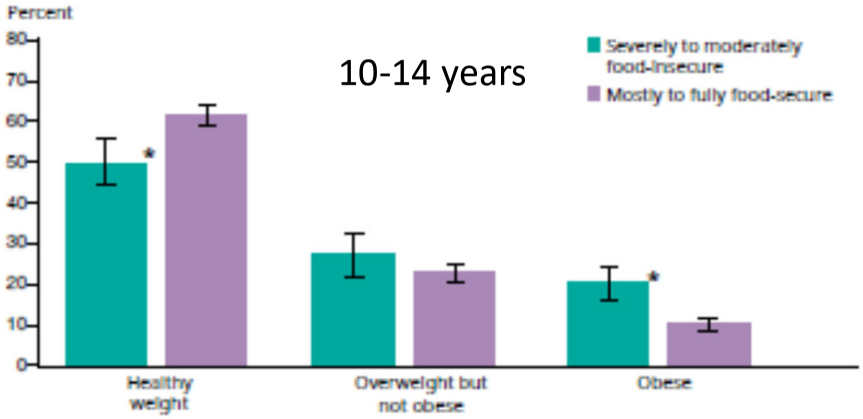


Based on questions such as – we eat less because of lack of money, variety of food limited
Household food Insecurity among children, New Zealand Health Survey 2014-2016

Food insecurity and body size



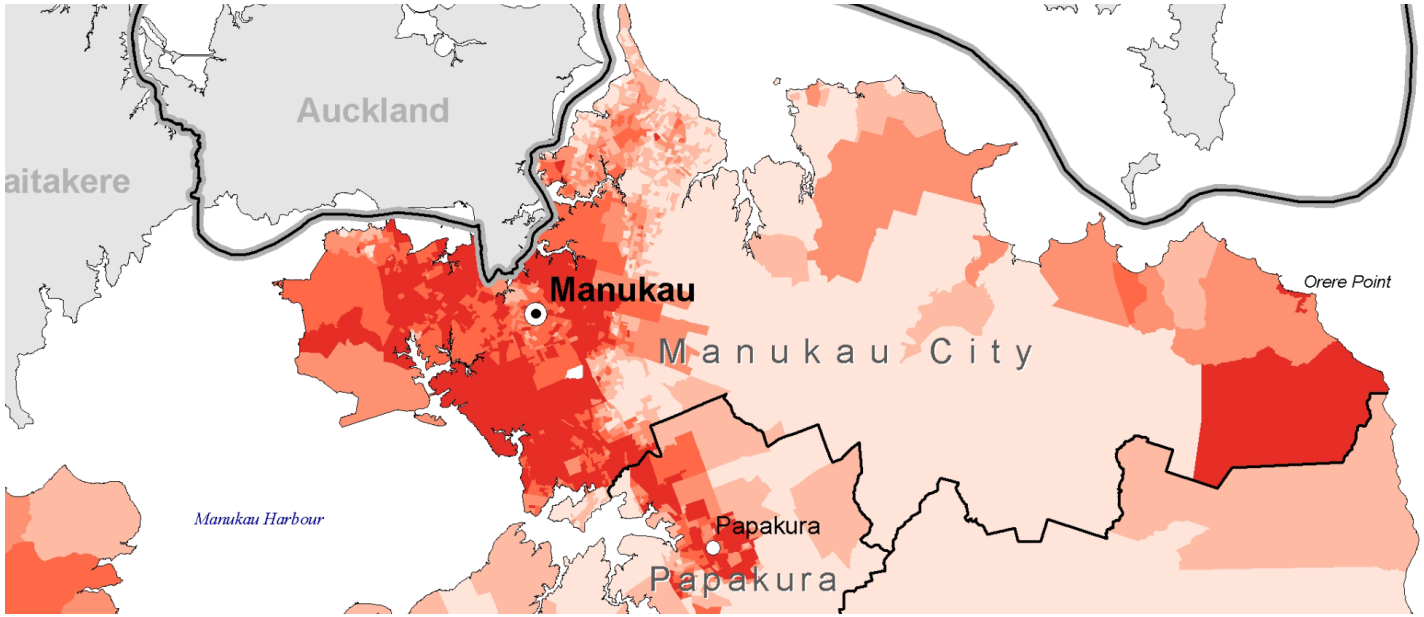




Food security


Pacific Islands
Families Study
Acknowledgement

PIF area of residence at birth
Counties Manukau District Health Board



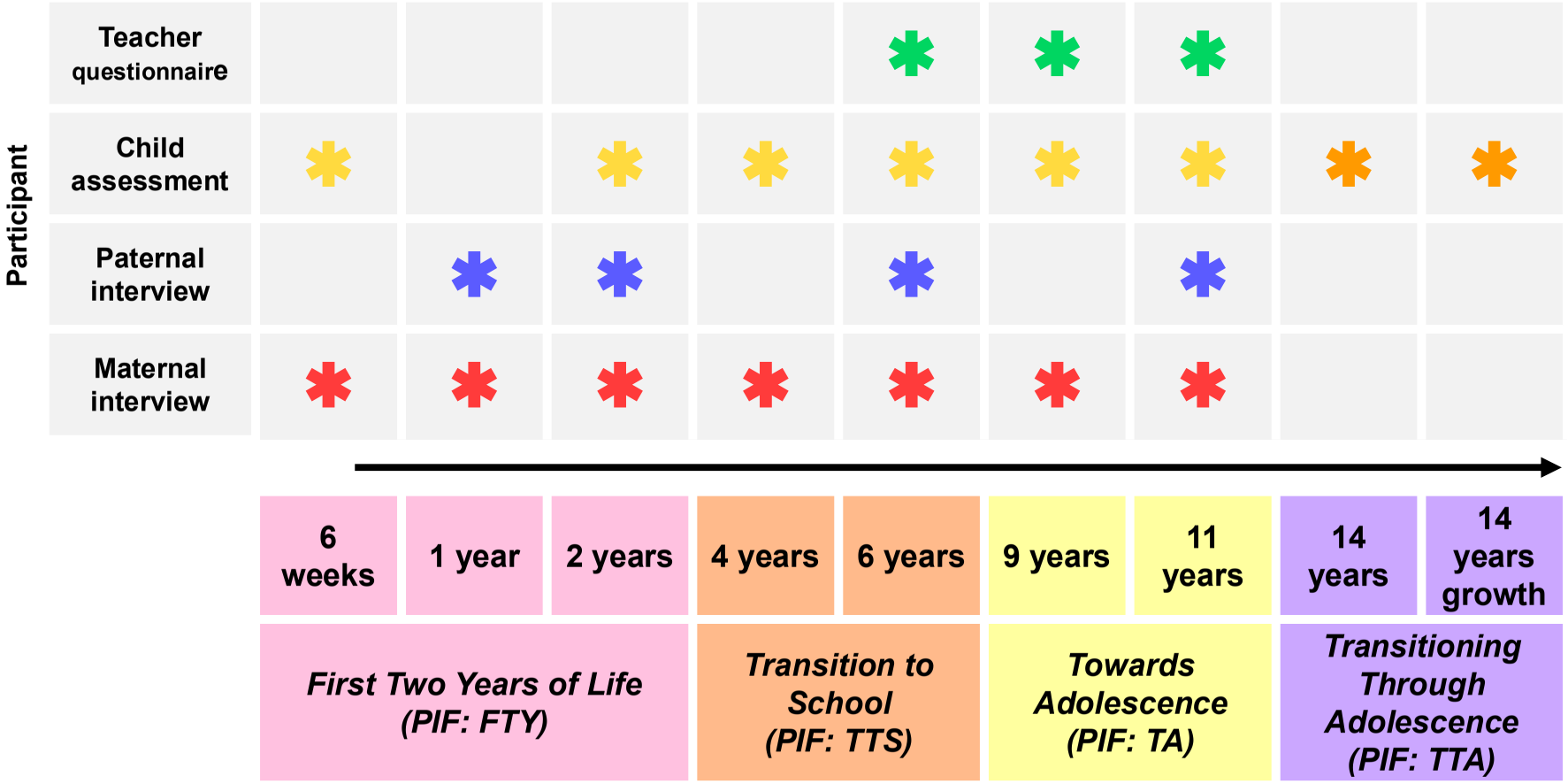
NZDep 2006
Quintiles of meshblocks

1 Least Deprived
2
3
4
5 Most Deprived

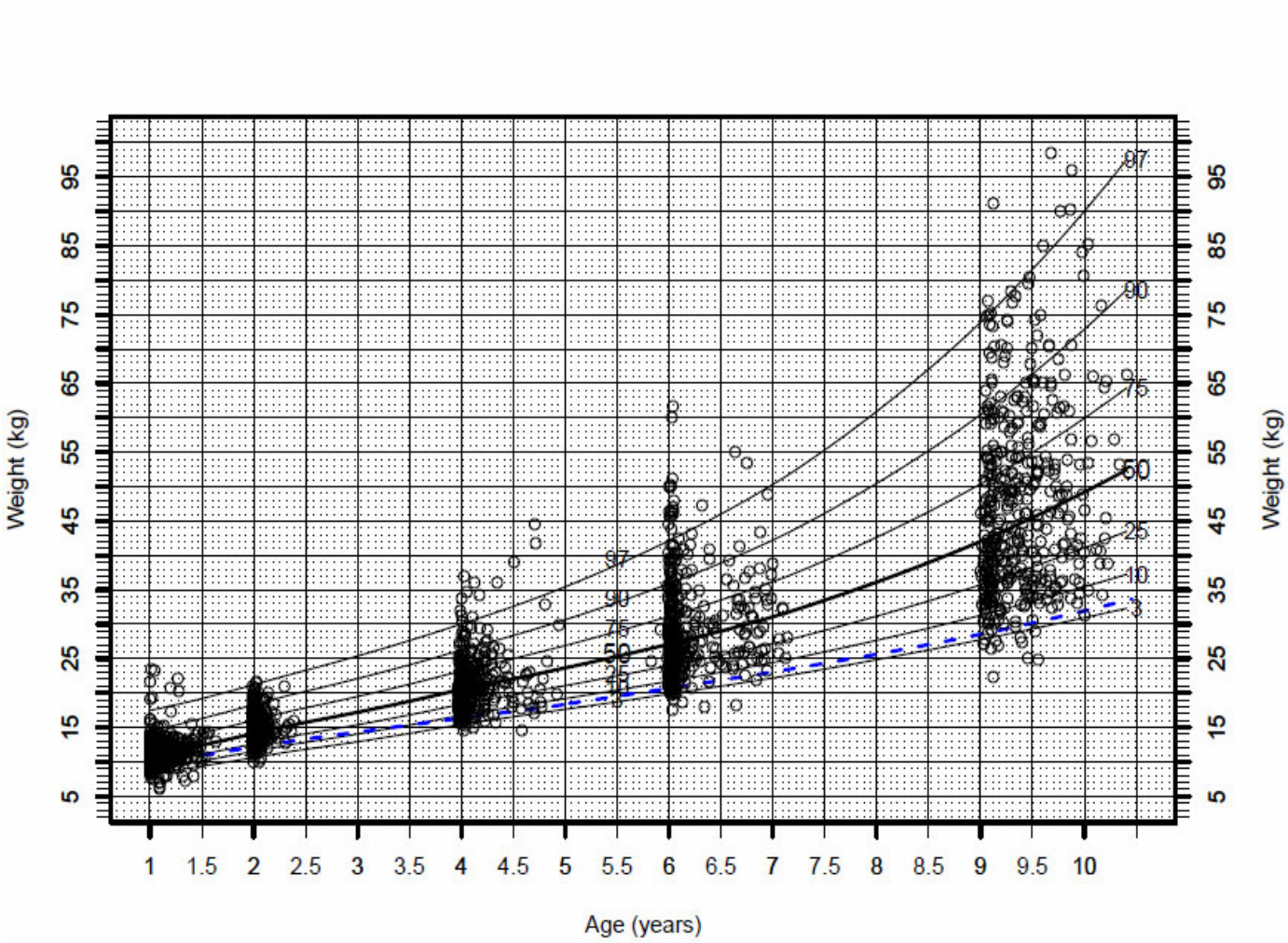

m&m's
STRETCH
TEXT
500
Skinny


MANGERE
OPEN 7 DAYS
FOODMARKET
SERVING ALL CULTURES
Fresh TARO
SPECIALS

Foundations of PIF Study
Original n=1394

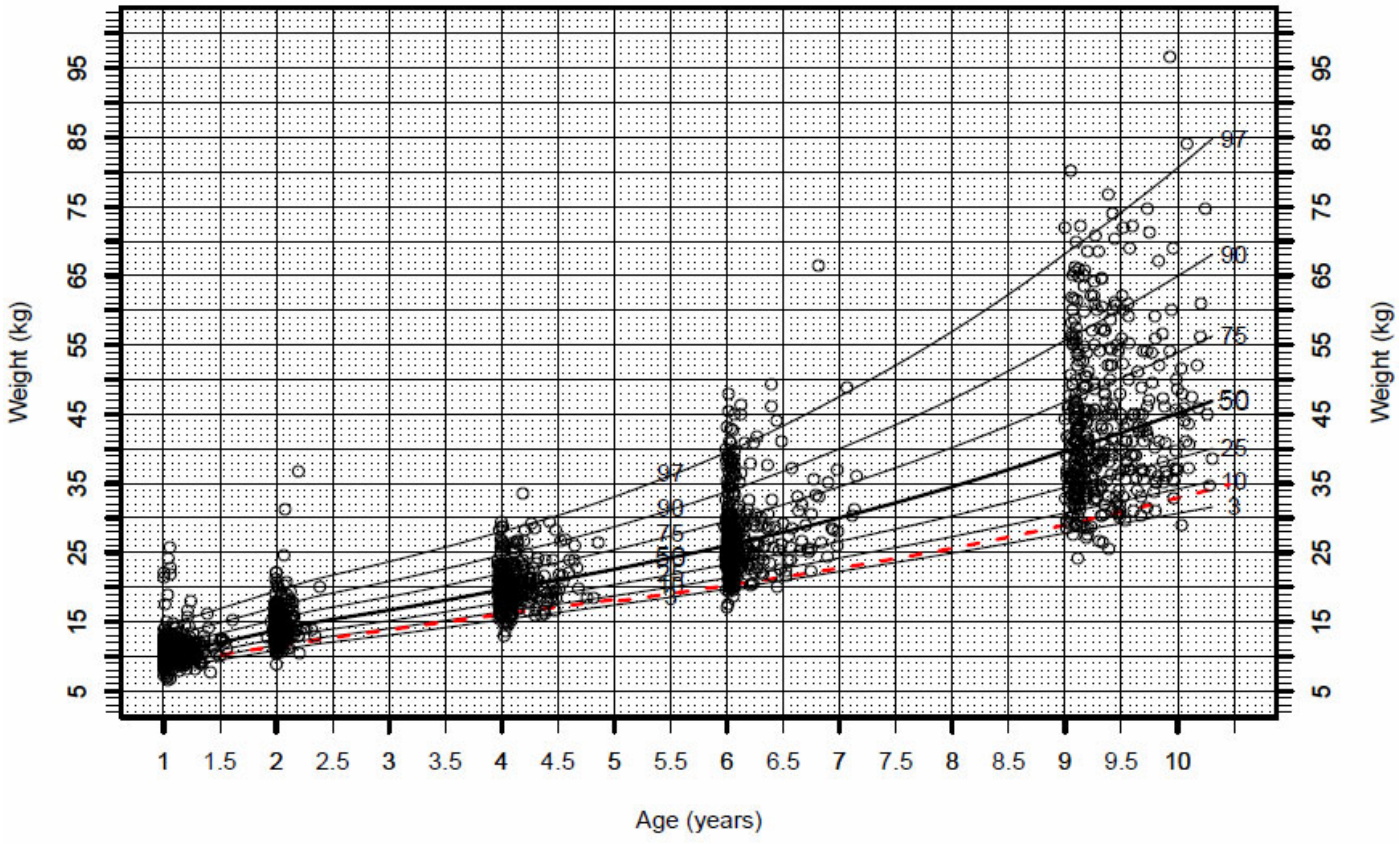


Boys, weight



PACIFIC ISLANDS FAMILIES STUDY

Girls, weight



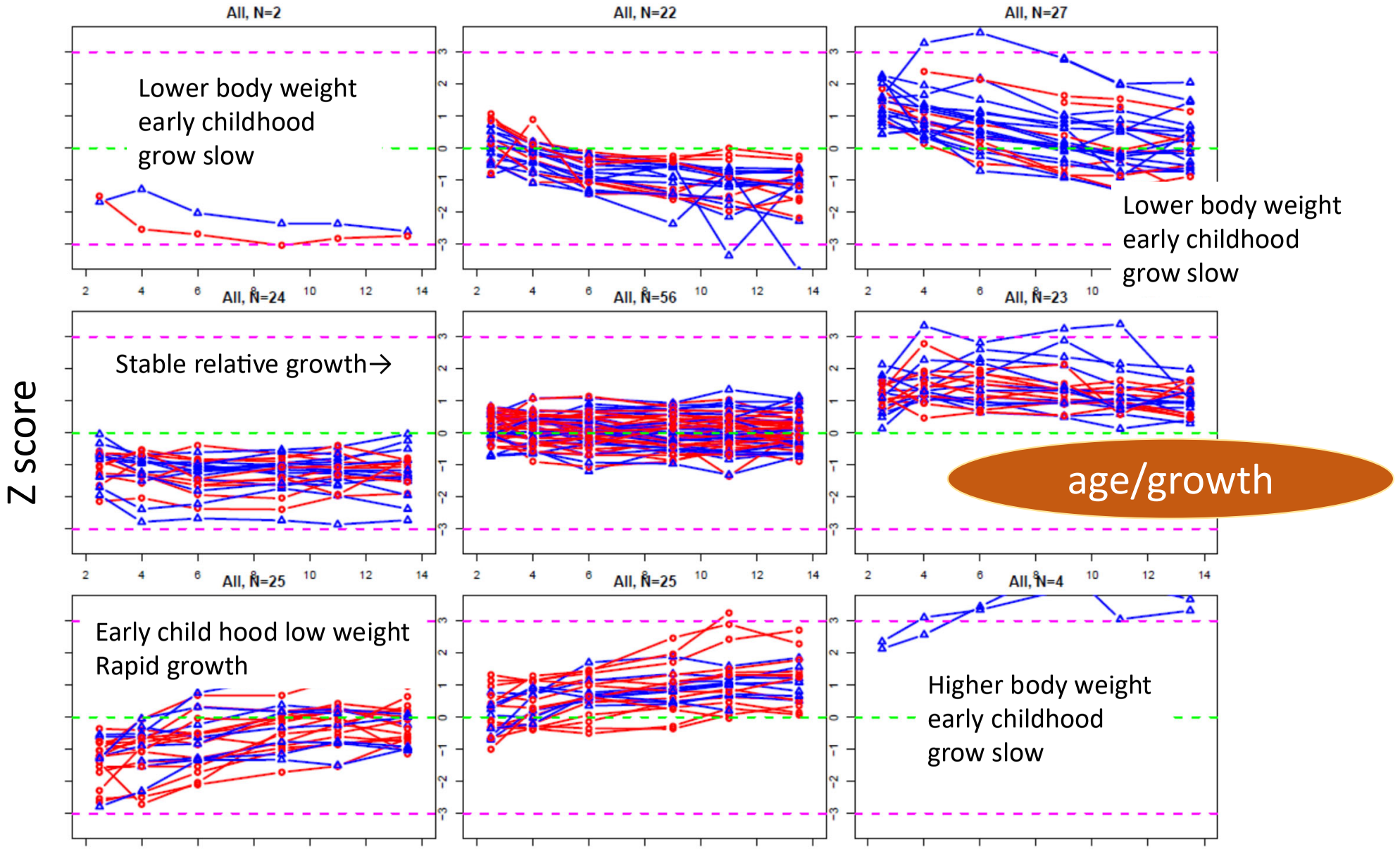
PACIFIC ISLANDS FAMILIES STUDY

Growth trajectories to age 14y

age/growth

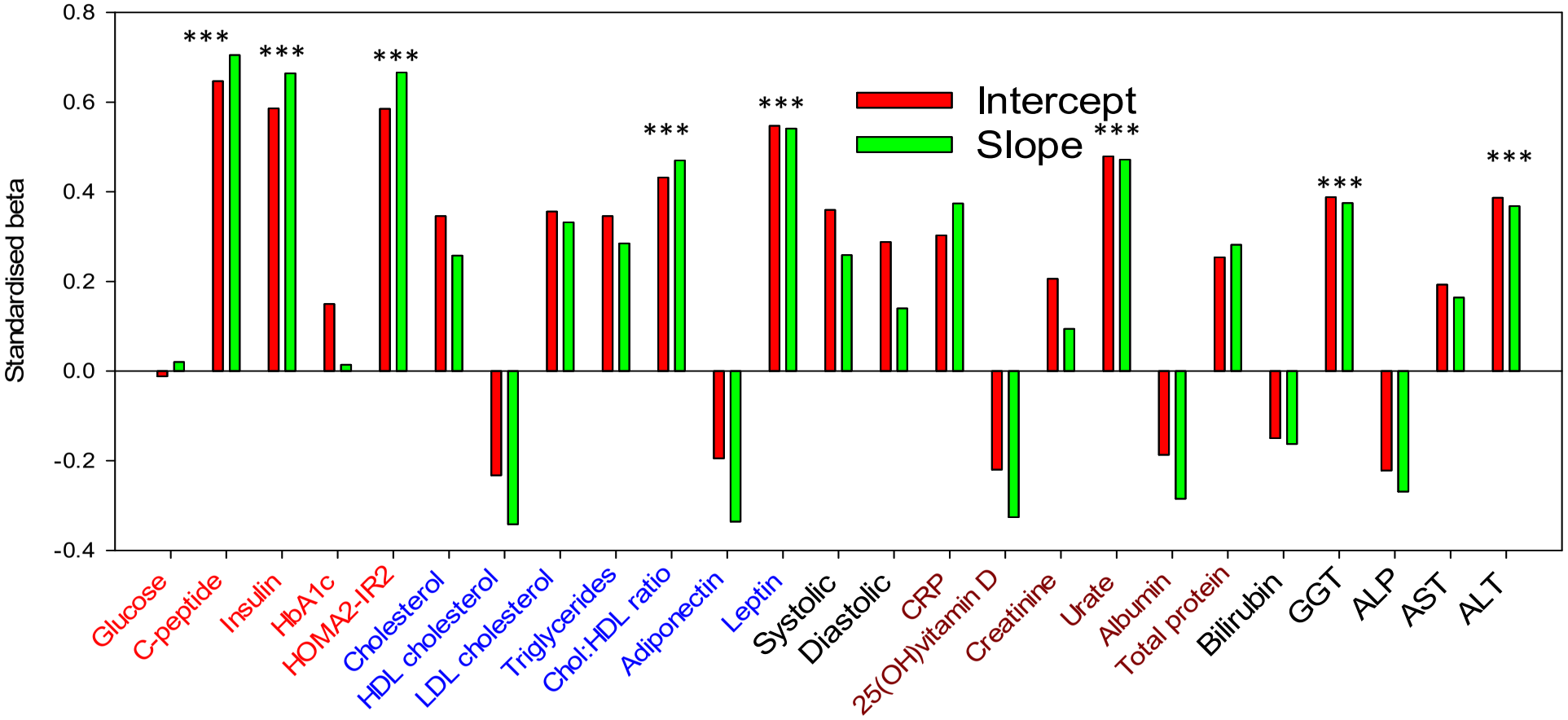
- Measured weights linearly interpolated to ages of 2.5, 4, 6, 9, 11, and 14 years for entire cohort – **1050** had at least 3 measurements.
- Normalised and individual weight **Z-scores determined within age**.
- Trajectories were approximated by **linear regression** (trend) of Z-score on age.
- **Intercept and slope** of the trend calculated.
- Substudy **(204) for** metabolic measurest the association with **intercept and slope adjusted for birthweight and sex by linear regression** was examined

Plank et al, 2019 Pediatric Obesity 14.5 (2019): e12497


All, N=2
Lower body weight
early childhood
grow slow
All, N=22
All, N=27
Lower body weight
early childhood
grow slow
Z score
All, N=24
Stable relative growth→
All, N=56
All, N=23
age/growth
All, N=25
Early child hood low weight
Rapid growth
All, N=25
All, N=4
Higher body weight
early childhood
grow slow

Growth and metabolites

relationships



Functional and nutrient measures are associated with body composition measures: Examples

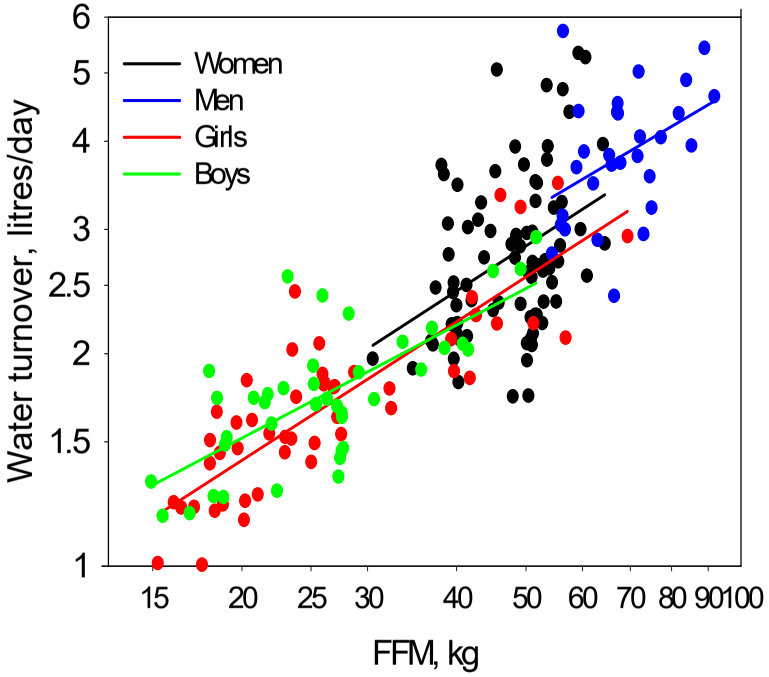
Distance walked in 6 minutes with leg length and body fat

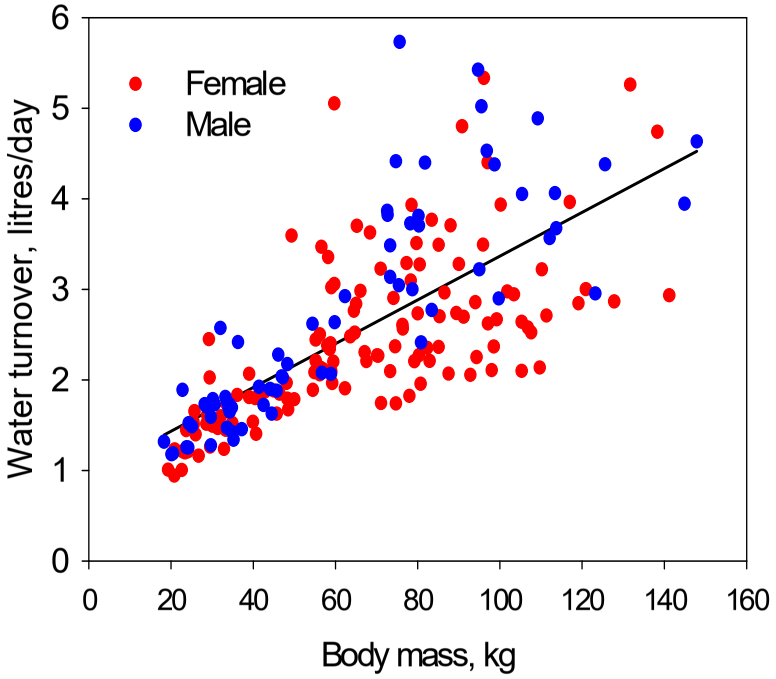
Uric acid with skeletal muscle mass

Fat soluble vitamins negatively associated with body mass

8 glasses of water a day?

Water turnover from doubly labelled water studies





Rush et al. Eur J Appl Physiol 2010 10.1007/s00421-010-1621-5

The world/ we are in balance?