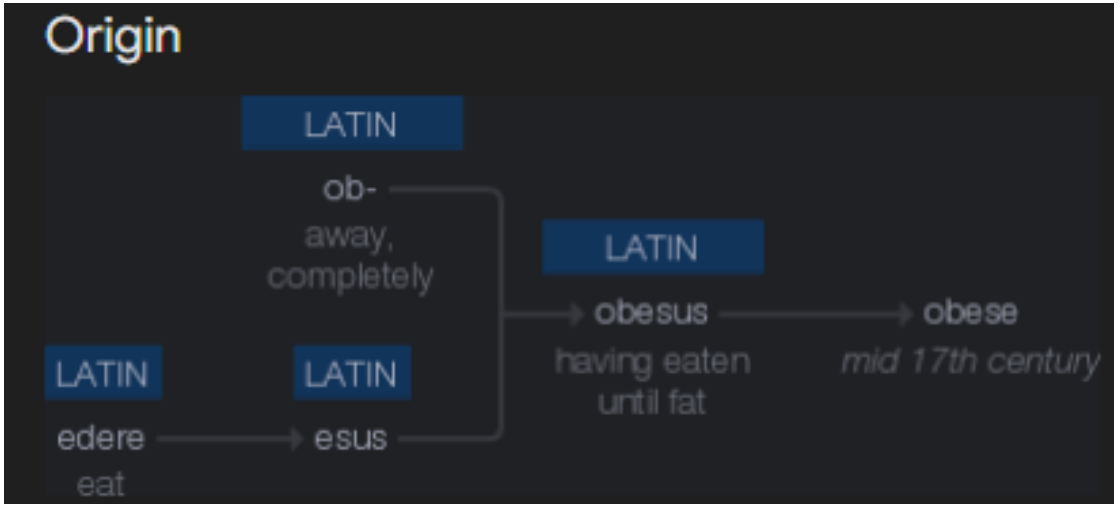
CHAPTER 1: INTRODUCTION

Prevalence and Assessment

Introduction

- A condition characterized by the excessive accumulation and storage of fat in the body



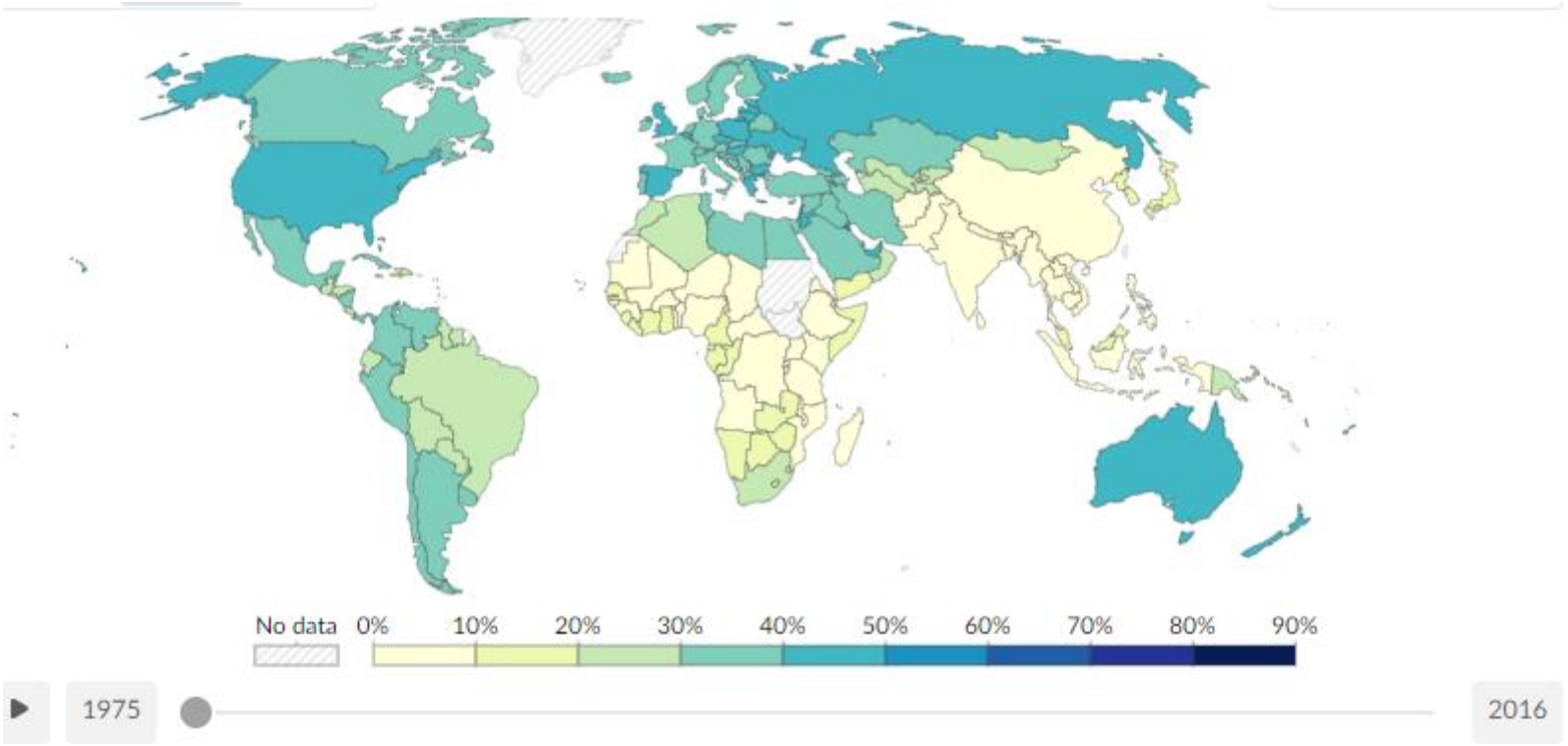
PART 1: PREVALENCE

The scale of the problem

- Worldwide obesity has **more than doubled** since 1990
- In 2022, **1 in 8 people** in the world were living with obesity.
- In 2022, more than **2.5 billion adults**, 18 years and older, were overweight. Of these over **890 million** were obese.
  - **43%** of adults aged 18 years and over were overweight in 2022, and **16%** were obese.
- **37 million** children under the age of 5 were overweight or obese in 2022. Over **390 million** children and adolescents aged 5–19 years were overweight

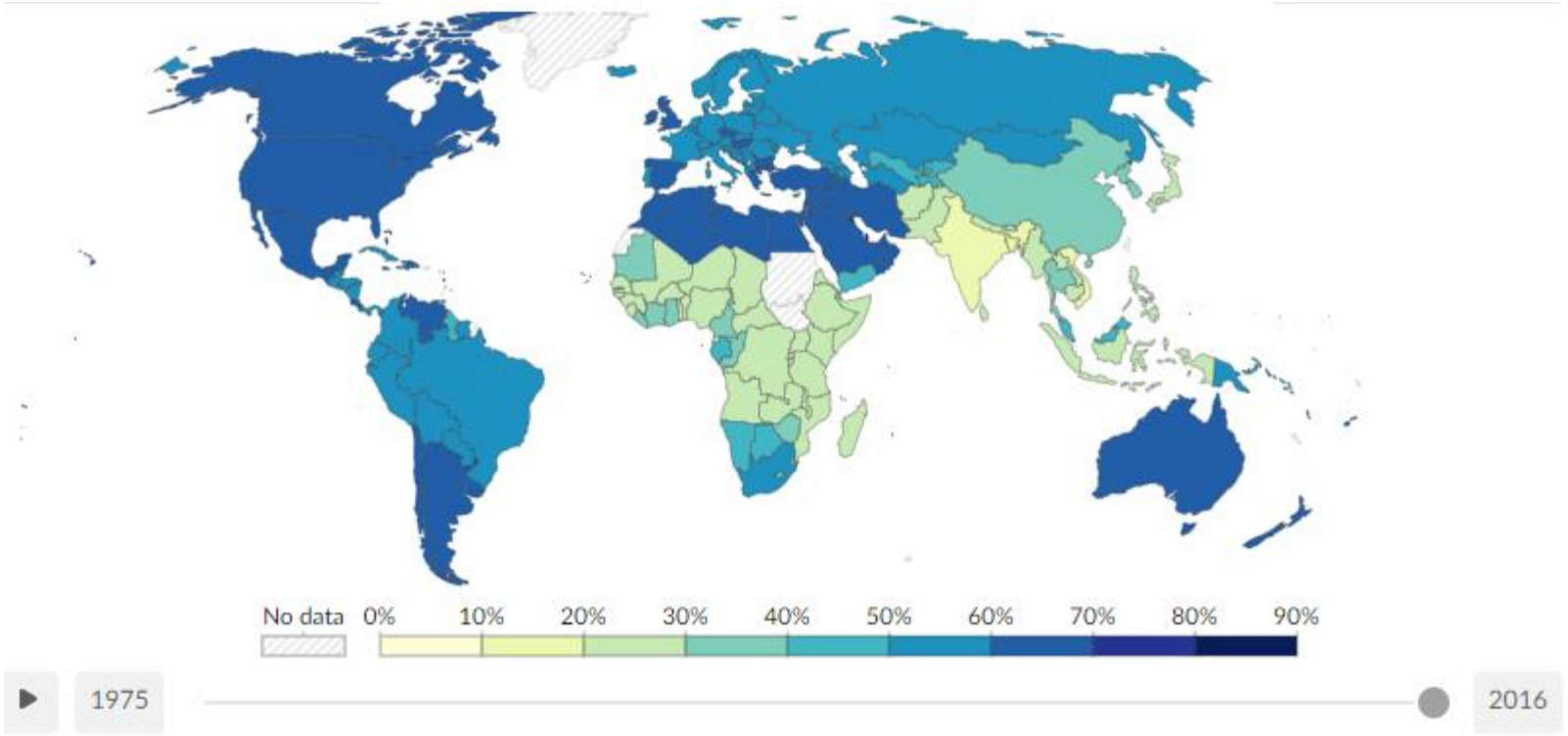
Most of the world's population (65%) live in countries where overweight and obesity kills more people than underweight

Trends: Adults who are overweight/obese



https://ourworldindata.org/obesity

Trends: Adults who are overweight/obese



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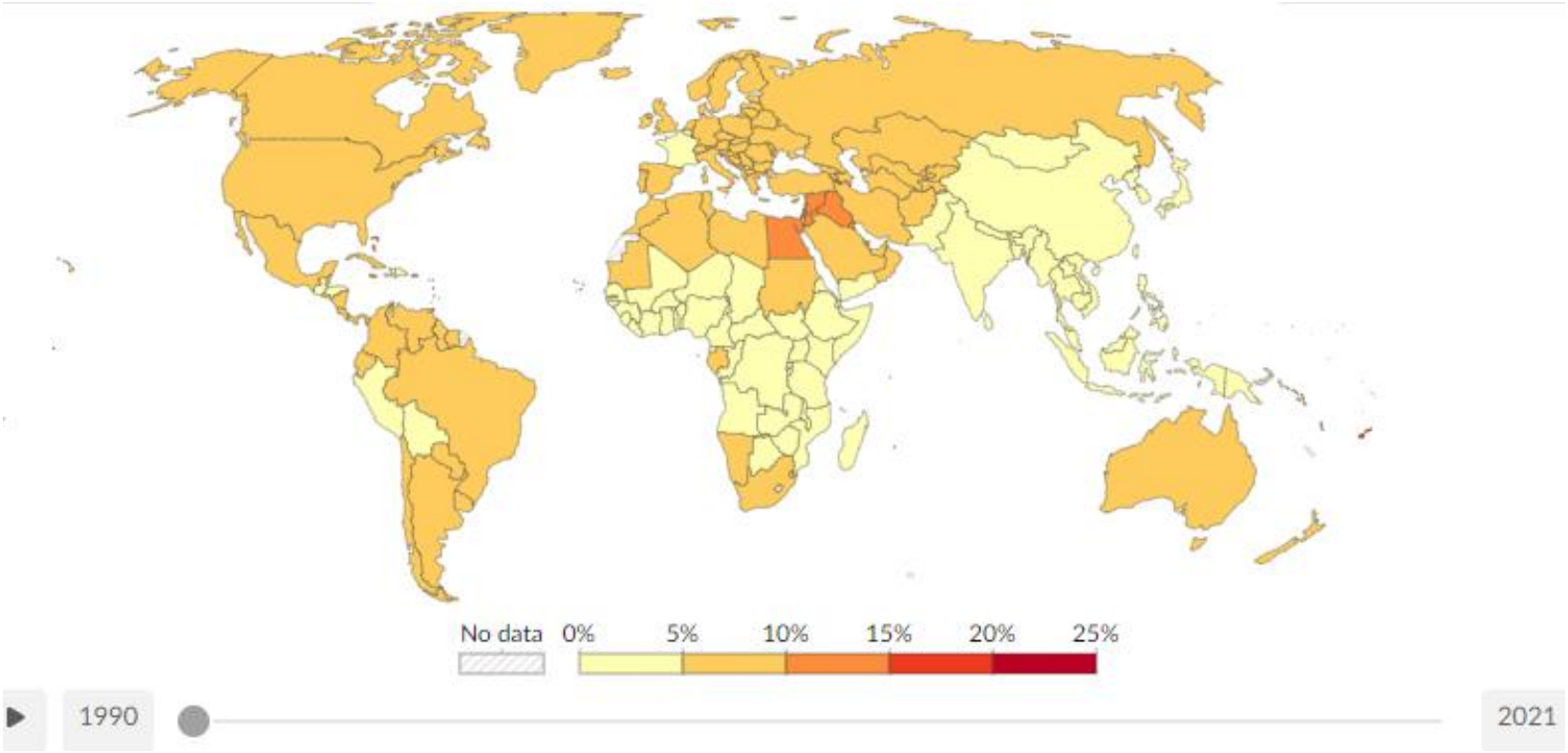
Trends: Deaths attributed to obesity



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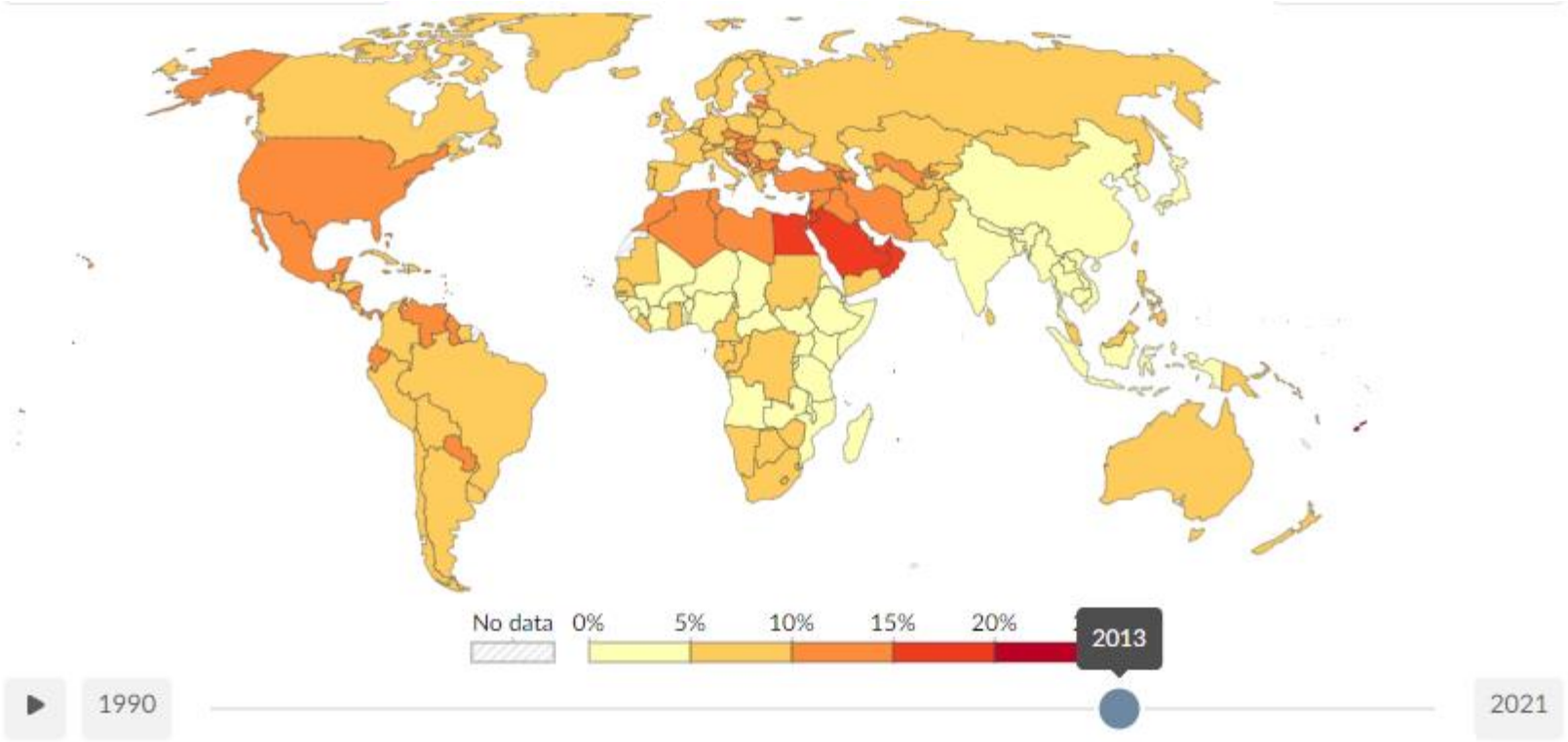

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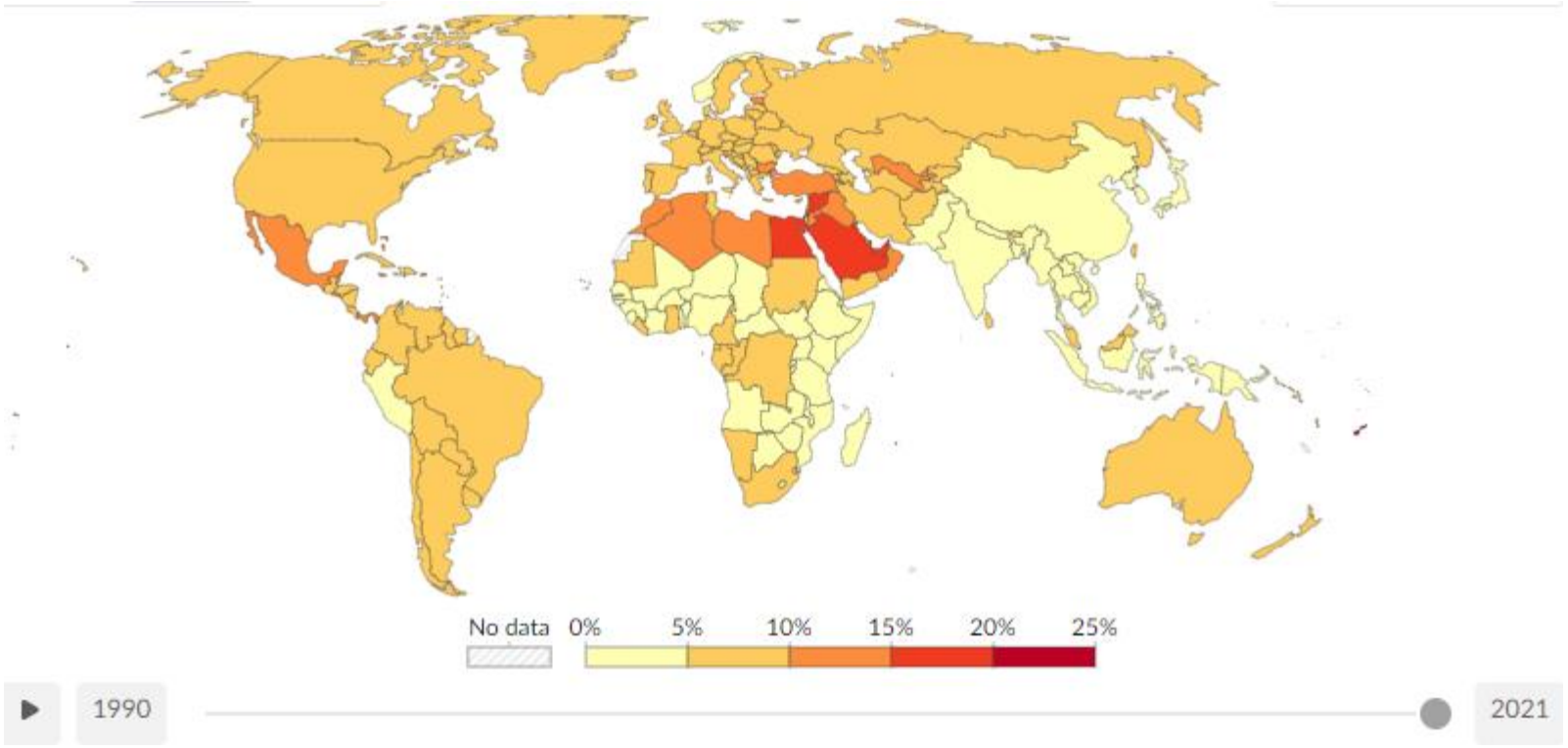
Trends: Deaths attributed to obesity



- It's not *only* the prevalence of obesity that plays a role but also other factors

NCD Mortality Rate Across Countries

High BMI prevalence is strongly determined by social, cultural, and economic variables that can work as protectors or risk factors according to the country's development and social status.

Kuźma, E., & Szwarcwald, C.L., 2023. Non-communicable diseases mortality rate and prevalence of high BMI by income and income inequality across countries: Associations and methodological considerations, an ecological analysis. *Population Medicine*, [online] Available at: https://www.populationmedicine.eu/Non-communicable-diseases-mortality-rate-and-prevalence-of-high-BMI-by-income-and,184056,0,2.html [Accessed 22 Sep. 2024].

NCD Mortality Rate Across Countries

- In low-income countries, the prevalence of being overweight or obese is driven by:
  - Economic growth
  - Industrialization
  - Mechanized transport
  - Urbanization
  - Increasingly sedentary lifestyle
  - Nutritional transition to processed food and high-calorie diets.

Kuźma, E., & Szwarcwald, C.L., 2023. Non-communicable diseases mortality rate and prevalence of high BMI by income and income inequality across countries: Associations and methodological considerations, an ecological analysis. *Population Medicine*, [online] Available at: https://www.populationmedicine.eu/Non-communicable-diseases-mortality-rate-and-prevalence-of-high-BMI-by-income-and,184056,0,2.html [Accessed 22 Sep. 2024].

NCD Mortality Rate Across Countries

- Paradoxically, as countries increase their economic development, **high BMI is increasingly concentrated in the poorest population group**
- The most privileged stratum have characteristics that reduce the prevalence of being overweight/obese:
  - Access to health and healthy foods
  - Higher education level
  - Sociocultural norms like healthism and a more positive value placed on being slim.

Kuźma, E., & Szwarcwald, C.L., 2023. Non-communicable diseases mortality rate and prevalence of high BMI by income and income inequality across countries: Associations and methodological considerations, an ecological analysis. *Population Medicine*, [online] Available at: https://www.populationmedicine.eu/Non-communicable-diseases-mortality-rate-and-prevalence-of-high-BMI-by-income-and,184056,0,2.html [Accessed 22 Sep. 2024].

The Paradox of Food Insecurity and Obesity

- Both obesity and food insecurity can coexist in the same families and the same individuals.
- Their coexistence sounds contradictory, but can be due to multiple reasons including:

1. **The need to maximize caloric intake**
2. **The trade-off between food quantity and quality**
3. **Overeating when food is available**

PART 2: DEFINITION & ASSESSMENT

Classification as a ‘Disease’

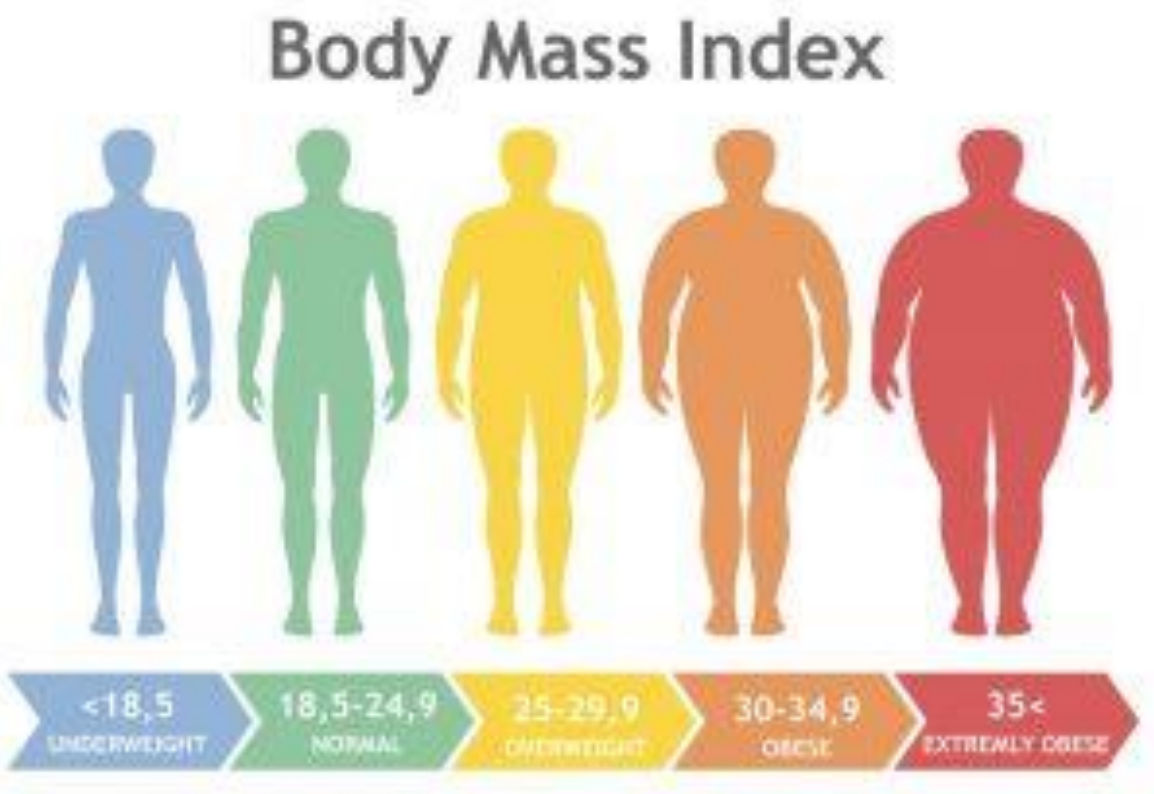
- **2024 ICD-10-CM Diagnosis Code E66.9: Obesity, unspecified**

A condition marked by an abnormally high, unhealthy amount of body fat.

- **American Medical Association (AMA)**: 2018

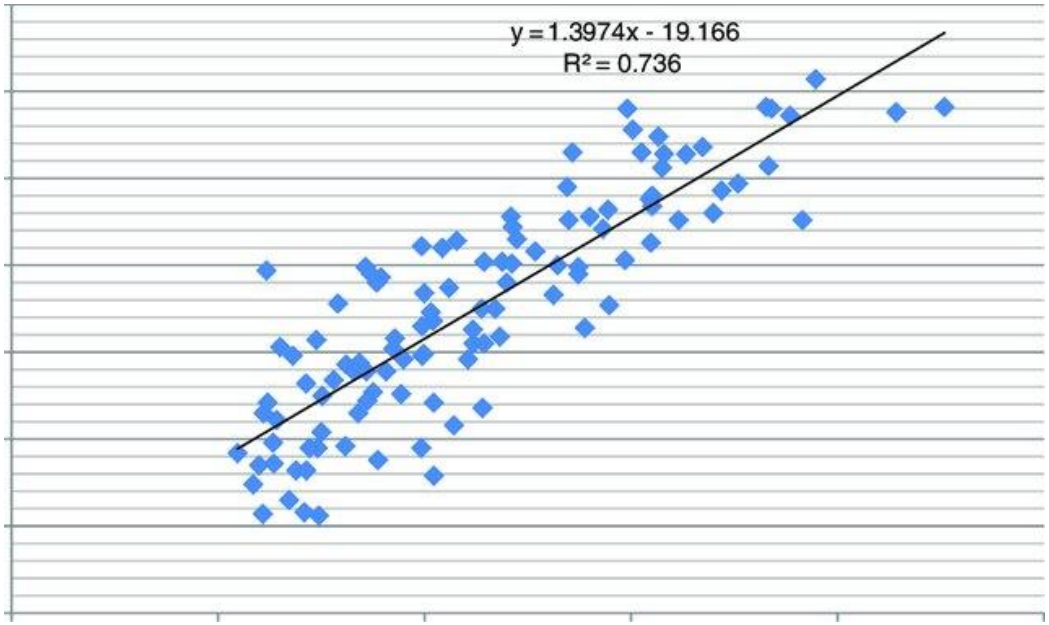
obesity as a disease state requiring treatment and prevention efforts.

How would you define obesity?



Let's discuss BMI ..

- Morbidity and mortality risks associated with increasing BMI are continuous. – There is a strong correlation between adiposity and BMI.



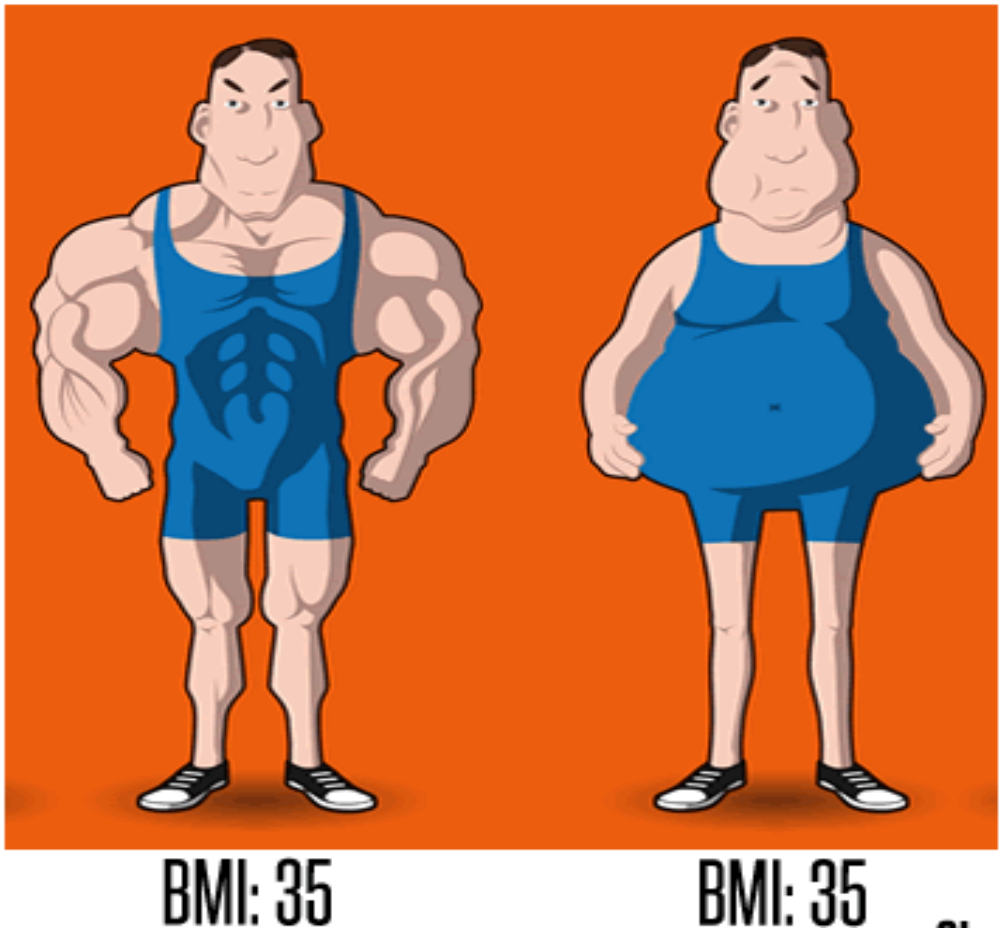
Correlation between BMI and % body fat as measured by DEXA (Grier et al., 2015)

Is BMI a valid diagnostic tool?

- BMI is a simple measure that is very useful for populations!
- … But, it can only predict risk
- BMI is a measure of size not health
- Also, it is not just the amount of fat, but also the distribution of fat that determines the risk that is associated with obesity. BMI is limited in how much it can assess adipose mass and distribution.

Ref: World Obesity Federation

Case 1: Higher muscle mass



Case 2: Metabolically Obese, Normal Weight (MONW)

Metabolically Obese Normal Weight (MONW)

High Visceral Fat
Low BMI
High Fat mass
Low Lean Body Mass
Low Insulin Sensitivity
High Liver Fat
High Triglycerides

Metabolically Healthy

Low Visceral Fat
Low BMI
Low Fat mass
High Lean Body Mass
High Insulin Sensitivity
Low Liver Fat
Low Triglycerides

BMI Limitations

1. Distinguish adipose from lean muscle mass
2. Assess adipose distribution (i.e. where adipose is located)
3. Risk at a given BMI can vary between populations (universal vs. ethnic specific cut-off points)

Morbidity burden starts at much lower BMIs

- The setting of these cut points has led many clinicians to assume that a **BMI between 20 and 25** is optimum as the mortality risk is minimum.
- However, the risk of diabetes, the incidence of hypertension, increases in blood cholesterol levels, and the risk of both cardiovascular diseases and colon cancer show *linear increases as the BMI moves up from a BMI of about 20*.
- So considering a BMI in the range of 20–25 as optimum may result in **neglecting all the increasing comorbidities** of weight gain within this “acceptable” range.

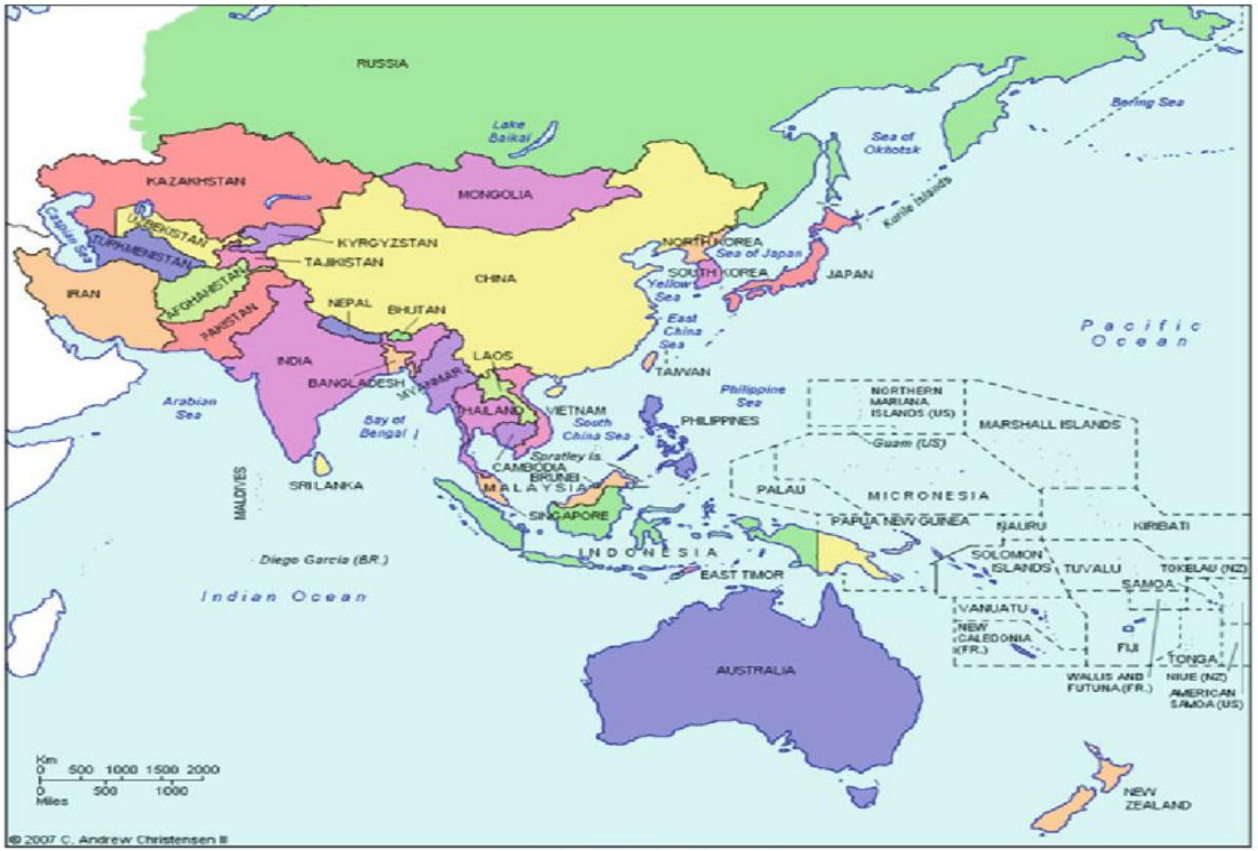
Different Cut-Off points

Table 2.2. Proposed classification of weight by BMI in adult Asians

Classification	BMI (kg/m^2)	Risk of co-morbidities
Underweight	< 18.5	Low (but increased risk of other clinical problems)
Normal range	18.5-22.9	Average
Overweight:	≥ 23	
At risk	23-24.9	Increased
Obese I	25-29.9	Moderate
Obese II	≥ 30	Severe

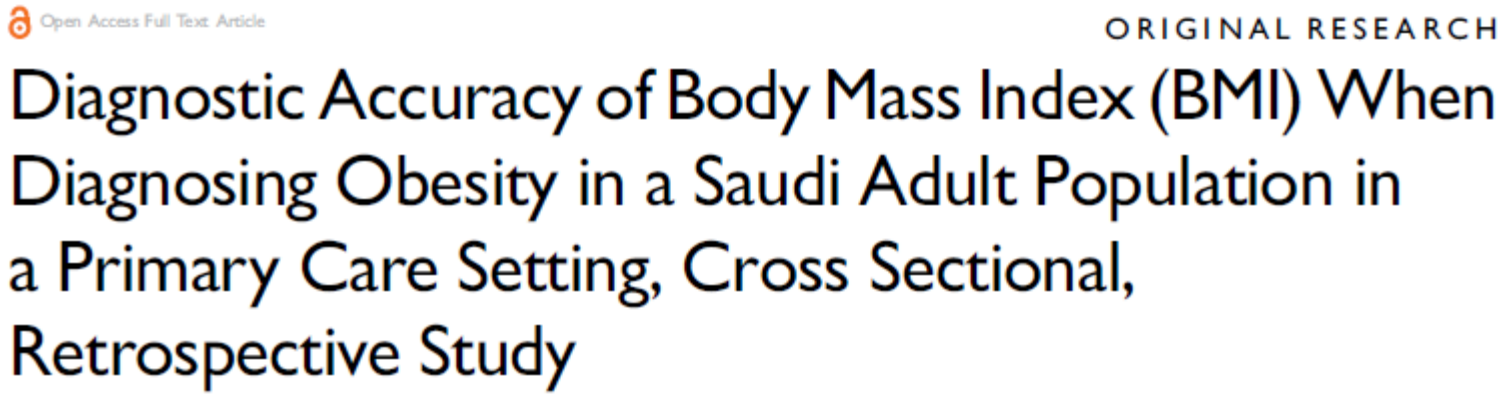
https://iris.who.int/bitstream/handle/10665/206936/0957708211_eng.pdf?sequence=1&isAllowed=y

Different Cut-Off points



- Where do we fall in within these groups?

Different Cut-Off points



Different regional burdens

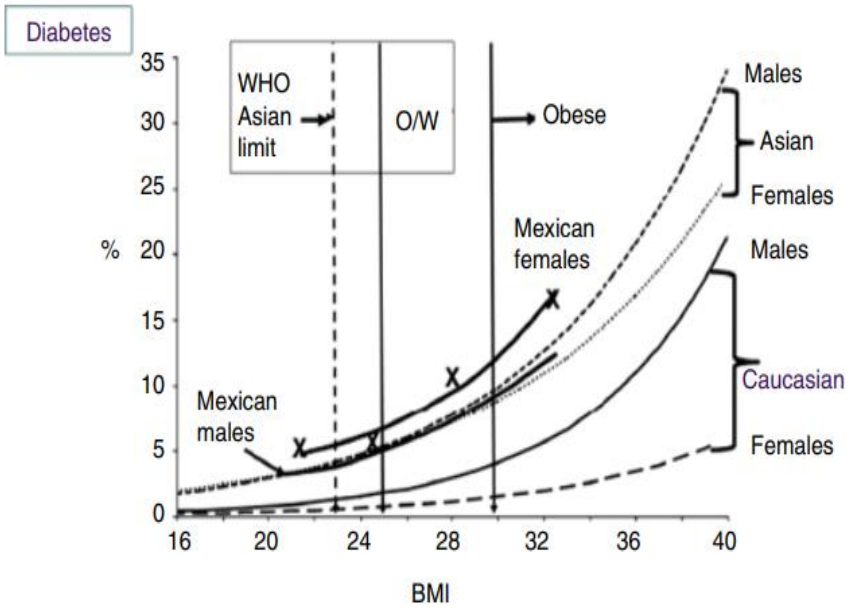


Figure 1.2 The prevalences of obesity in men and women in cohorts with over 263,000 adults either from Asia or from Australasia and Iran (depicted as Caucasians) [30]. Superimposed on this graph are data from the Mexican national survey in 2000 [35]. The Mexican study compared the national survey data with nationally representative data for US non-Hispanic Whites, but these data are not shown in this graph as they were almost identical to those of the Australasian/Iranian data from the Asian study.

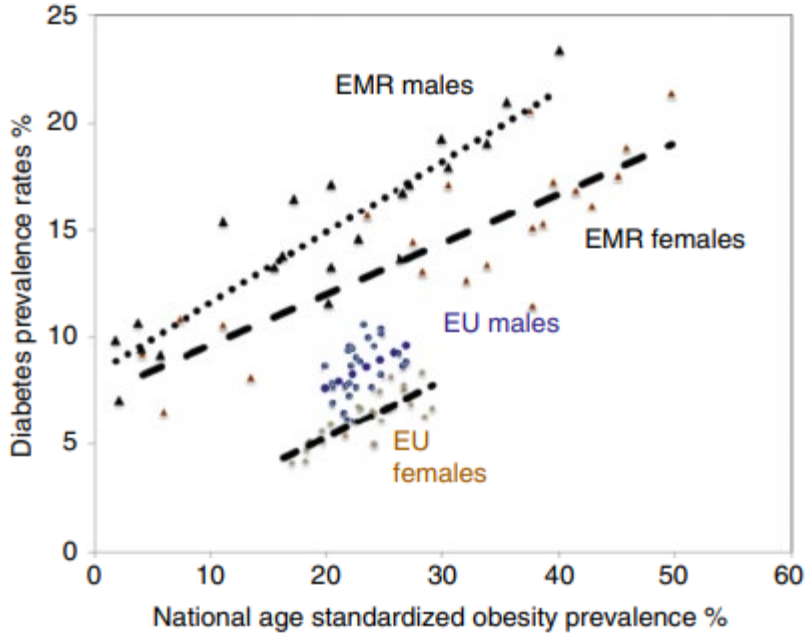


Figure 1.3 The relationship between the prevalences of obesity and diabetes in each of the 21 WHO Eastern Mediterranean countries compared with equivalent data from the 28 countries of the European Union. Diabetes prevalence rates are about twice as high in the Eastern Mediterranean countries as in the European Union at equivalent obesity rates. These data are based on randomly selected adults with measured anthropometry and fasting blood glucose levels in each country undertaken according to a standard protocol (the WHO STEPS program). (Source: Reproduced from Alwan et al. [43].)

what might be the basis for the increased susceptibility?

Other measurements

- Waist circumference
- Waist to hip ratio
- Edmonton Obesity Staging System (EOSS)
- %Body Fat measurements

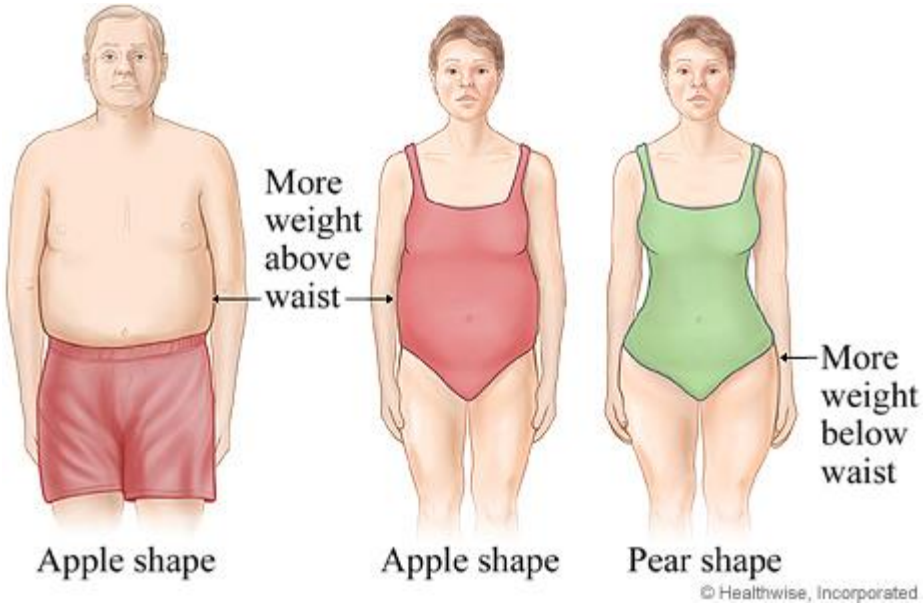
The importance of abdominal obesity

- The INTER-HEART study: A large case-control study in 52 countries

- The study showed that waist size and W/H ratios were better indices of the risk of CHD than BMI

Waist-Related Measures

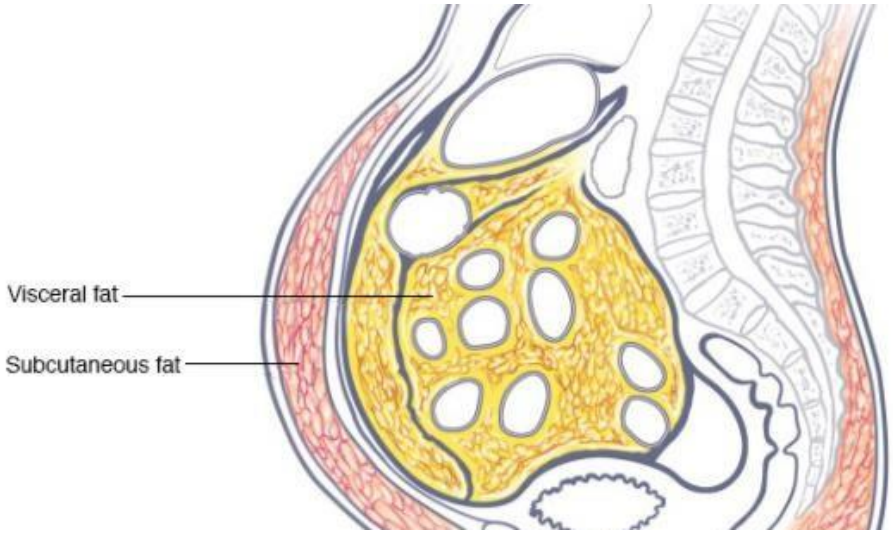
- Body fat distribution and Health Risk



Waist-Related Measures

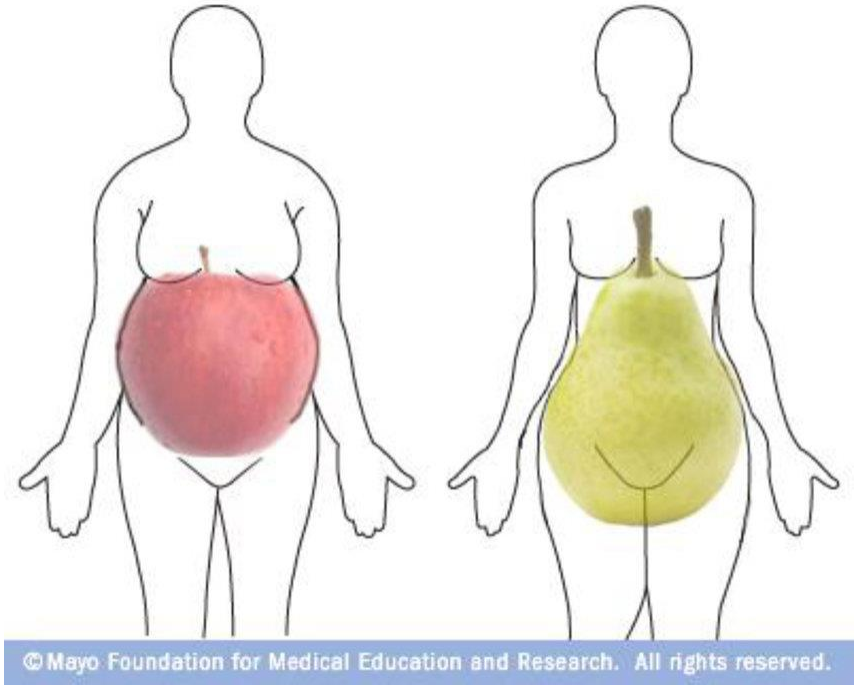
- Abdominal Obesity
  - Also referred to as central obesity or visceral obesity

Increased adipose tissue surrounding the intra-abdominal organs



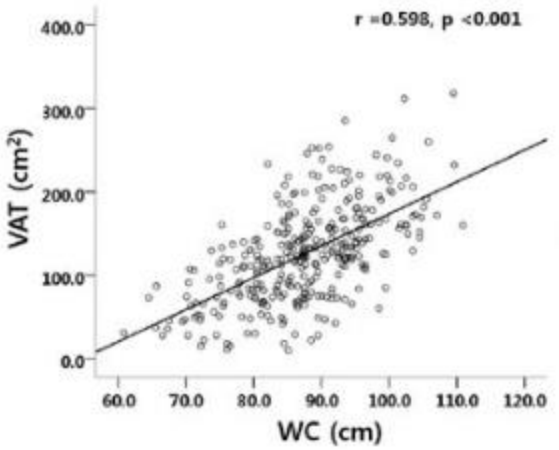
Waist-Related Measures

- Central obesity (apple), particularly visceral, is a risk factor for obesity-related disease
- It is is often a more crucial determinant of morbidity and mortality than total adiposity



Waist Circumference

- A cheap and easy method of measurement
- Considered a reasonable indicator of intra-abdominal or visceral fat (Kang et al., 2011)



- WHO Cut-off points:

Indicator	Men	Women	Risk of metabolic complications
WC	>94 cm	>80 cm	Increased
WC	>102 cm	>88 cm	Substantially increased
WHR	≥0.90	≥0.85	Substantially increased

Waist Circumference

- Population-specific considerations?
- International Diabetes Federation cut-off points

	Men	Women
Europoid / African	≥94 cm	≥80 cm
South Asian, Chinese Japanese	≥90 cm	≥80 cm

Waist Circumference

- Combining BMI and WC for health-risk assessment

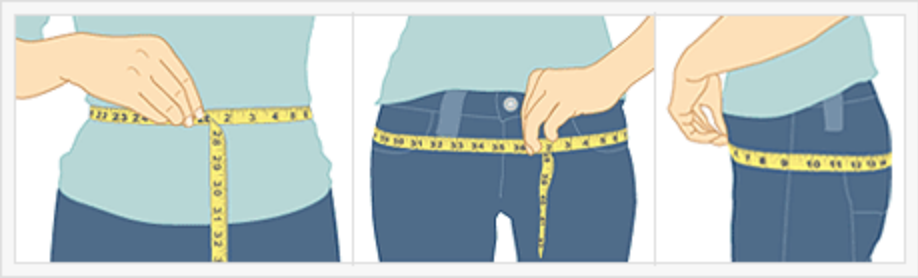
Table 5.1 Combined recommendations of body mass index and waist circumference cut-off points made for overweight or obesity, and association with disease risk

	Body mass index	Obesity class	Disease risk (relative to normal weight and waist circumference)	
			Men < 102 cm Women < 88 cm	Men >102 cm Women >88 cm
Underweight	<18.5			
Normal	18.5–24.9			
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9 35.0–39.9	I II	High Very high	Very high Very high
Extreme obesity	>40.0	III	Extremely high	Extremely high

Source: NHLBI Obesity Education Initiative (2000)

Waist-to-Hip Ratio

- Involves two measurements
- Calculated by dividing the circumference of the waist by the circumference of the hips
- This can serve as a better predictor of fat distribution



Waist-to-Hip Ratio

- Abdominal obesity is further defined as waist–hip ratio above 0.90 for males and above 0.85 for females

Table A1 World Health Organization cut-off points and risk of metabolic complications

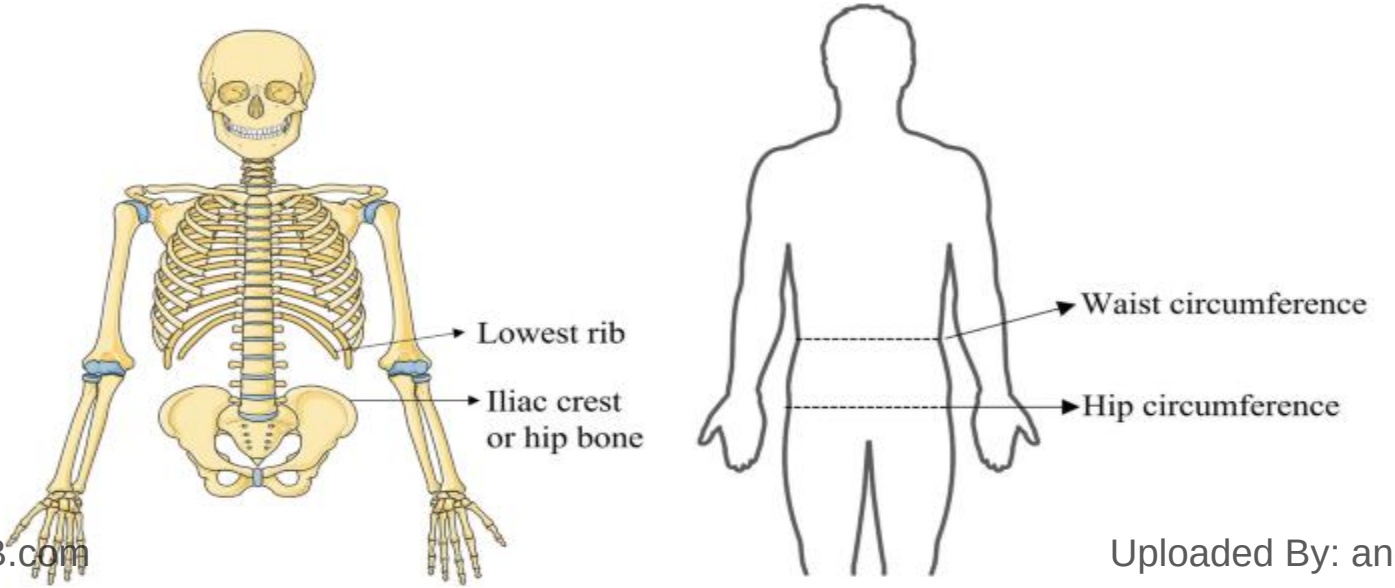
Indicator	Cut-off points	Risk of metabolic complications
Waist circumference	>94 cm (M); >80 cm (W)	Increased
Waist circumference	>102 cm (M); >88 cm (W)	Substantially increased
Waist–hip ratio	≥0.90 cm (M); ≥0.85 cm (W)	Substantially increased

M, men; W, women

WHO Measurement Protocol

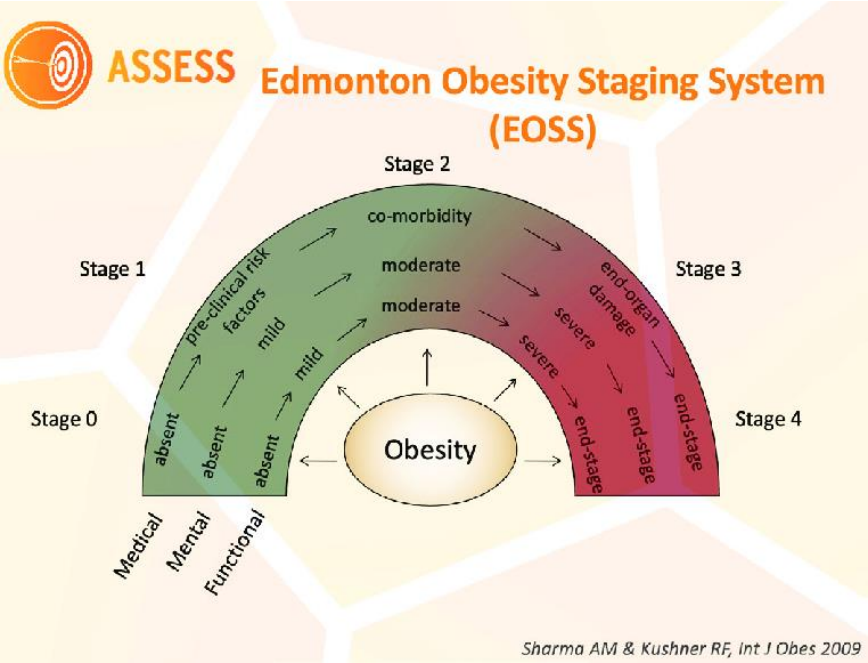
- Waist circumference at the end of several consecutive natural breaths, midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the mid axillary line.
- Hip circumference, at the largest circumference of the buttocks.

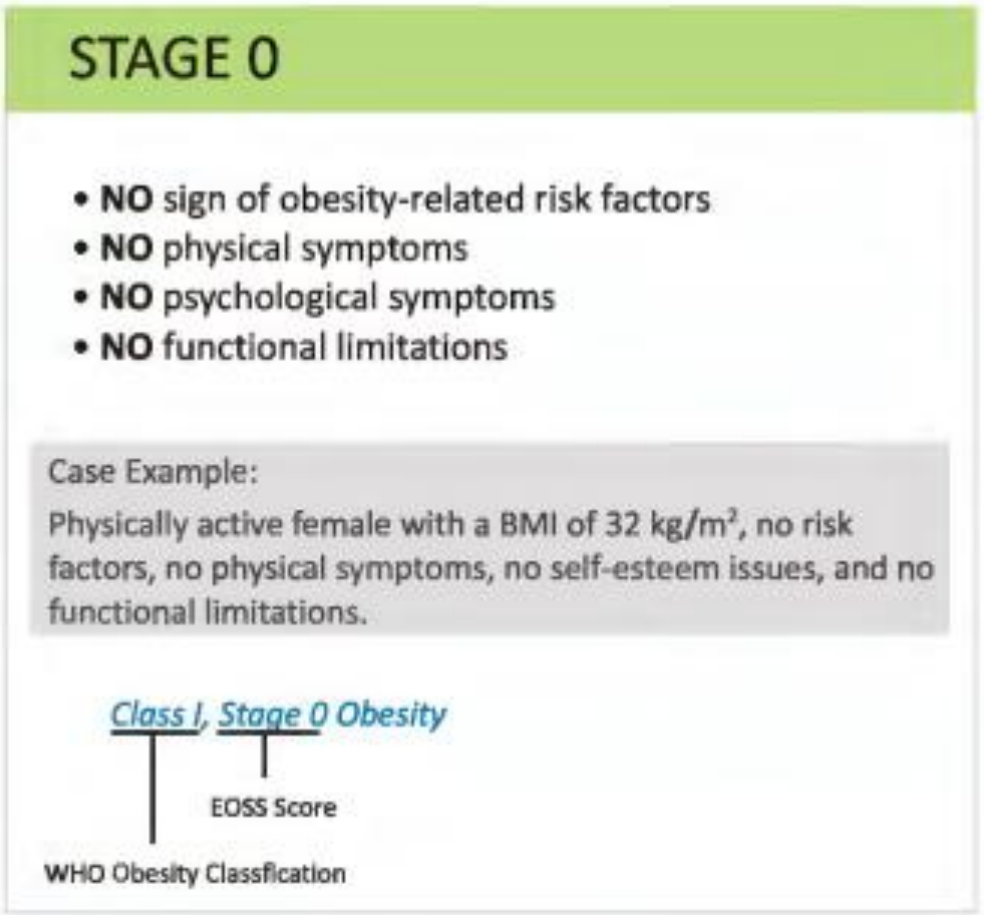
Make both measurements with a stretch-resistant tape that is wrapped snugly. Keep the tape level and parallel to the floor at the point of measurement.



Edmonton Obesity Staging System

- he EOSS diagnoses and considers the severity of obesity based on a clinical assessment of weight-related health issues, mental health and quality of life.
- This is useful at an individual level.





https://www.ottawahospital.on.ca/fr/documents/2017/05/edmonton-obesity-staging-system-staging-tool.pdf/

STAGE 1

- Patient has obesity-related **SUBCLINICAL** risk factors
  (borderline hypertension, impaired fasting glucose, elevated liver enzymes, etc.)

- OR -

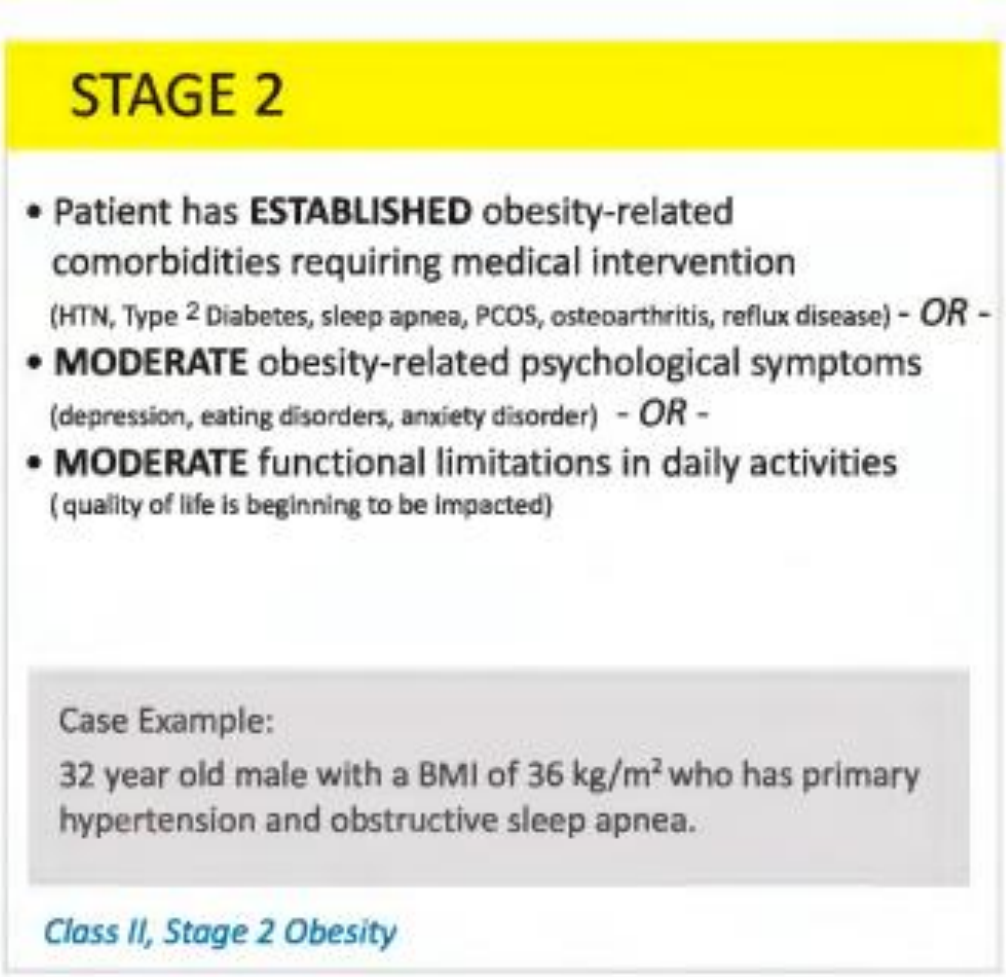
- **MILD** physical symptoms - patient currently not requiring medical treatment for comorbidities
  (dyspnea on moderate exertion, occasional aches/pains, fatigue, etc.) *- OR -*
- **MILD** obesity-related psychological symptoms and/or mild impairment of well-being
  (quality of life not impacted)

Case Example:

38 year old female with a BMI of 59.2 kg/m^2, borderline hypertension, mild lower back pain, and knee pain. Patient does not require any medical intervention.

Class III, Stage 1 Obesity

https://www.ottawahospital.on.ca/fr/documents/2017/05/edmonton-obesity-staging-system-staging-tool.pdf/



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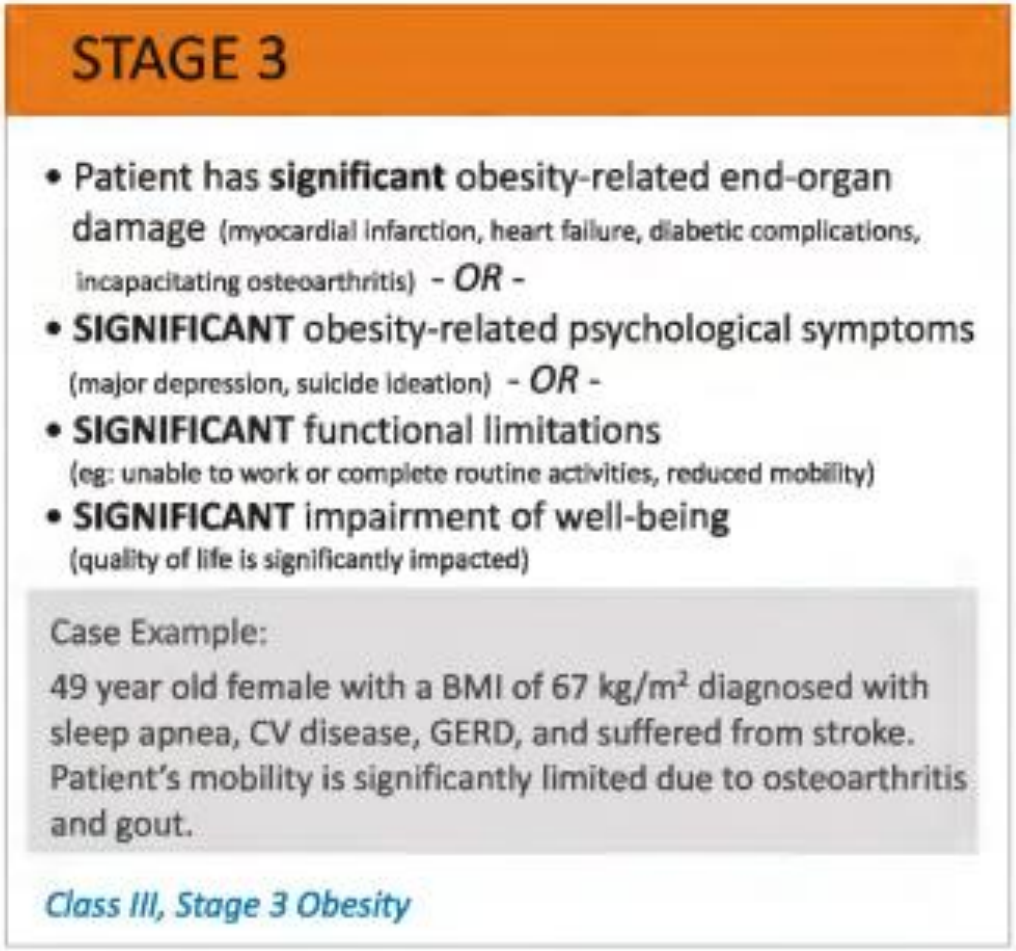

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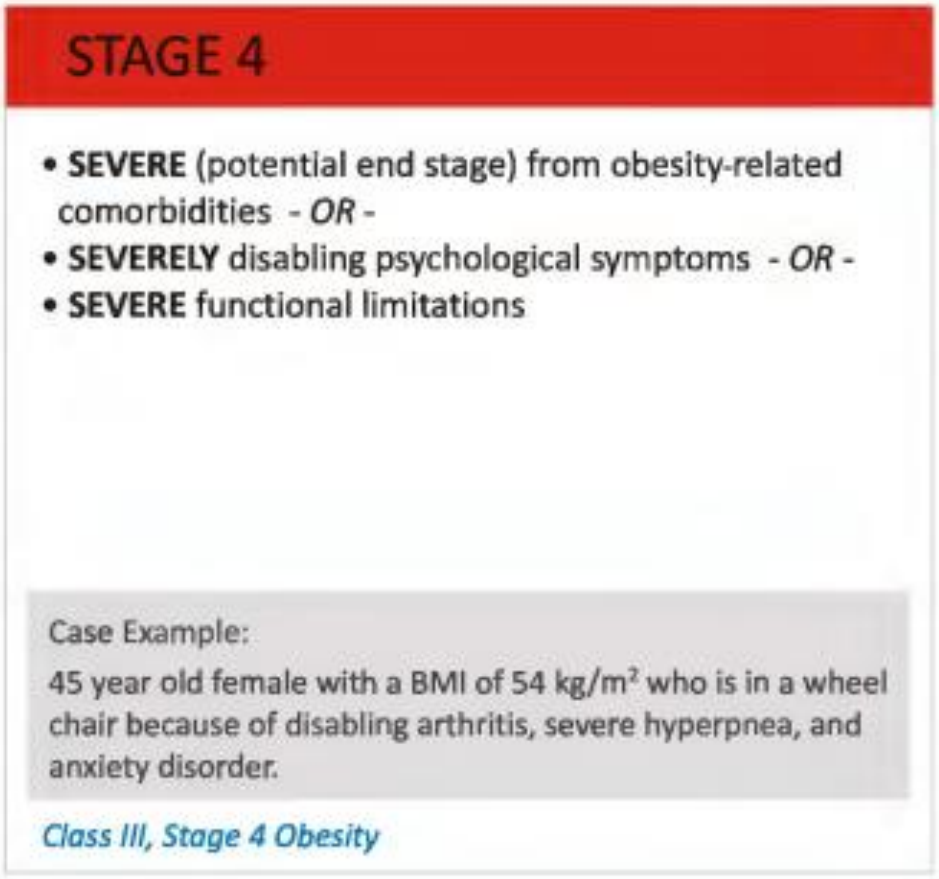

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EOSS Online Calculator

- https://www.mdcalc.com/calc/10536/edmonton-obesity-staging-system-eoss#when-to-use

MANAGEMENT

The derivation study for this tool proposed management based on the resulting clinical and functional staging:

Stage	Management
0	• Identify factors contributing to increased body weight. • Provide counseling on lifestyle measures, such as healthy eating and physical activity.
1	• Investigate for other (non-weight related) contributors to risk factors. • Implement more intensive lifestyle interventions, including diet and exercise. • Monitor risk factors and health status.
2	• Initiate obesity treatments, including consideration for all behavioral, pharmacological, and surgical options. • Closely monitor and manage comorbidities, as indicated.
3	• Initiate more intensive obesity treatment. • Aggressively manage comorbidities, as indicated.
4	• Pursue aggressive obesity management, as deemed feasible. • Consider additional measures, including pain management, occupational therapy, and psychosocial support.

EOSS Online Calculator: Notes About EOSS

- This tool evaluates obesity-related comorbidities, physical and functional impairments, and psychological factors to stage the health implications and clinical risks associated with increased body fat.
- Some components of this tool rely on clinical judgment, which can introduce variability in staging between different healthcare providers.
- The EOSS should be used in conjunction with other assessments and should not serve as the sole determinant of obesity-related health risks or treatment decisions.
  - https://www.mdcalc.com/calc/10536/edmonton-obesity-staging-system-eoss#when-to-use

Measures of Body Fat %

- WHO cut-off points for body fat % are
  - 25% for men
  - 35% for women

These values correspond to a BMI of 30 kg/m2 in young Caucasians

***General* Body Fat Percentage Categories**

Classification	Women (%fat)	Men (% fat)
Essential	9-11%	3-5%
Below Average/Athletes	12-19%	6-13%
General Fitness	20-24%	14-17%
Average/Acceptable	25-29%	18-24%
Obese (Level I & II)	30% +	25% +

https://www.stonybrook.edu/

Measures of Body Fat %

- Measuring BF% allows us to calculate FMI (Fat Mass/height^2), instead of relying on BMI
- Advantages of FMI: Measures of excess fat not confounded by lean mass!

Fat Mass Index (FMI) & Body Mass Index (BMI) Kg/m^2

FMI Class	Severe Fat Deficit	Moderate Fat Deficit	Mild Fat Deficit	Normal	Excess Fat	Obese Class 1	Obese Class II	Obese Class III
Male	< 2	2 to < 2.3	2.3 to < 3	3 - 6	> 6 to 9	> 9 to 12	> 12 to 15	> 15
Female	< 3.5	3.5 to < 4	4 to < 5	5 - 9	> 9 to 13	> 13 to 17	> 17 to 21	> 21

BMI Class	Underweight	Normal	Overweight	Obese Class I	Obese Class II	Obese Class III
Male & Female	< 18.5	18.5 to < 25	25 to < 30	30 to < 35	35 to < 40	≥ 40

Classification ranges for FMI that match the prevalence of the WHO BMI classifications, using NHANES calibration. Unlike BMI, FMI is a gender specific measure of fat not confounded by lean tissue (Kelly et al, 2009).

https://www.bodydexafit.com.au/health-tools-useful-links/

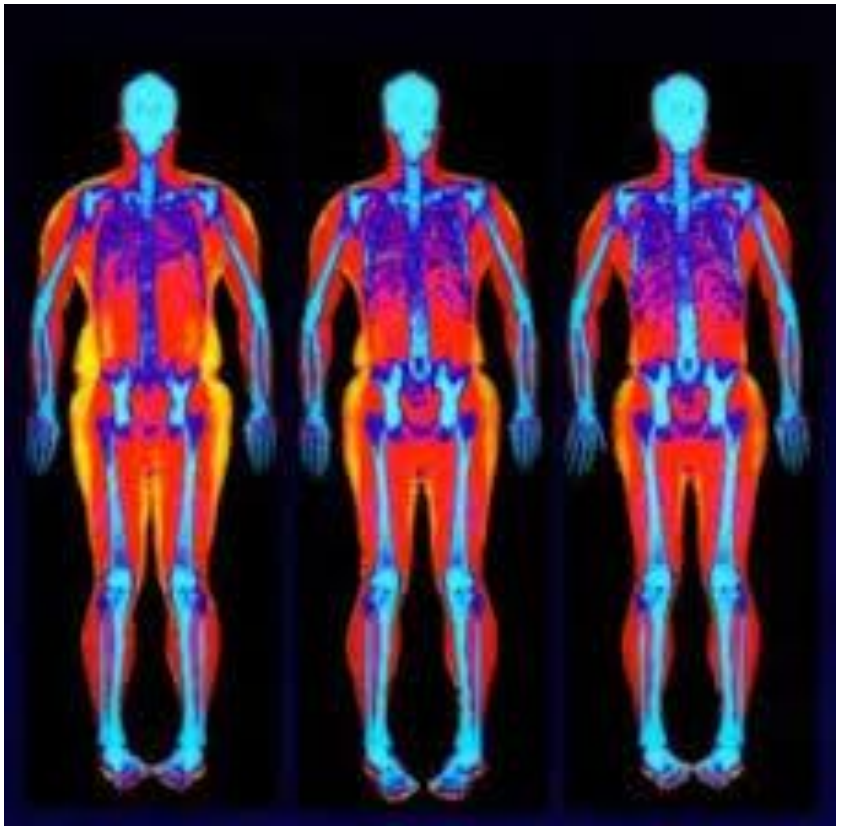
Criterion Methods for BF%

Dual-Energy X-ray Absorptiometry

- One of the most accurate methods for measuring body fat
- A typical whole body scan takes approximately 10 to 20 minutes and exposes the subject to <5 mrem of radiation.

Dual-Energy X-ray Absorptiometry

- Yellow: Higher %Fat
- Orange/Red: Progressively lower %Fat
- Blue: Bone



Results from DXA

Adipose Indices

Measure	Result	Percentile YN	Percentile AM
Total Body % Fat	**30.6**	**22**	**13**
Fat Mass/Height² (kg/m²)	8.47	45	33
Android/Gynoid Ratio	0.64		
% Fat Trunk/% Fat Legs	0.64	17	10
Trunk/Limb Fat Mass Ratio	0.63	19	10
Est. VAT Mass (g)	141		
Est. VAT Volume (cm³)	153		
Est. VAT Area (cm²)	29.3		

This is the total body fat percentage, 30.6%

Body Composition Results

Region	Fat Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat	%Fat Percentile YN	%Fat Percentile AM
L Arm	1604	2773	4376	36.6	37	25
R Arm	1597	3057	4653	34.3	29	19
Trunk	9557	29723	39279	24.3	17	9
L Leg	5722	9406	15129	37.8	29	23
R Leg	6226	9862	16088	38.7	32	25
Subtotal	24705	54821	79527	31.1	21	13
Head	1075	3691	4765	22.5		
Total	**25780**	**58512**	**84292**	**30.6**	**22**	**13**
Android (A)	1237	3907	5145	24.0		
Gynoid (G)	5541	9226	14767	37.5		

YN = 22% Fat Percentile
AM = 13% Fat Percentile

Android % Fat can show how close you are for a six-pack abdomen

This is the total body fat mass in grams or 25.8kg

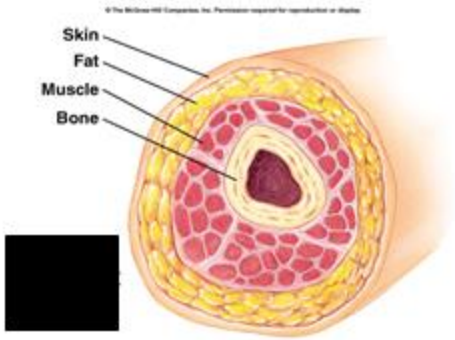
Identify muscle imbalance & symmetry

This represents your fat free mass or everything in your body except fat (58.5kg). It includes lean mass and bone mineral content. This number is used to determine resting metabolic expenditure, a very useful indicator of the number of calories required to sustain life at rest.

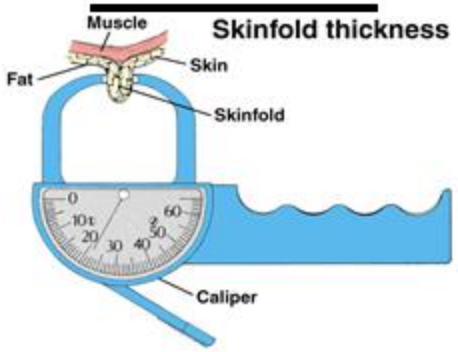
Indirect Measurement of BF%

1. Skinfolds

Used to characterize subcutaneous fat thickness at various regions of the body



They are particularly useful in monitoring changes in fatness in children because of their small body size, and the majority of fat is subcutaneous even in obese children.



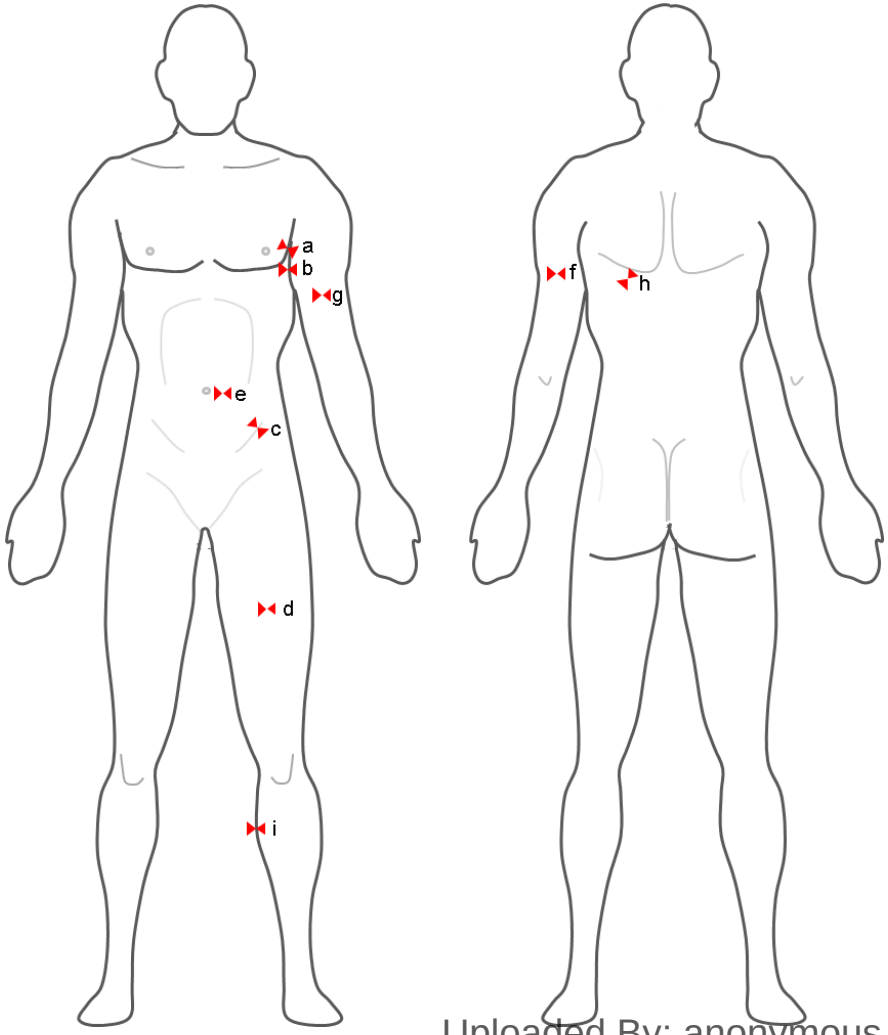
Weir, C. B., & Jan, A. (2023). BMI classification percentile and cut-off points. *In StatPearls [Internet]*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2769821/pdf/dst-02-1139.pdf

Indirect Measurement of BF%

1. Skinfolds

Skinfold measurement can be obtained from 2-9 different standard anatomical sites (most common: subscapular and triceps)

- **Chest or pectoral skinfold**
- **Mid-Axillary**
- **Supra-iliac or flank:**
- **Quadriceps or mid-thigh**
- **Abdominal**
- **Triceps**
- **Biceps**
- **Subscapular**
- **Medial calf**



Indirect Measurement of BF%

1. Skinfolds

Jackson & Pollock (1985)

1. Men *4-Site Skinfold Equation (for calculating % body fat)*

% Body Fat = (0.29288 * sum of skinfolds) – (0.0005 * square of the sum of skinfolds) + (0.15845 * age) – 5.76377, where the skinfold sites (mm) are abdominal, triceps, thigh and supra-iliac

1. Women *4-Site Skinfold Equation (for calculating % body fat)*

% Body Fat = (0.29669 * sum of skinfolds) – (0.00043 * square of the sum of skinfolds) + (0.02963 * age) + 1.4072, where the skinfold sites (mm) are abdominal, triceps, thigh and supra-iliac

1. Women *3-Site Skinfold Equation*

% Body Fat = (0.41563 * *sum of skinfolds)* – (0.00112 * *square of the sum of skinfolds)* + (0.03661 * age) + 4.03653, where the skinfold sites (mm) are abdominal, triceps and supra-iliac

Other equations can be found in the link below for different measurements and different age groups

https://www.measurement-toolkit.org/anthropometry/objective-methods/simple-measures-skinfolds

Indirect Measurement of BF%

2. Bioelectrical Impedance

Bio-Electrical Impedance Analysis (BIA)

- Based on how resistance correlates with the amount of body water and lean tissue

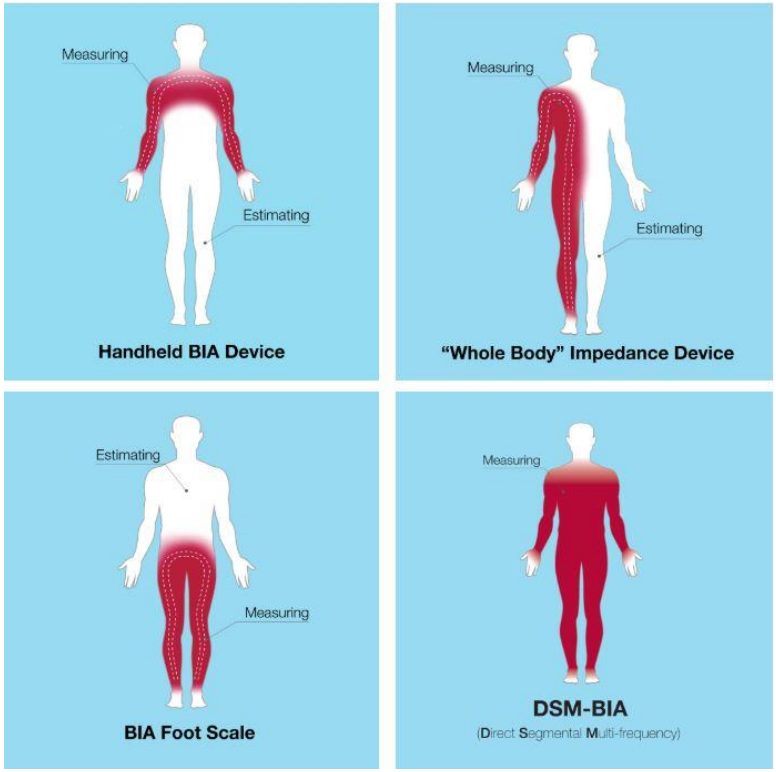
→ Total Body Weight and FFM.

- Total FM is then calculated = Body Weight - FFM

Impedance to the electrical current is greatest in fat tissue (only 14–22% water content).

Indirect Measurement of BF%

- The impedance index [stature squared divided by resistance (S^2/R) at a frequency, most often 50 kHz] is proportional to the volume of **total water** and is an independent variable in **regression equations to predict body** composition
- *Such the equations are useful only for subjects that closely match the reference population in body size and shape*



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Applicability in an obese population?

Comparison of Three Bioelectrical Impedance Methods with DXA in Overweight and Obese Men

Ian R. Pateyjohns,† Grant D. Brinkworth,* Jonathan D. Buckley,† Manny Noakes,* and Peter M. Clifton**

Paper Discussion

- Introduction
  - Compare DXA and BIA from a practical point of view
  - What is the difference between SF and MF- BIA
  - What is the objective of this study?
- Methods
  - Who were the study subjects
  - What measurements did the researchers take, and how?
- Results
  - From Table 2, what differences resulted from the different methods?
  - From the text, what is the correlated between MF and SF-BIA with DXA?
- Discussion
  - What are the main findings?
  - What are the study limitations?