TEXAS TECH UNIVERSITY

Obesity Treatment and Body Composition

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Disclosures

- **Research grants** from Prism Labs (manufacturer of 3D body scanners), several nutrition companies (Bunge Loders Croklaan, EHP Labs, Nutraceutical International Corporation, 8 POiNT LLC, Legion Athletics, Vital Pharmaceuticals, and MTI Biotech), and the American College of Sports Medicine
- **Equipment loan/donation** from body composition assessment companies (InBody, RJL Systems, MuscleSound, Size Stream, Naked Labs, Prism Labs)
- **Data license contract** with Intel Corporation
- **Speaking honoraria** from Collegiate and Professional Sports Dietitians Association, CrossFit, National Strength and Conditioning Association, and International Society of Sports Nutrition
- **Patent** for use of dietary supplement (beta-hydroxy-beta-methylbutyrate) during intermittent fasting
- **Owner** of Tinsley Consulting LLC (data analysis and manuscript preparation services; dietary supplement formulation)

Obesity Treatment & Body Composition

Relevance of Body Composition in Obesity Treatment

Agarwal AA, Narayan A, Stanford FC. *JAMA Intern Med* 2024.

- FDA process for weight loss medications based on **weight loss**, not fat loss.
- Proportion of **fat** and **lean** loss is an important consideration.
- "*...we recommend incorporating accessible analytical methods, alongside biomedical indices…in drug trials*."

Obesity Treatment & Body Composition

Outline

1. Fundamentals of Body Composition
2. Expected Loss of Lean and Muscle Mass
3. Minimizing Loss of Lean and Muscle Mass
4. Estimating Body Composition
5. Summary

Obesity Treatment & Body Composition

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Obesity Treatment & Body Composition

Fundamentals of Body Composition

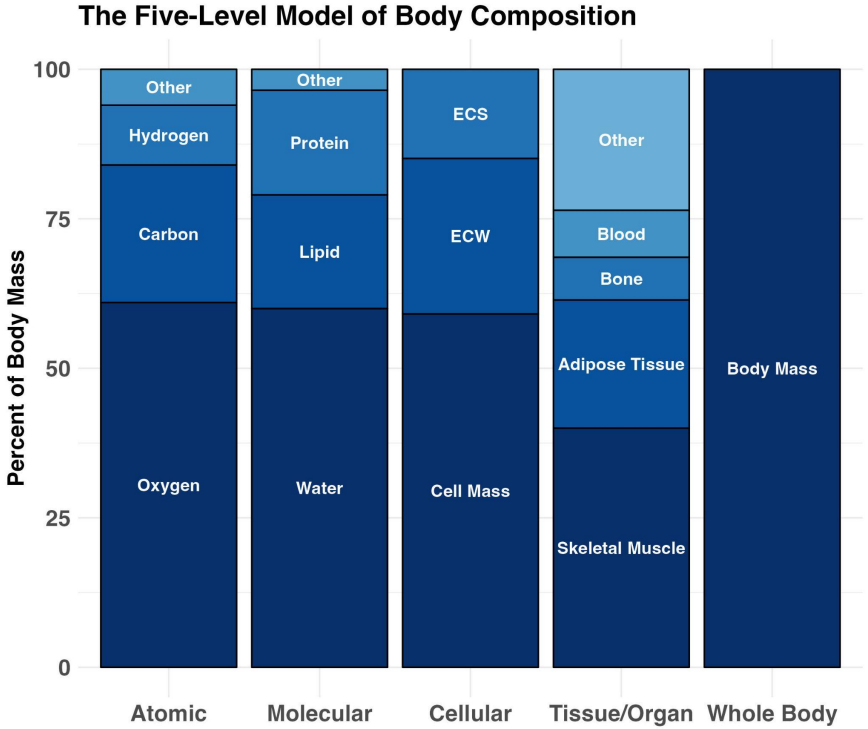
"The composition of your body reflects the net lifetime accumulation of nutrients and other substrates acquired from the environment and retained by the body."

Heymsfield, Lohman, Wang, and Going.
Human Body Composition, 2nd Edition

Obesity Treatment & Body Composition

Fundamentals of Body Composition

- Body composition assessment examines the **masses** and **proportions** of different estimable entities within the body.
- There are multiple "**levels**" at which body composition can be evaluated:
  - **Atomic**
  - **Molecular**
  - **Cellular**
  - **Tissue/Organ**
  - **Whole Body**

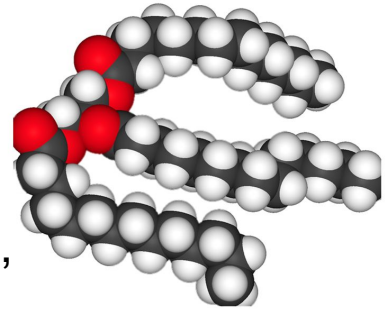


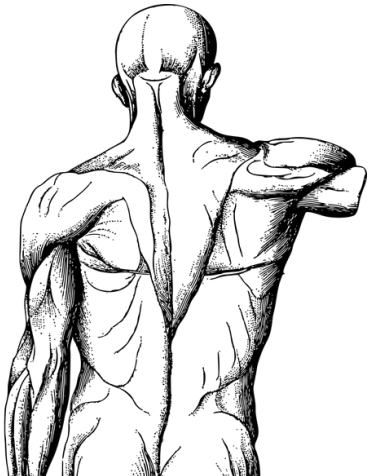
Adapted from Wang et al. 1992, Am J Clin Nutr

Obesity Treatment & Body Composition

Fundamentals of Body Composition

- Different levels have different components we can estimate.
  - **Molecular**: Body fat %, fat-free mass (FFM), fat mass, total body water, mineral, protein
  - **Tissue/Organ**: skeletal muscle, adipose tissue, etc.
  - **Whole Body**: body mass / BMI, body volume, body density, height, limb lengths, circumferences





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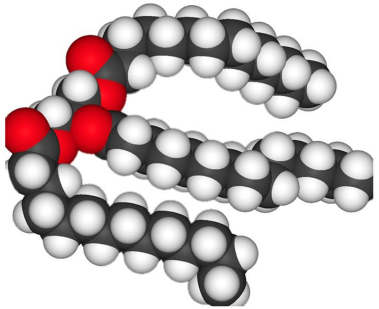
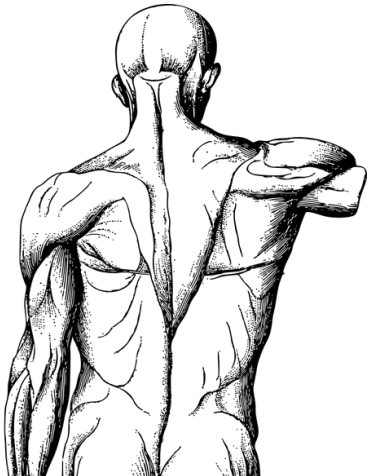
Fundamentals of Body Composition





Why does this matter?

- We may be most interested in **organ/tissue level entities** like adipose tissue and skeletal muscle.
  - Physiological and functional importance
- We are typically estimating **molecular level entities** like fat mass and lean mass.
- **These distinct entities are not the same.**
  - Fat mass ≠ adipose tissue
  - “Lean mass” ≠ skeletal muscle
    - “Lean mass” typically means FFM
      - A diverse, variable component

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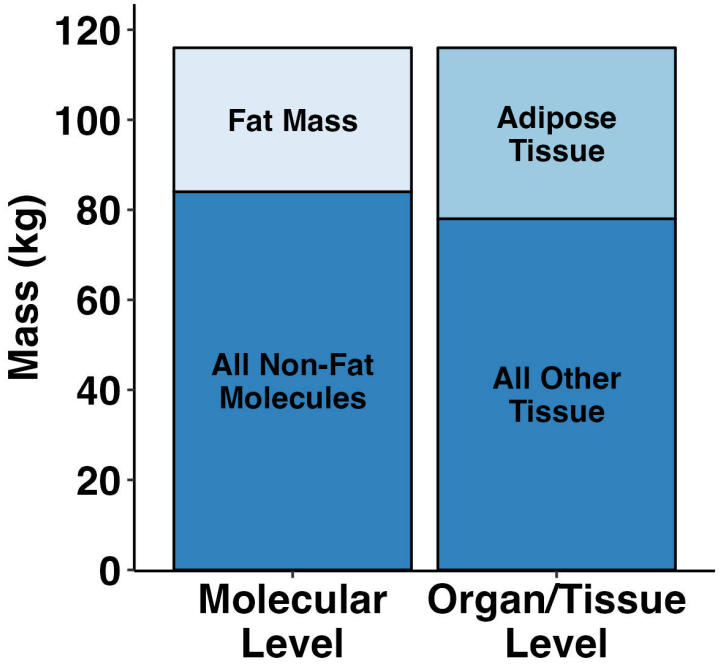
Fundamentals of Body Composition

Fat mass ≠ adipose tissue



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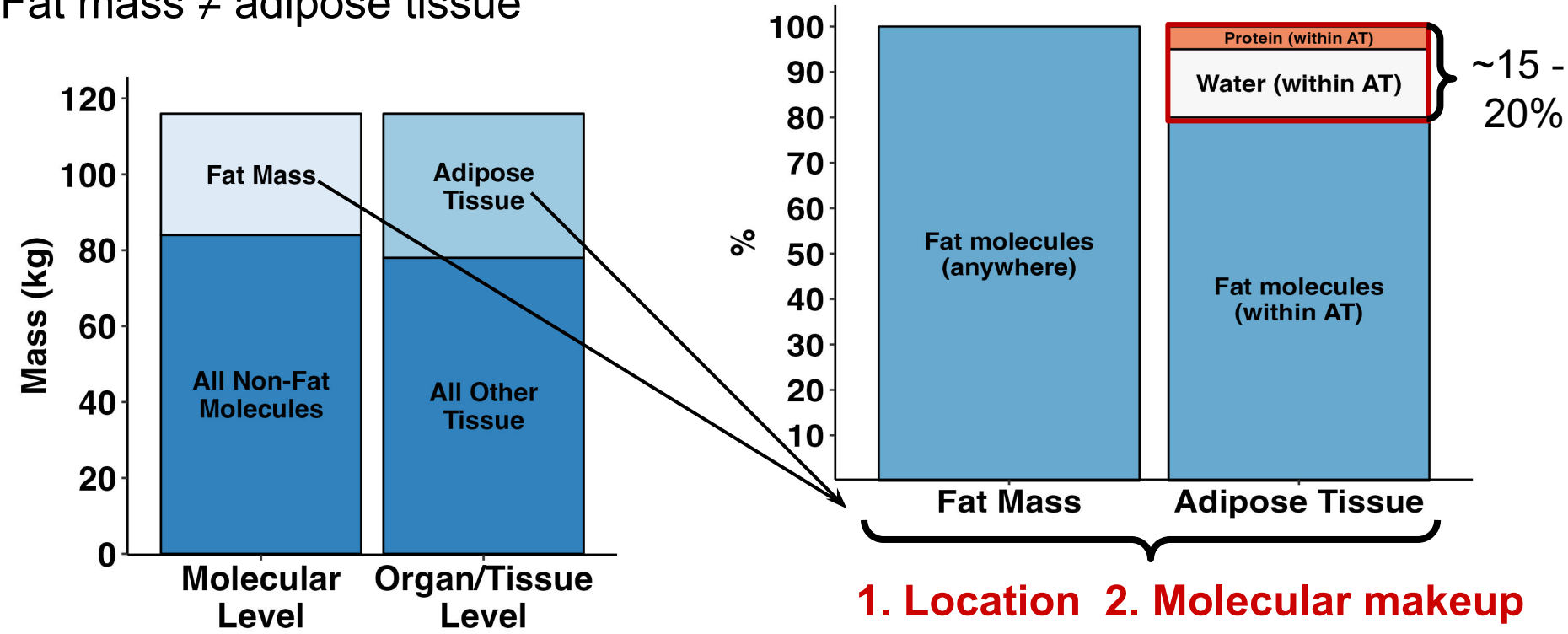
Fundamentals of Body Composition

Fat mass ≠ adipose tissue



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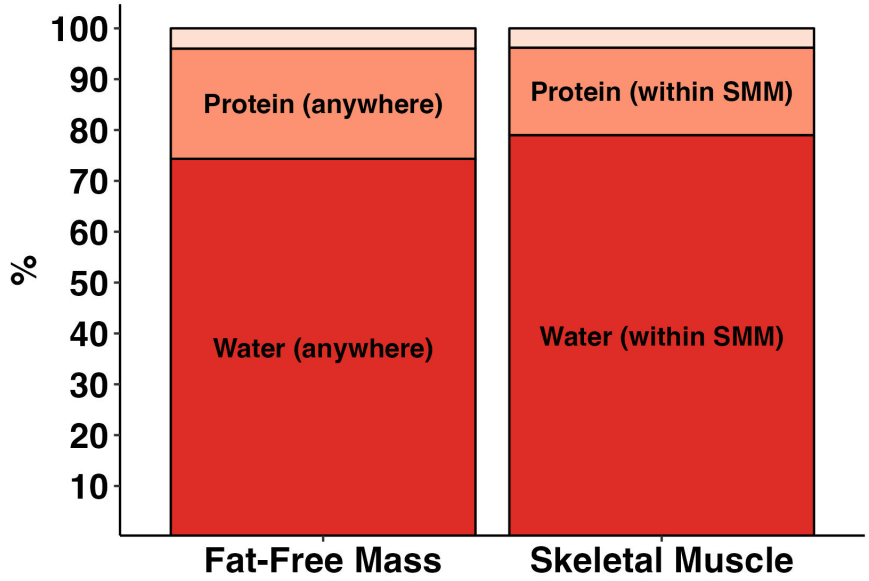
Fundamentals of Body Composition

"Lean mass" ≠ skeletal muscle



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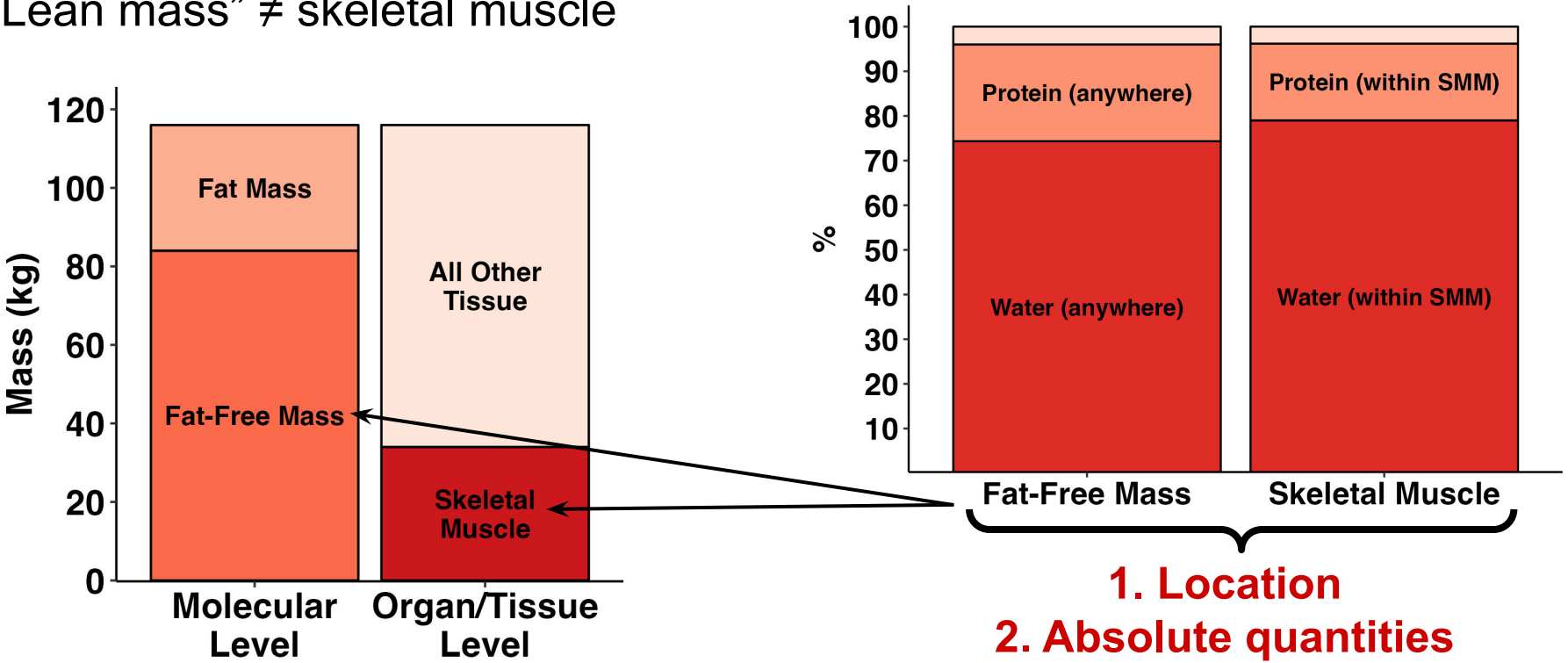
Fundamentals of Body Composition

"Lean mass" ≠ skeletal muscle

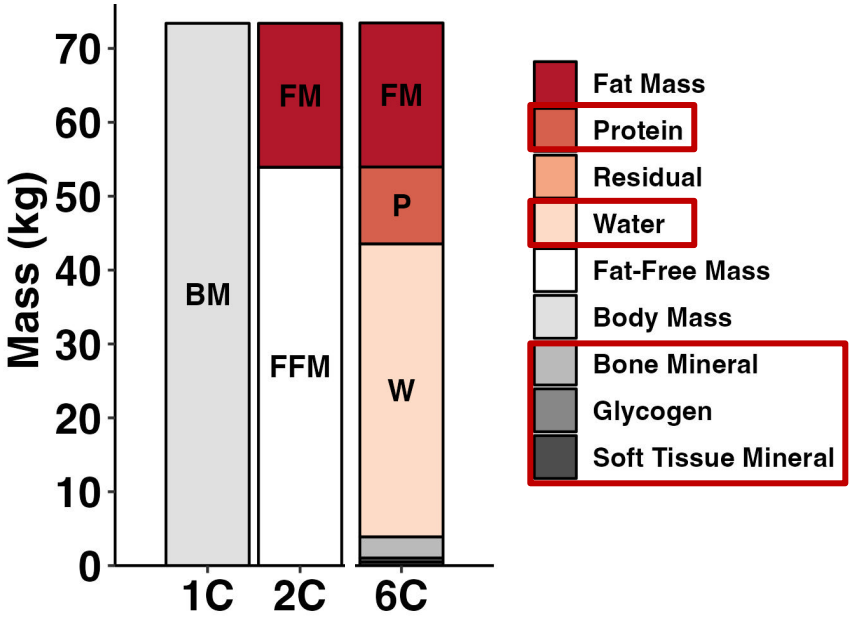


Obesity Treatment & Body Composition

Fundamentals of Body Composition

"Lean mass" (FFM) is a diverse, variable body component.[1]

- **Water**
  - Assumed: ~73%
  - Ranges from ~68 to 80%
- **Mineral**
  - Assumed: ~6.6%
  - Ranges from ~5 to 8%
- **Residual** (protein + glycogen)
  - Assumed: ~20%
  - Ranges from ~14 to 23%
  - Proportion varies



[1] *Snyder et al. 1975*

Obesity Treatment & Body Composition

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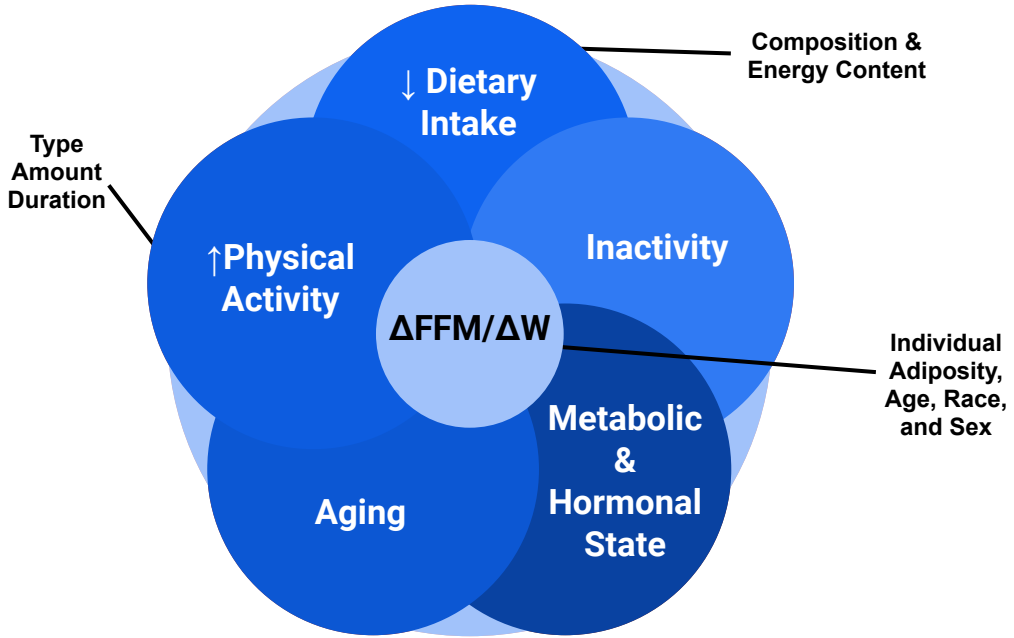
Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

1. **"Quarter FFM Rule"** historically states FFM loss is ~25% of weight loss[1]
   - Group-level support for this approximation as a reference point
   - Many factors can influence individual FFM loss (ΔFFM/ΔWeight)



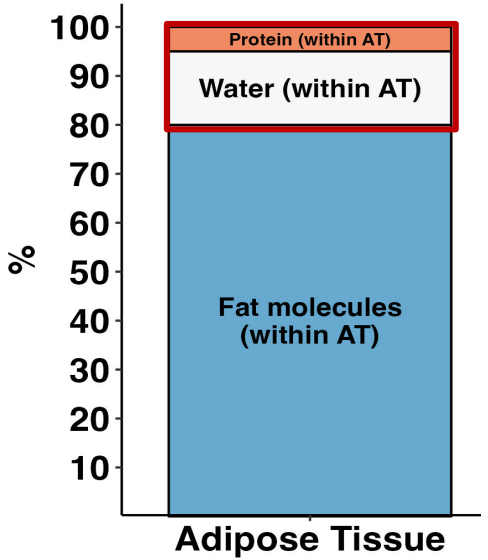
[1] *Adapted from Heymsfield et al. 2014, Obesity*

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

2. Adipose tissue has a **lean component** that contributes to FFM loss.

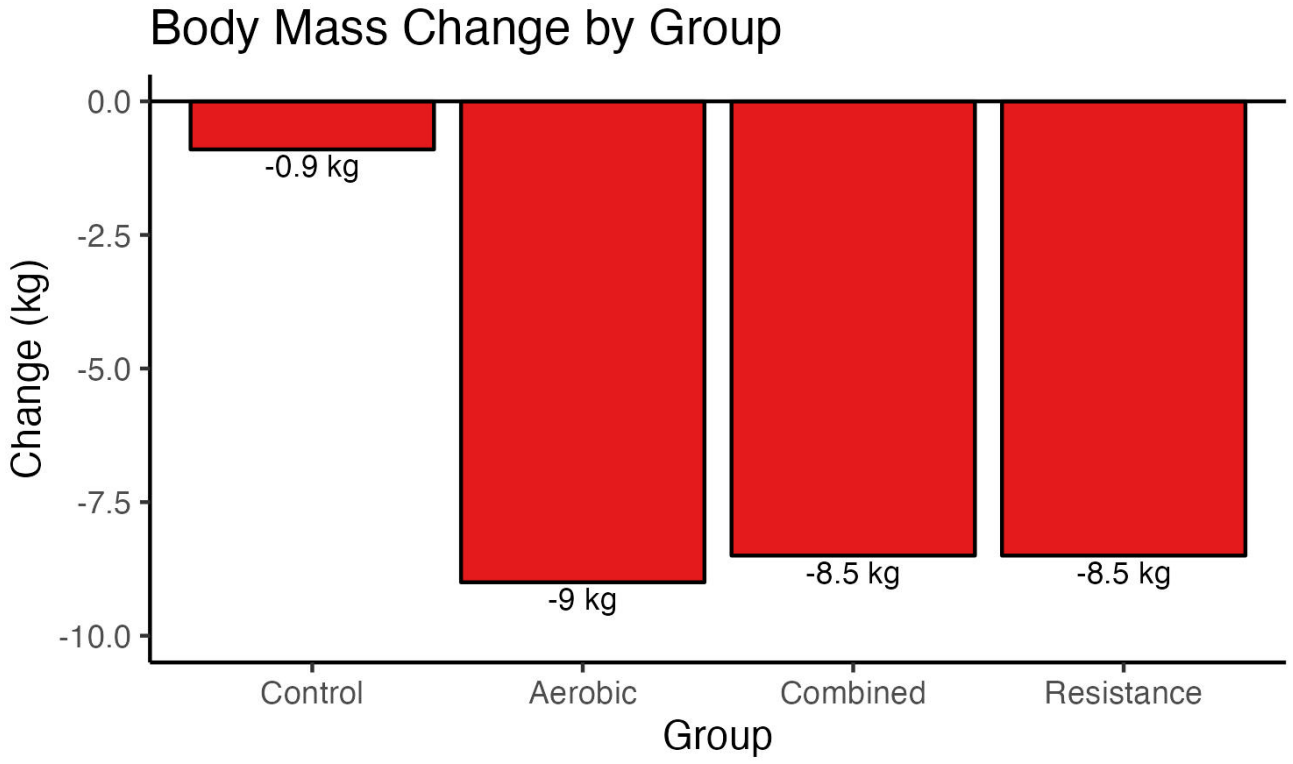
- Lean = non-fat
- Mostly a concern for large weight changes.
- *Obligatory* lean loss likely occurs.
  - Accounting for this reduces apparent FFM loss.[1]



[1]*Abe et al. 2019, Obesity*

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

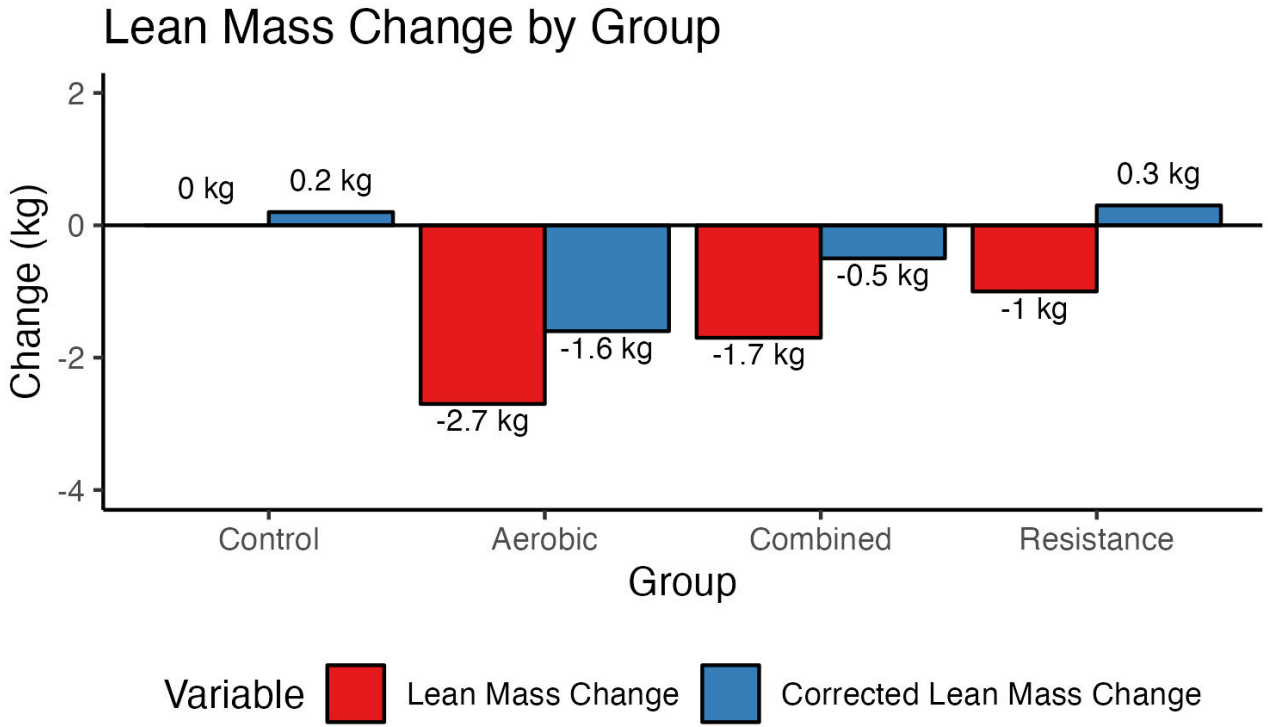


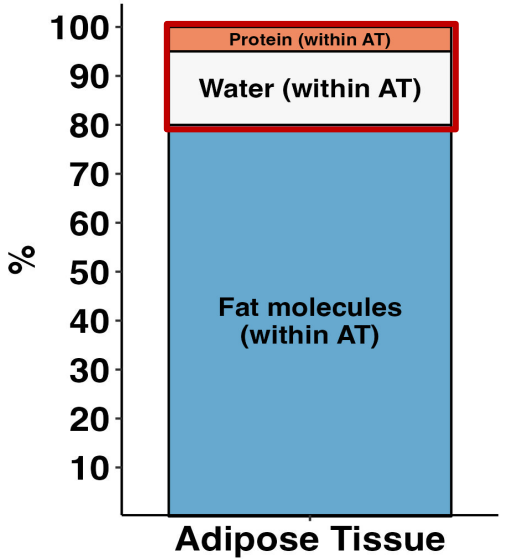
[1]*Abe et al. 2019, Obesity*

[2]***Villareal et al. 2017, N Engl J Med***

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass





[1]*Abe et al. 2019, Obesity*

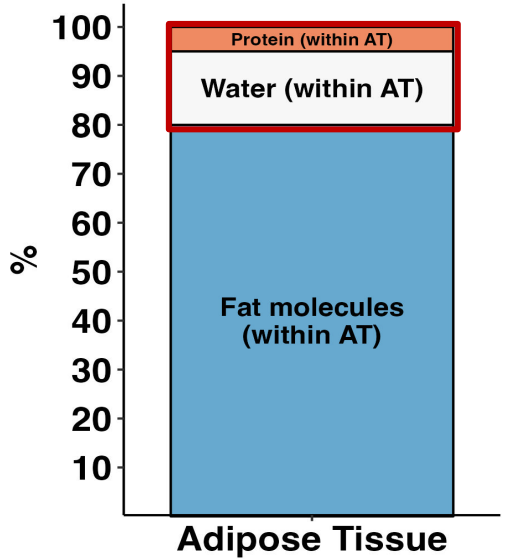
[2]***Villareal et al. 2017, N Engl J Med***

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

2. Adipose tissue has a **lean component** that contributes to FFM loss.

- Accounting for this reduces apparent FFM loss[1]
  - Aerobic exercise: **-30%** → **-17%** FFM loss
  - Combined exercise: **-20%** → **-6%** FFM loss
  - Resistance exercise: **-12%** → **+4%** FFM gain



[1]*Abe et al. 2019, Obesity*

[2]***Villareal et al. 2017, N Engl J Med***

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

2. Adipose tissue has a **lean component** that contributes to FFM loss.
   - The same corrections can be performed for GLP-1RA trials.
   - Example: Once weekly semaglutide (STEP 1 trial)[1]

	Reported Δ Lean Mass	Corrected Δ Lean Mass
Semaglutide	-6.9 kg (**40%** of weight loss)	-5.1 kg (**29%** of weight loss)
Placebo	-1.5 kg (**55%** of weight loss)	-1.3 kg (**48%** of weight loss)

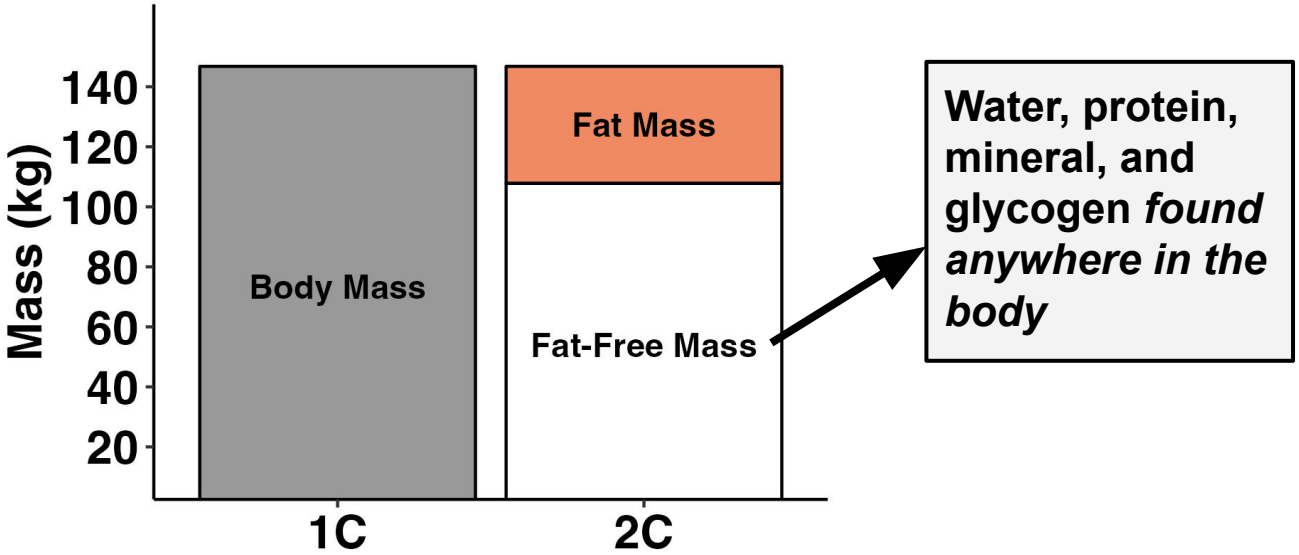
[1]*Wilding et al., N Engl J Med 2021*

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

3. The fact that “lean mass” ≠ skeletal muscle has implications for interpreting lean mass loss.

- **Lean mass lost is not exclusively skeletal muscle.**



Obesity Treatment & Body Composition

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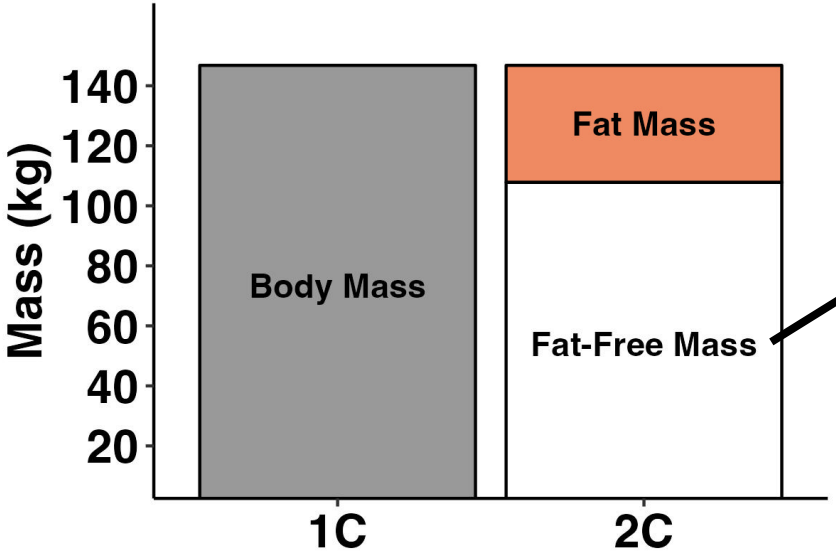
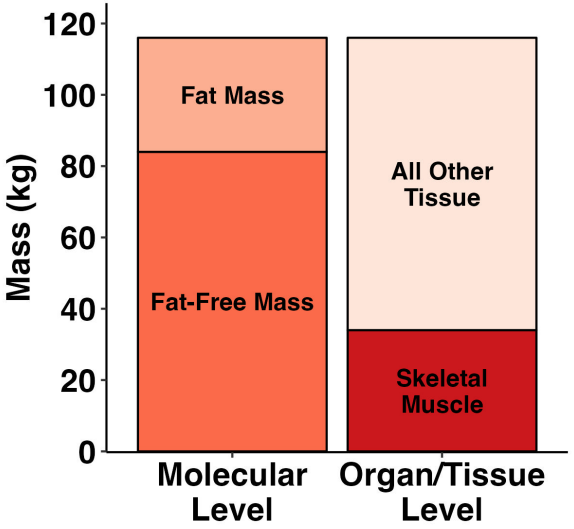


Water, protein, mineral, and glycogen *found anywhere in the body*



Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

3. The fact that “lean mass” ≠ skeletal muscle has implications for interpreting lean mass loss.

- **Lean mass lost is not exclusively skeletal muscle.**
  - Example: 9.5 ± 3.4 kg weight loss in women with overweight/obesity[1]
    - ↓ 8.0 ± 2.9 kg fat mass (84% of weight loss)
    - ↓ 1.5 ± 3.1 kg FFM (16% of weight loss)
      - ↓ **0.9 kg skeletal muscle mass (60% of FFM loss)**
      - ↓ 0.1 kg kidney, heart, liver masses (7% of FFM loss)
      - ↓ 0.5 kg lean component of adipose tissue, GI tract, skin, or unmeasured components (33% of FFM loss)

[1]*Bosy-Westphal et al. 2009, Am J Clin Nutr*

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

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    - ↓ 8.0 ± 2.9 kg fat mass (84% of weight loss)
    - ↓ 1.5 ± 3.1 kg FFM (16% of weight loss)
      - **↓ 0.9 kg skeletal muscle mass (60% of FFM loss)**
        - ~0.7 kg water (~46% of FFM loss)
        - ~0.15 kg protein (~10% of FFM loss)

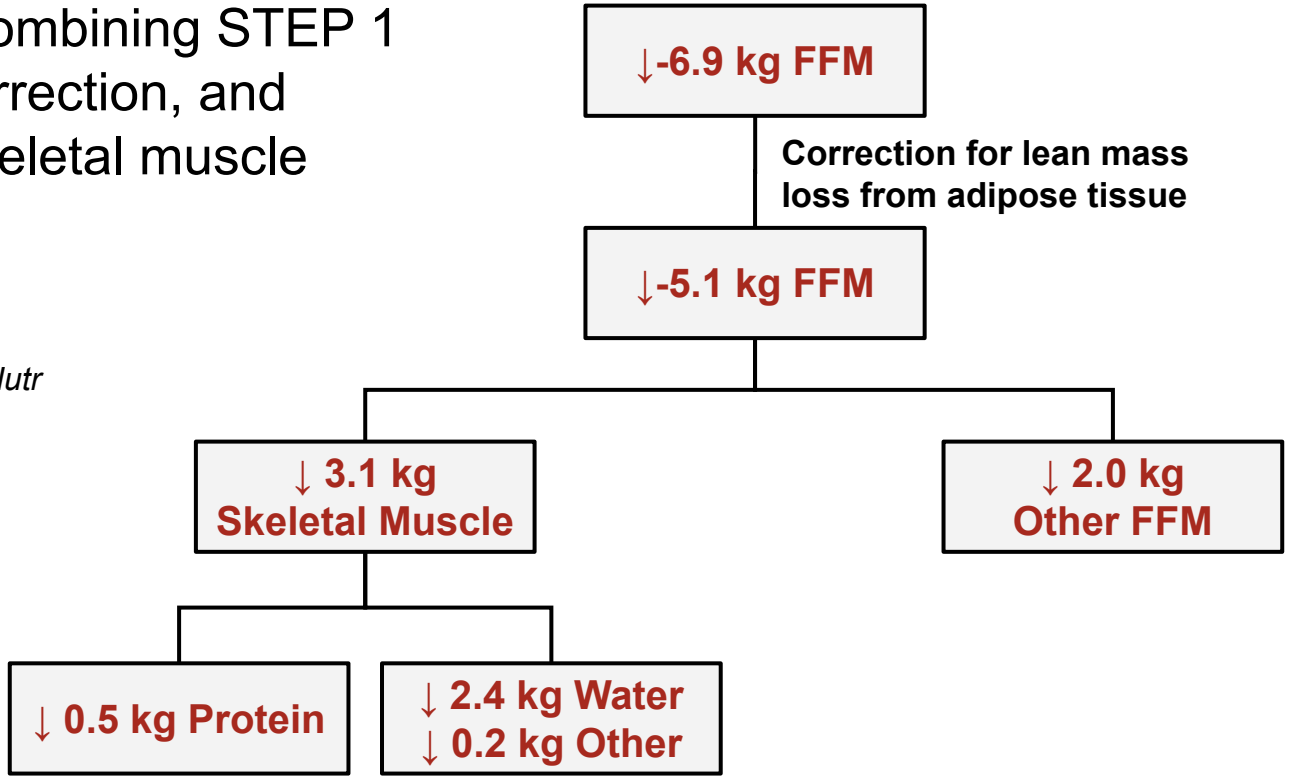
[1]*Bosy-Westphal et al. 2009, Am J Clin Nutr*

Obesity Treatment & Body Composition

Expected Loss of Lean and Muscle Mass

Hypothetical example combining STEP 1 data, lean mass loss correction, and proportion of FFM as skeletal muscle components.[1-3]

[1]Wilding et al., N Engl J Med 2021
[2]Abe et al. 2019, Obesity
[3]Bosy-Westphal et al. 2009, Am J Clin Nutr



Obesity Treatment & Body Composition

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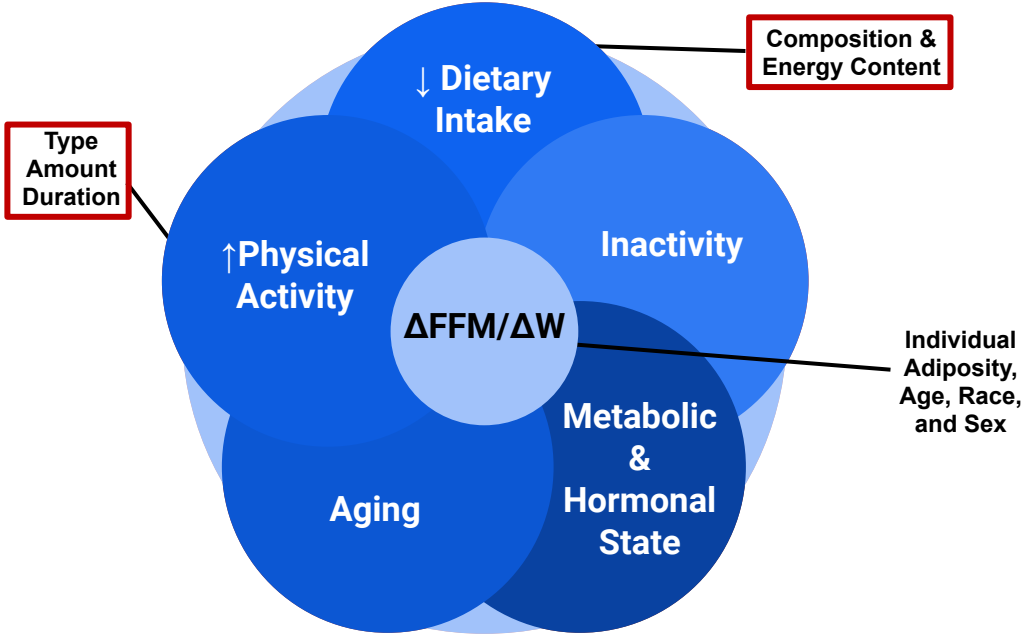
Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass



[1] *Adapted from Heymsfield et al. 2014, Obesity*

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

1. Resistance Exercise
    - Multiple forms of physical activity promote health, may aid weight loss, and promote lean and muscle retention with weight loss.[1]
    - **Resistance exercise** may be particularly effective for maintaining lean and muscle mass.[2,3]

[1]*Weinheimer et al. 2010, Nutr Rev*
[2]*Villareal et al. 2017, N Engl J Med*
[3]*Sardeli et al. 2018, Nutrients*

Obesity Treatment & Body Composition

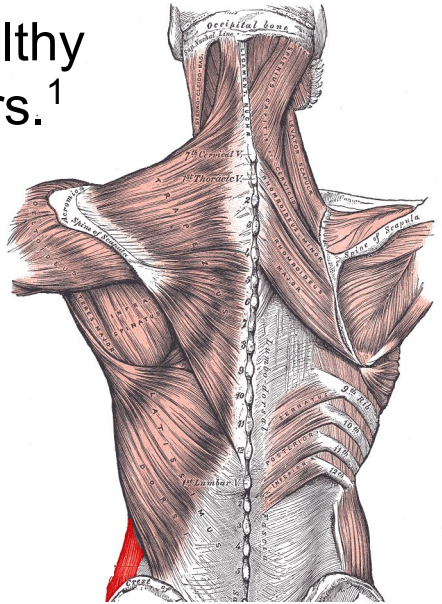
Minimizing Loss of Lean and Muscle Mass

1. Resistance Exercise
    - ***The Physical Activity Guidelines for Americans*** recommends muscle-strengthening exercise for those wanting to lose >5% body weight or trying to maintain weight loss.
    - **CDC** and **American College of Sports Medicine** (ACSM) recommendations include ≥2 “muscle strengthening activities” per week.

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

1. Resistance Exercise
    - ACSM provides resistance training (RT) recommendations for muscle strength and size in healthy adults with no RT experience or no RT in several years.[1]
        - **Exercise selection:** include a variety of exercises
            - Target all major muscle groups (i.e., legs, back, chest, shoulders, arms, core)
            - Multiple muscle actions (concentric, eccentric, isometric)
            - Bilateral and unilateral
            - Multi-joint and single-joint
            - Machine and/or free weights

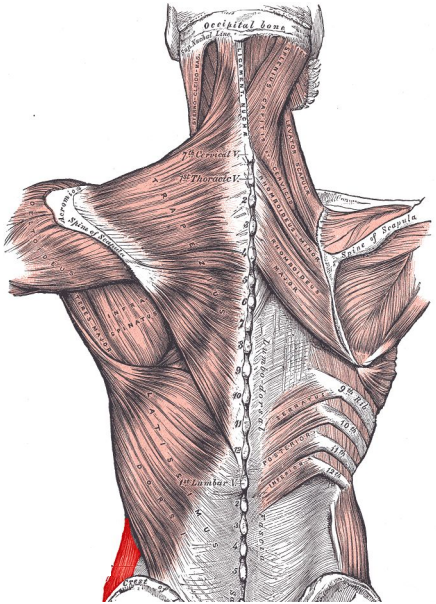


[1]*Position Stand, Med Sci Sport Exerc 2009*

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

1. Resistance Exercise
    - **Exercise Frequency**: 2 - 3 days per week
    - **Exercise Order** (within a session)
        - Large before small muscle groups
        - Multi-joint before single joint
        - Higher intensity before lower intensity

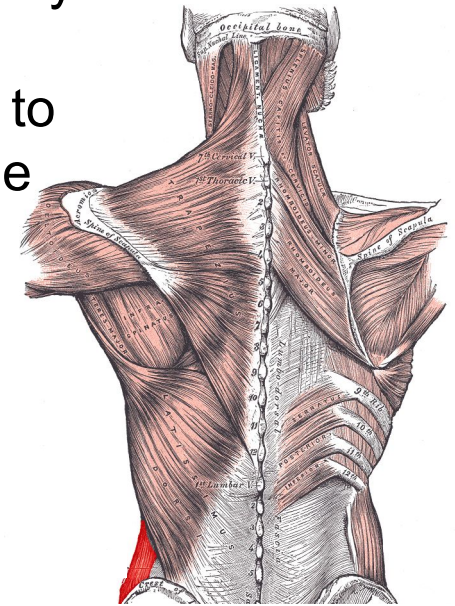


[1]*Position Stand, Med Sci Sport Exerc 2009*

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

1. Resistance Exercise
    - **Load and repetitions**: highest weight that can safely be used for 8 - 12 repetitions per set
        - Progression: weight is increased when needed to maintain challenging stimulus in repetition range
    - **Sets:** 1 - 3 sets per exercise recommended
    - **Speed**: moderate velocity
        - Not purposefully fast or slow
    - **Rest Periods**: 1 - 2 minutes between sets



[1]*Position Stand, Med Sci Sport Exerc 2009*

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

2. Protein intake
    - Background
        - Recommended dietary allowance (RDA): **0.8 g/kg**
        - Acceptable Macronutrient Distribution Range (AMDR): **10 to 35% of energy**

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

2. Protein intake
    - Demonstrated that 2X RDA (**1.6 g/kg**) reduces lean mass loss during 40% energy deficit as compared to RDA.[1]
    - Over 12 ± 9 weeks, intakes of **1.1 - 1.6 g/kg** led to greater weight loss and better lean mass preservation than 0.6 - 0.9 g/kg in individuals with overweight or obesity.[2,3]
    - **Collectively, numerous studies support benefits of protein intake above the RDA for lean mass maintenance during weight loss.**

[1]Pasiakos et al. 2013, FASEB
[2]Leidy et al. 2015, Am J Clin Nutr,
[3]Wycherley et al. 2012, Am J Clin Nutr

Obesity Treatment & Body Composition

Minimizing Loss of Lean and Muscle Mass

2. Protein intake
    - Total intake of **≥1.2 g/kg** or **≥20%** of energy may be appropriate
        - Typically prescribed as g/kg body mass, but could need tailoring for individuals with high body mass (e.g., g/kg relative to target body mass)
    - **Practical strategies**
        - 20 - 40 grams protein at each eating occasion
        - ≥ 3 eating occasions per day
        - *Behaviors* that promote target daily protein intake without need for long-term tracking

[1]*Pasiakos et al. 2013, FASEB*
[2]*Leidy et al. 2015, Am J Clin Nutr,*
[3]*Wycherley et al. 2012, Am J Clin Nutr*

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Obesity Treatment & Body Composition

Estimating Body Composition

All methods provide an *estimate* of body composition.

Method	What is *Measured*?
Bioimpedance	Raw bioimpedance (R, Xc, Z)
Hydrostatic weighing	Body density (mass/volume)
Air displacement plethysmography	Body density (mass/volume)
3D optical scanners	Circumferences and volumes
Skinfolds	Subcutaneous tissue thickness
Anthropometric body fat equations	Circumferences
Dual-energy X-ray absorptiometry	Attenuation of X-rays

Obesity Treatment & Body Composition

Estimating Body Composition

For more accurate estimates, **standardize** everything you can.

- Method of assessment
- Protocol
  - Pre-assessment
    - Equipment
    - Patient
  - Assessment
    - Trained assessor
    - Procedures
  - After Assessment
    - Data processing
    - Data use/interpretation

Nutritional status
- Fasted is ideal
- Limited or controlled fluid intake

Prior exercise
- Rested overnight is ideal

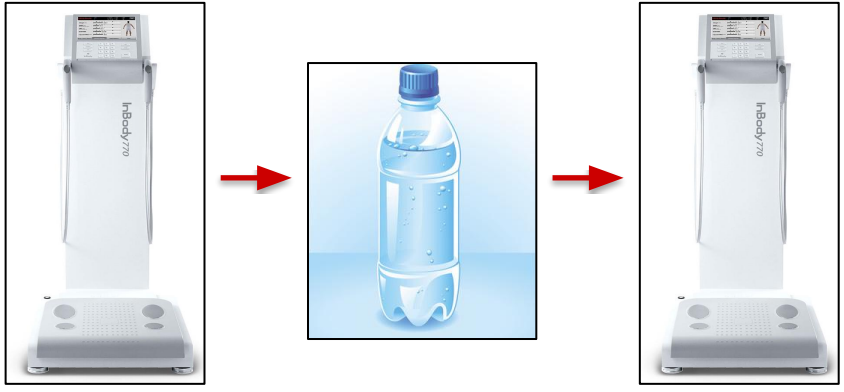
Time of day
- Morning is ideal

Sequence of events
- Void bladder
- Clothing/accessories
- Duration standing, supine, etc.
- Assessment steps

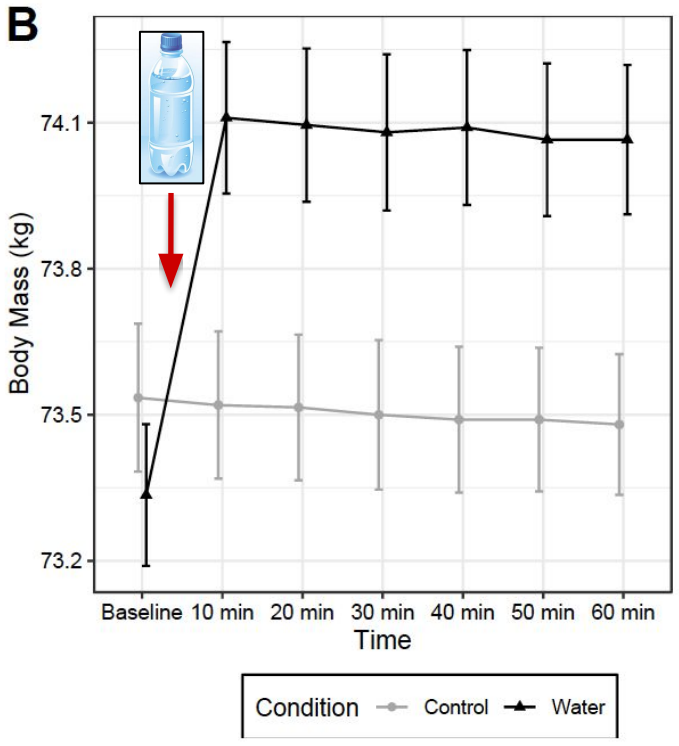
Obesity Treatment & Body Composition

Estimating Body Composition

How much does this really matter?



<u>Example</u>: Acute water consumption after overnight period of fasting and resting.

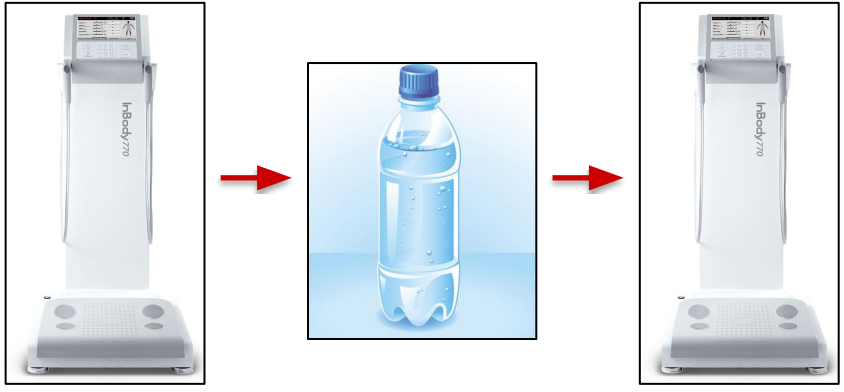


Tinsley et al. 2022, JoEB

Obesity Treatment & Body Composition

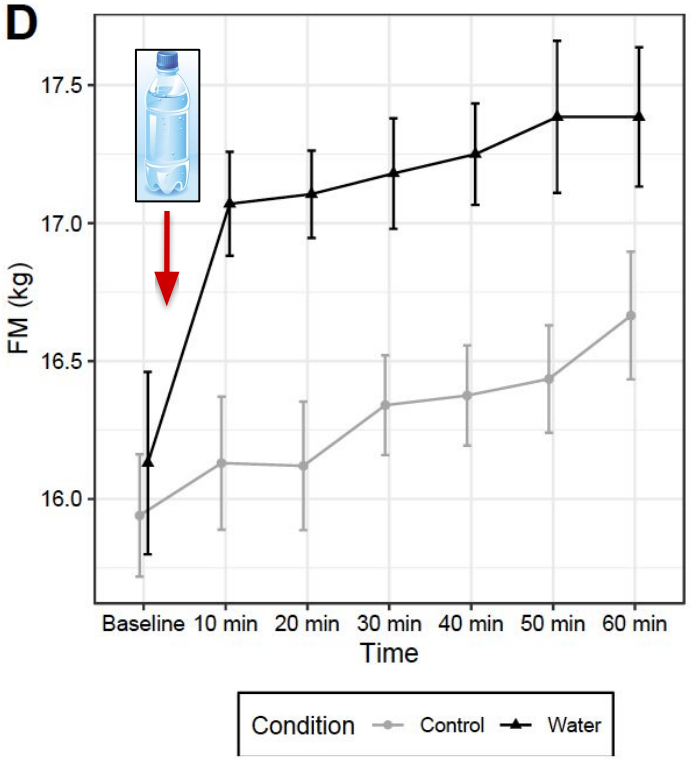
Estimating Body Composition

How much does this really matter?



Water consumption detected exclusively as **fat mass** (~1 kg) due to detection by built-in scale.

Tinsley et al. 2022, JoEB

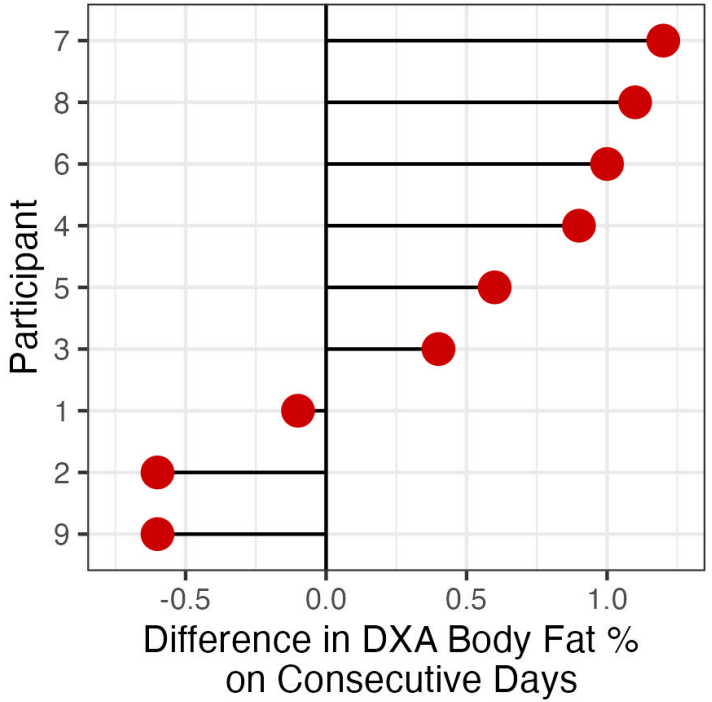


Obesity Treatment & Body Composition

Estimating Body Composition

Interpret results appropriately.

- Remember values are only an **estimate.**
- Understand the **technology** being used.
- Recognize that all methods have a margin of **error**.
  - Ideally, your facility-specific error should be considered.
- Interpret **holistically** and **cautiously**.



Obesity Treatment & Body Composition

Outline

1. Fundamentals of Body Composition
2. Expected Loss of Lean and Muscle Mass
3. Minimizing Loss of Lean and Muscle Mass
4. Estimating Body Composition
5. **Summary**

Obesity Treatment & Body Composition

Summary

1. Body composition principles can help contextualize body weight changes.
2. Large magnitudes of weight loss may result in artificially inflated loss of lean mass (fat-free mass), which is *not* synonymous with skeletal muscle.
3. Nonetheless, reducing the magnitude of lean and skeletal muscle loss is a worthy goal.
4. Exercise, especially resistance training, and higher protein intake can help preserve lean and muscle mass during weight loss.
5. If body composition is being estimated to track progress, understanding and minimizing errors can help maximize utility of data.

Thank you!

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