Sarcopenia: The Intersection of Aging, Loss of Lean Body Mass, and Frailty

Presented by

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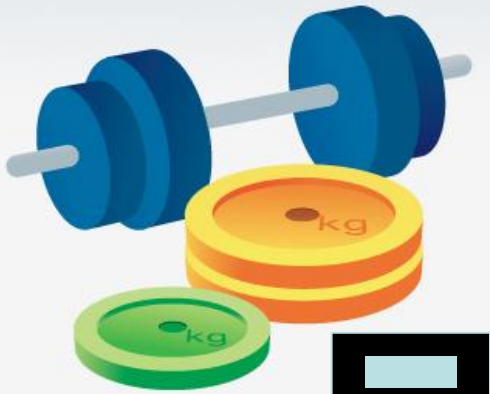
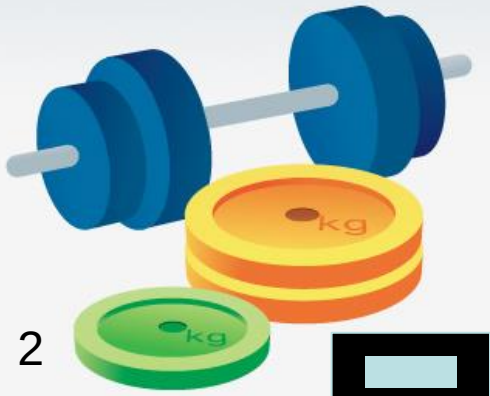


Presentation Objectives

- Describe the physiological roles of lean body mass
- Review the mechanisms and consequences of loss of lean body mass including frailty
- Discuss intervention steps to improve quality of life



Aging: Is 80 the New 50?

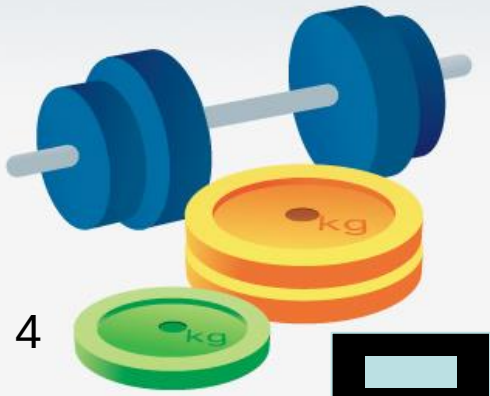
Oldest yoga teacher, Tao Porchon-Lynch, is 98 years old[1]

84-year-old Jules Winkler ran his 41st marathon last year[2]

1. Rosman K. A 98-year-old yoga celebrity tells it all. *New York Times* website.. Published November 26, 2016. Accessed September 8, 2021. https://www.nytimes.com/2016/11/26/fashion/tao-porchon-lynch-oldest-living-yoga-celebrity.html?_r=0
2. Hanc J. 6 things you can learn from an 84-year-old marathoner. Runners World website. http://www.runnersworld.com/boston-marathon/6-things-you-can-learn-from-an-84-year-old-marathoner. Published April 15, 2016. Accessed September 8, 2021.

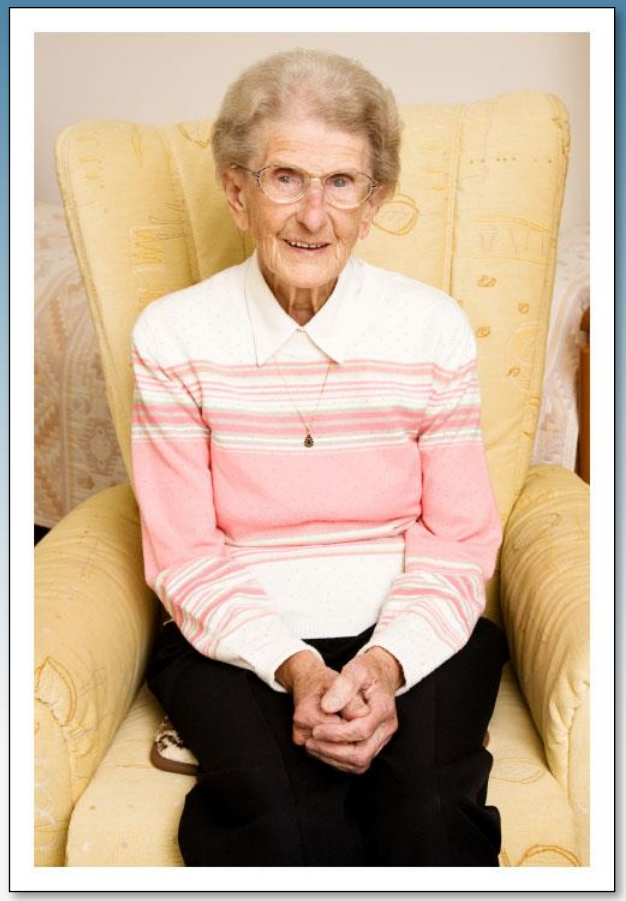
An Aging Population

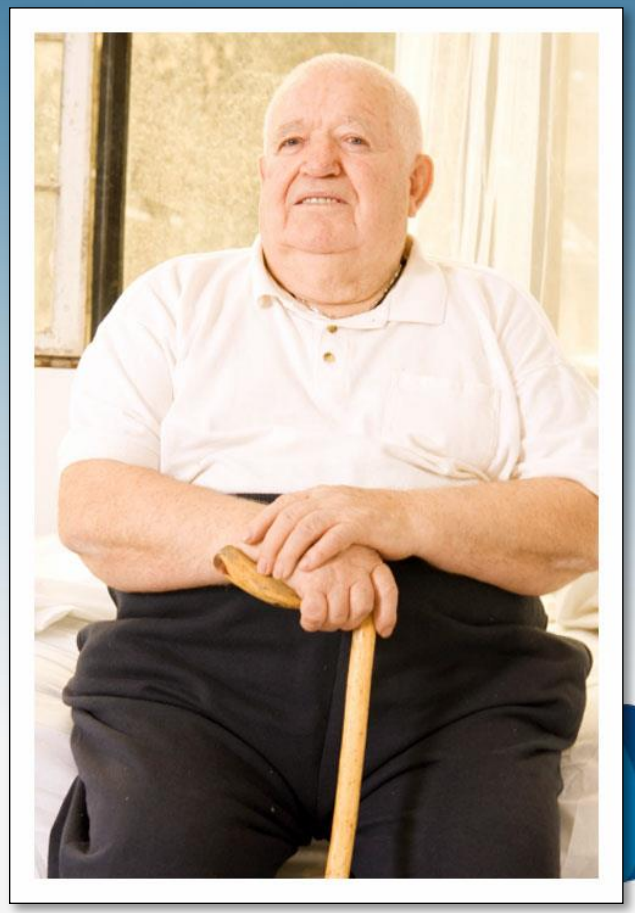
2014	2018	2060
46.2 million	52 million	95 million
14.5% of population	16% of population	>23% of population



Source: Population Reference Bureau. Fact Sheet: Aging in the United States. Available at https://www.prb.org/resources/fact-sheet-aging-in-the-united-states/. Accessed September 8, 2021.

What Is the Difference Between These Two Patients?





Fat vs Lean Mass[1]

Fat mass: less metabolically active tissue

- Pure energy source
- Expands/contracts with calorie intake and activity level

Lean mass: metabolically active tissue

- Compartment size is highly regulated
- Essential for survival
- Includes skeletal and smooth muscle, bone, tissue, collagen, vital organs, skin

1. Demling, RH. Nutrition, anabolism, and the wound healing process: an overview. *Eplasty*. 2009;9:e9.

What Is Lean Body Mass (LBM)?

- Organs, muscles, and bone[1]
- Responsible for body's functions[1]:
  - Supports skeleton
  - Muscles and connective tissue provide body with ability to move
  - Brain and nervous system—think, speak, learn, react, and adapt
  - Skin protection from environment
  - Organs—sustain life, digest nutrients, carry oxygen, maintain stable internal environment

1. Wardlaw GM, Kessel M. *Perspectives in Nutrition.* 5th ed. New York, NY: McGraw-Hill; 2002.

Causes of Loss of LBM[1,2]

Normal

- Aging
- Overtraining
- Poor diet
- Yo-yo dieting
- Lack of physical activity

Abnormal—stressed state

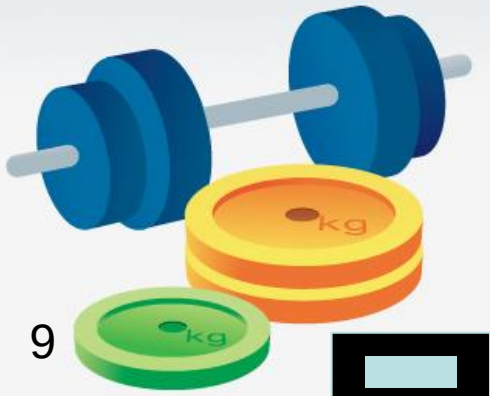
- Chronic conditions:
  - Cancer
  - Wounds
- Acute illnesses/complications:
  - Flu
  - Sepsis
- Surgical healing/immobilization:
  - General
  - Orthopedic
  - Cardiac
- Acute injuries/immobilization:
  - Sports related
  - Trauma/accidents
  - Burns

1. Hickson M. Malnutrition and ageing. *Postgrad Med J.* 2006;82(963):2-8.
2. Dhanapal R, Saraswathi TR, Govind RN. Cancer cachexia. *J Oral Maxillofac Pathol.* 2011;15(3):257-260.

Average Loss of Muscle With Age[1-6]

- After 40 years of age, muscle mass decreases by approximately 8% per decade
- After 70 years of age, muscle loss accelerates up to 15% per decade

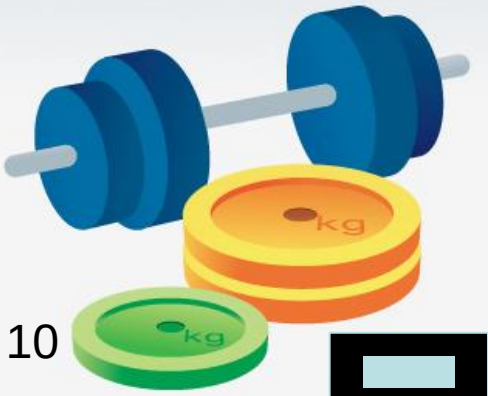
1. Grimsby G, Saltin B. *Clin Physiol.* 1983;3(3):209-218.
2. Janssen I et al. *J Appl Physiol.* 2000;89(1):81-88.
3. Grimsby GB et al. *Acta Physiol Scand.* 1982;115(1):125-131.
4. Larsson L et al. *J Appl Physiol.* 1979;46(3):451-456.
5. Flakoll P et al. *Nutrition*. 2004;20(5):445-451.
6. Baier S et al. *J Parenter Enteral Nutr*. 2009;33(1):71-82.



Loss of LBM[1]

Loss of LBM leads to:

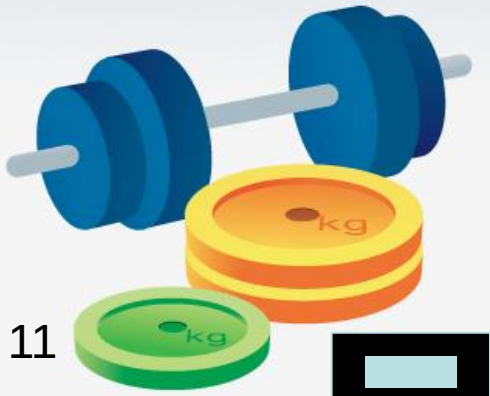
- Inability to heal and recover from surgery, illness, or disease
- Decreased strength and energy
- Loss of independence
- Increased risk of falls and fractures
- Weakened immune system and increased risk of infections
- Impaired healing
- Weakness/fatigue
- Increased susceptibility to illness
- Decreased quality of life



1. Wolfe RR. The underappreciated role of muscle in health and disease. *Am J Clin Nutr.* 2006;84(3):475-482.

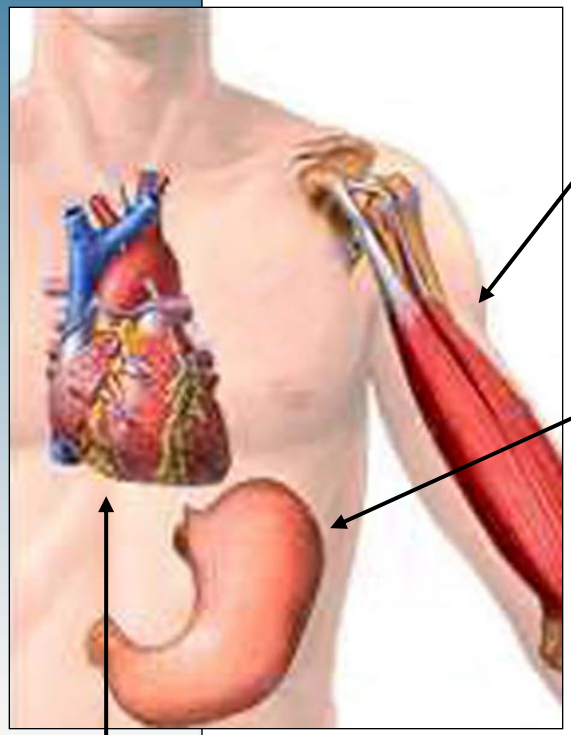
Loss of LBM Is Devastating[1]

Loss of total LBM (%)	Complications	Associated mortality (%)
10	Decreased immunity, increased infections	10
20	Decreased healing, weakness, increased infections	30
30	Too weak to sit, pressure injuries, pneumonia, no healing	50
40	Death, usually from pneumonia	100



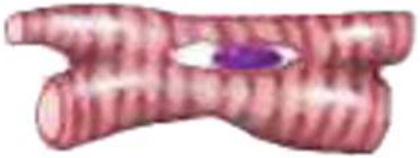
1. Demling RH, DeSanti L. Use of anticatabolic agents for burns. *Curr Opin Crit Care.* 1996;2:482-491.

Types of Muscles



Skeletal Muscle: attached to bones and moves the skeleton[1]

Smooth Muscle: located in the walls of hollow internal structures[1]

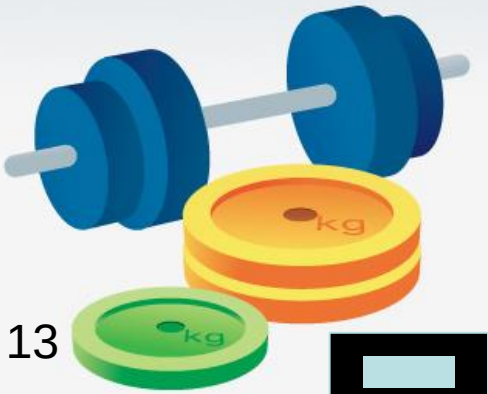


Cardiac Muscle: forms the heart[1]

1. Tortora GJ, Derrickson B. *Principles of Anatomy and Physiology*. 12th ed. Hoboken, NJ: John Wiley and Sons; 2009.

Functions of Skeletal Muscle[1]

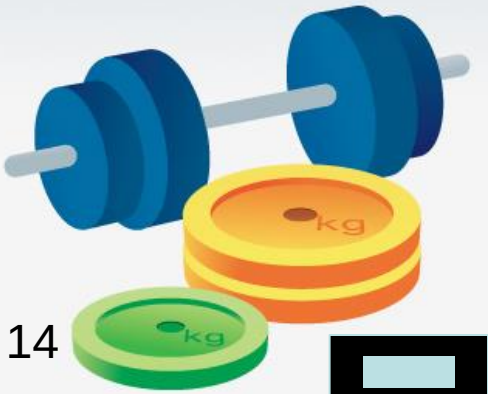
- Mobility
- Stabilizing body position
- Storing and moving substances in the body
- Generation of heat
- Serves as pool for protein for the body, not just for muscle, but for many tissues:
  - Skin integrity
  - Immune function
  - Healing
  - Repair
  - Digestion



1. Tortora GJ, Derrickson B. *Principles of Anatomy and Physiology*. 12th ed. Hoboken, NJ: John Wiley and Sons; 2009.

Maintenance of Muscle Is Clinically Important[1]

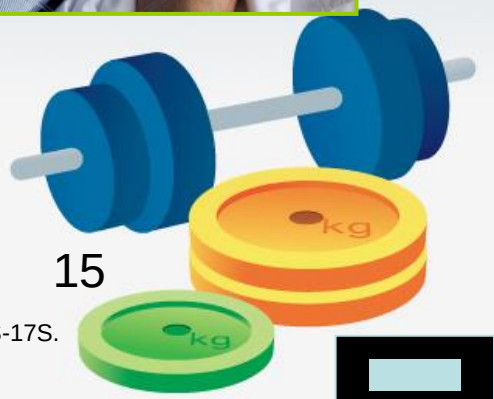
- Reservoir of amino acids to maintain protein synthesis
- Conservation of protein content in vital organs—skin, brain, heart, liver—essential for survival
- Normal cardiac, respiratory, and intestinal function
- Whole-body protein metabolism necessary for survival of the stress response



1. Wolfe RR. The underappreciated role of muscle in health and disease. *Am J Clin Nutr.* 2006;84(3):475-482.

Role of Muscle Mass in Stressed State

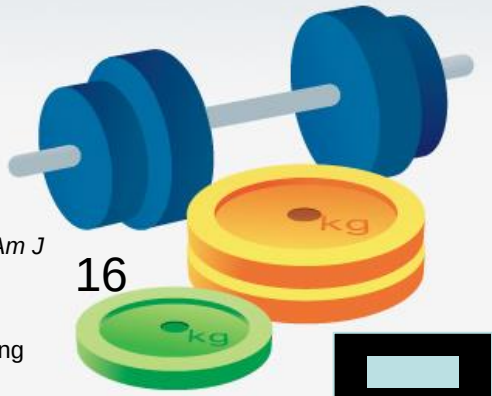
- Sepsis, cancer, trauma[1,2]:
- Accelerated synthesis of acute-phase proteins in liver, immunoproteins, proteins needed for wound healing[1]:
  - Great demand for amino acids— up to 4 times normal
- Muscle breaks down to provide amino acids[1]



1. Wolfe RR. The underappreciated role of muscle in health and disease. *Am J Clin Nutr.* 2006;84(3):475-482.
2. Cooper C. The crippling consequences of fractures and their impact on quality of life. *Am J Med.* 1997;103(2A):12S-17S.

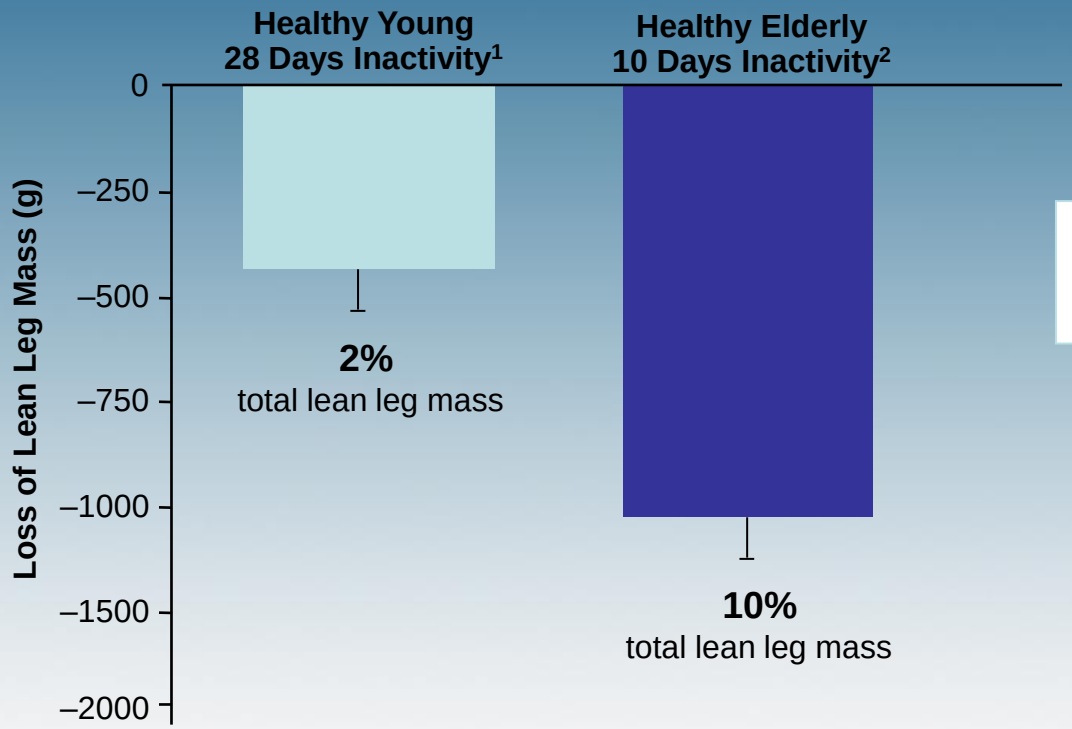
Impact of Muscle Mass, Strength, and Function on Recovery

- Inability to recover:
  - >50% of women older than 65 years of age who break a hip in a fall may never walk again[1]
- Inability to return to work:
  - <50% of individuals employed before entering an ICU return to work in the first year post-discharge[2]
- Recurrence of disease:
  - The amount of body protein predicted recurrence of disease[2]
  - Sarcopenic obesity is associated with[3]:
    - Poorer functional status
    - Independent predictor of survival



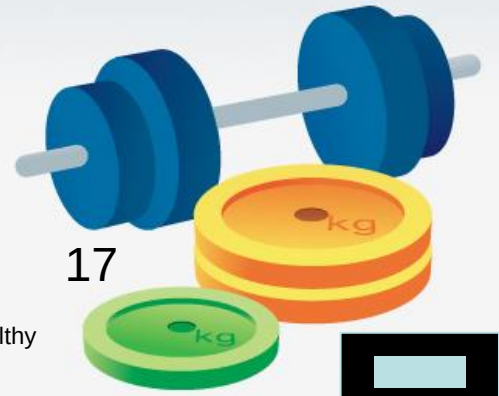
1. Baumgartner RN, Koehler KM, Gallagher D, et al. Epidemiology of sarcopenia among the elderly in New Mexico. *Am J Epidemiol*. 1998;147(8):755-763.
2. Bams JL, Miranda DR. Outcome and costs of intensive care. A follow-up on 238 ICU-patients. *Intensive Care Med.* 1985;11(5):234-241.
3. Kadar L, Albertsson M, Areberg J, Landberg T, Mattsson S. The prognostic value of body protein in patients with lung cancer. *Ann N Y Acad Sci*. 2000;904:584-591.

Muscle Loss With Inactivity



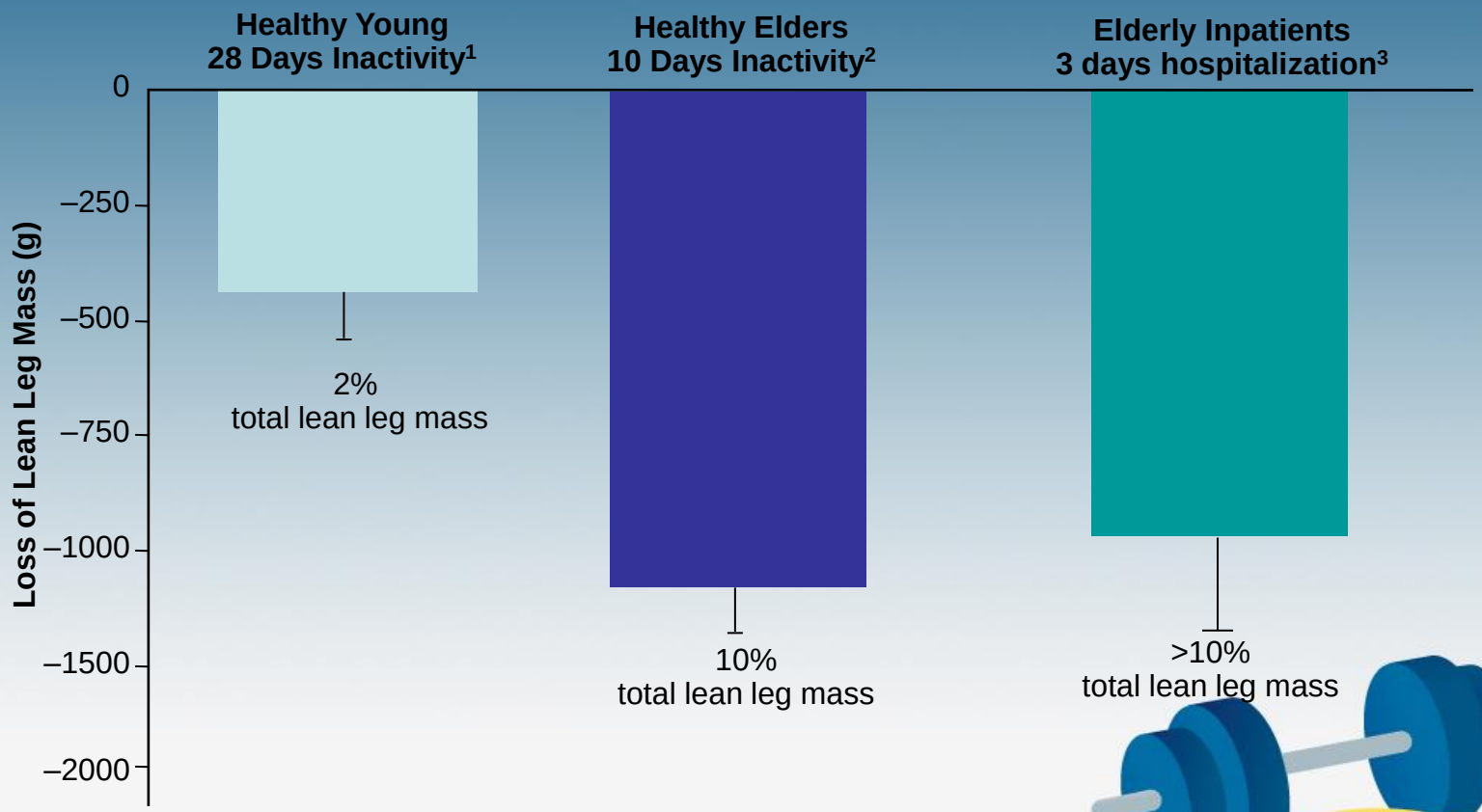
- 3 times more muscle loss
- 1/3 the time

Note: All volunteers consumed the RDA for protein.



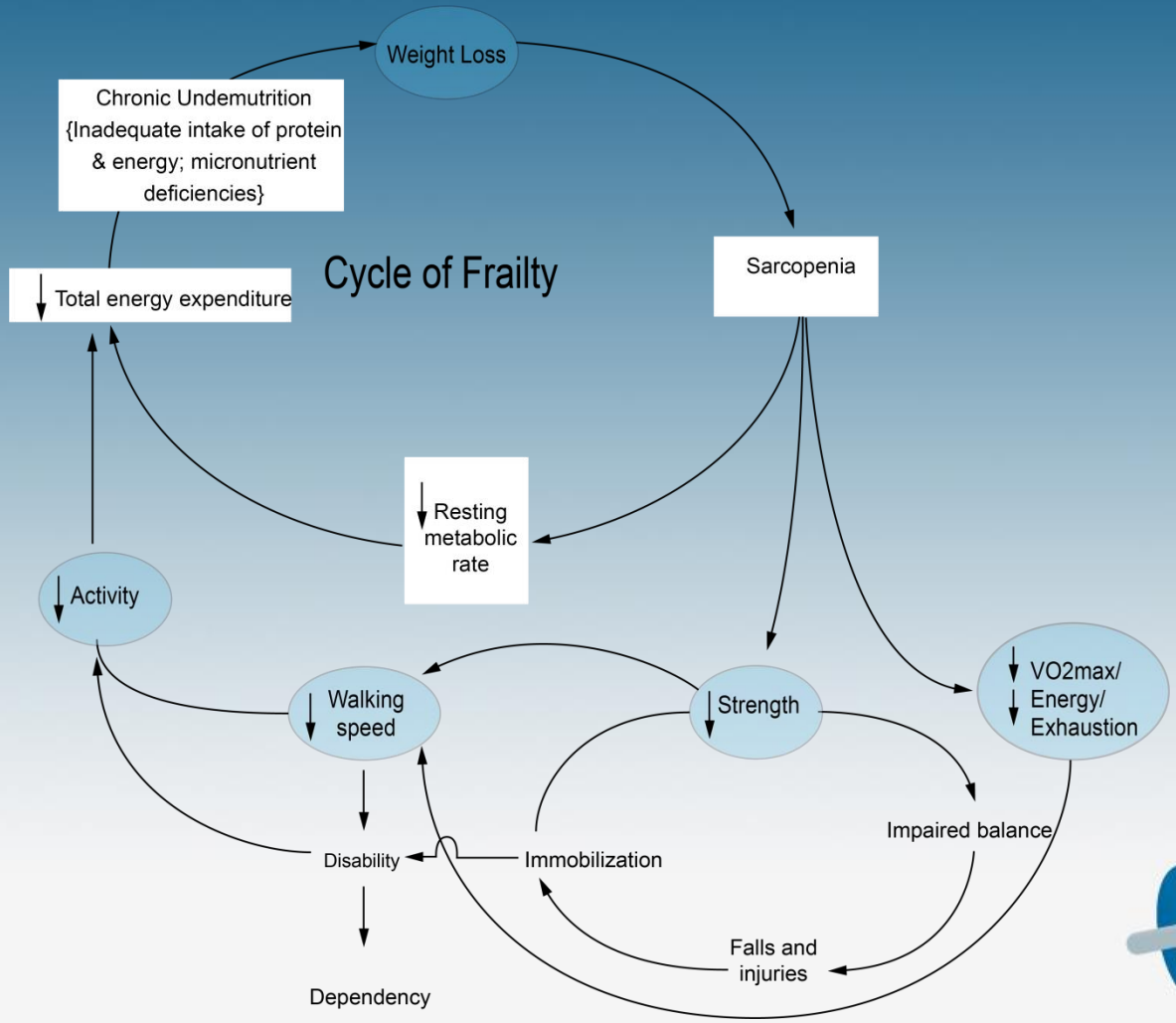
1. Paddon-Jones D, Sheffield-Moore M, Urgan RJ, et al. Essential amino acid and carbohydrate supplementation ameliorates
muscle protein loss in humans during 28 days bedrest. *J Clin Endocrinol Metab.* 2004;89(9):4351-4358.
2. Kortebein P, Ferrando A, Lombeidea J, Wolfe R, Evans WJ. Effect of 10 days of bed rest on skeletal muscle in healthy older adults. *JAMA.* 2007;297(16):1772-1774.

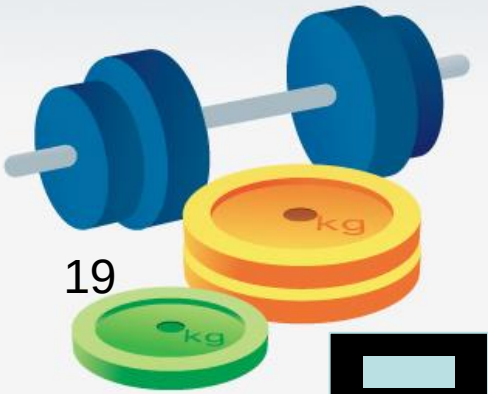
Muscle Loss in Hospitalized Elders



1. Paddon-Jones D, Sheffield-Moore M, Urban RJ, et al. Essential amino acid and carbohydrate supplementation ameliorates muscle protein loss in humans during 28 days bedrest. *J Clin Endocrinol Metab.* 2004;89(9):4351-4358.
2. Kortebein P, Ferrando A, Lombeida J, Wolfe R, Evans WJ. Effect of 10 days bed rest on skeletal muscle in healthy older adults. *JAMA.* 2007;297(16):1772-1774.
3. Paddon-Jones D. Lean body mass loss with age. In: Gussler J, Graham MA , eds. *The Role of Nutrition in the Accretion, Retention, and Recovery of Lean Body Mass,* Report of the 110th Abbott Nutrition Research Conference. Columbus, OH: Abbott Nutrition; 2010: 95-100.

Cycle of Frailty[1]





1. Xue QL, Bandeen-Roche K, Varadhan R, et al. Initial manifestations of frailty criteria and the development of frailty phenotype in the Women's Health and Aging Study II. *J Gerontol A Biol Sci Med Sci* .2008;63(9):984-90.

Clinical Frailty Scale*

1 **Very Fit** – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.

2 **Well** – People who have **no active disease symptoms** but are less fit than category 1. Often, they exercise or are very **active occasionally**, e.g. seasonally.

3 **Managing Well** – People whose **medical problems are well controlled,** but are **not regularly active** beyond routine walking.

4 **Vulnerable** – While **not dependent** on others for daily help, often **symptoms limit activities.** A common complaint is being "slowed up", and/or being tired during the day.

5 **Mildly Frail** – These people often have **more evident slowing,** and need help in **high order IADLs** (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.

6 **Moderately Frail** – People need help with **all outside activities** and with **keeping house**. Inside, they often have problems with stairs and need **help with bathing** and might need minimal assistance (cuing, standby) with dressing.

7 **Severely Frail** – **Completely dependent for personal care**, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).

8 **Very Severely Frail** – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.

9. **Terminally Ill** - Approaching the end of life. This category applies to people with **a life expectancy <6 months**, who are **not otherwise evidently frail.**

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common **symptoms in mild dementia** include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In **moderate dementia**, recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In **severe dementia**, they cannot do personal care without help.

* 1. Canadian Study on Health & Aging, Revised 2008.
2. K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489-495.

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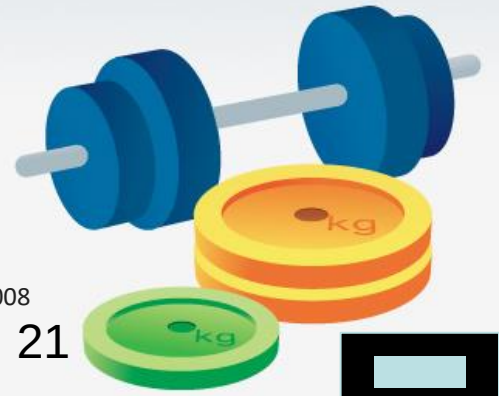
Source: Geriatric Medicine Research, Dalhousie University, Halifax, Canada, 2009.

Screening for Frailty[1]

- F (Fatigue): Is the patient easily fatigued?
- R (Resistance): Is the patient unable to walk up one flight of stairs?
- A (Ambulation): Is the patient unable to walk one block?
- Illnesses: Does the patient have more than five illnesses?
- L (Loss of weight): Has the patient lost more than 5% of weight in the past 6 months?

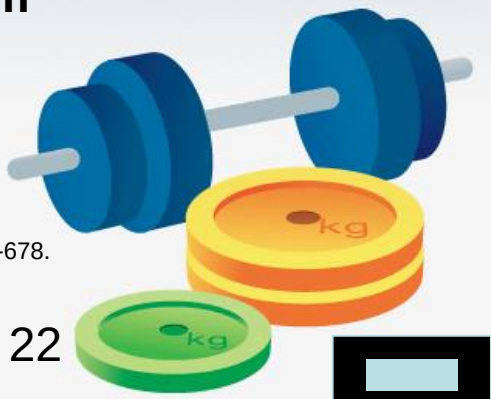
- Not Frail: 0 • Intermediate: 1-2 • Frail: ≥3



1. Abellan van Kan G, Rolland YM, Morley JE, Vellas B. Frailty: toward a clinical definition. J Am Med Dir Assoc. 2008 Feb;9(2):71-2. doi: 10.1016/j.jamda.2007.11.005. PMID: 18261696.

Sarcopenia vs Wasting vs Cachexia

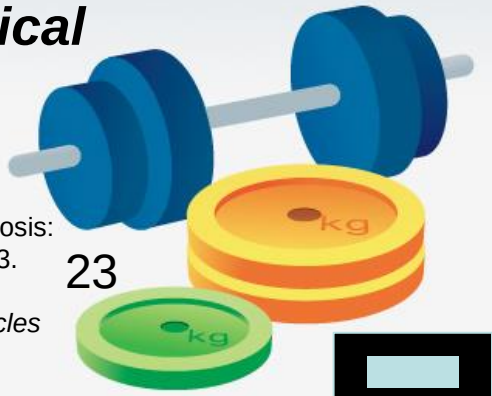
- **Sarcopenia** is progressive loss of muscle mass, functionality, and strength[1]:
  - Driven by the **normal aging process** in everyone, even athletes
- **Wasting** is involuntary loss of weight[2]:
  - Driven by **inadequate dietary intake** and **anorexia**
- **Cachexia** is "a complex metabolic syndrome associated with underlying illness and characterized by loss of muscle with or without loss of fat mass"[3]:
  - Driven by **hypercatabolism** and **hypermetabolism**



1. Bauer J, Soeber CC. Sarcopenia and frailty: a clinician's controversial point of view. *Exp Gerontol.* 2008;43(7):674-678. doi:10.1016/j.exger.2008.03.007.
2. Roubenoff R. The pathophysiology of wasting in the elderly. *J Nutr.* 1999;129(1S suppl):256S-259S.
3. Evans WJ, Morley JE, Argilés J, et al. Cachexia: a new definition. *Clin Nutr.* 2008;27(6):793-799. doi:0.1016/j.clnu.2008.06.013.

Sarcopenia: Definition

- Definition:
  - Syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength that comes with **aging**[1]
  - Most people begin to lose modest amounts of muscle mass after 30 years of age, but the resulting loss of strength increases exponentially with age[1,2]
  - Possible effects include decreased muscle strength, problems with mobility, frailty, falls and fractures, decreased activity levels, and a ***loss of physical function and independence***[1]

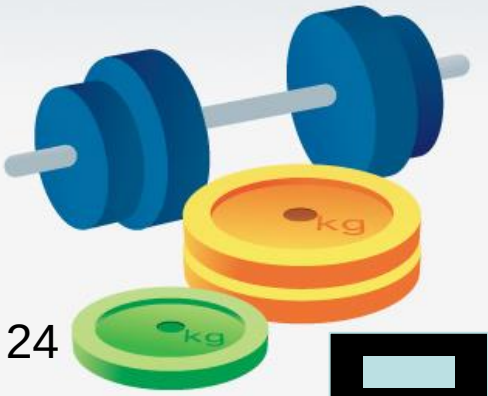


1. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing*. 2010;39(4):412-423. doi:10.1093/ageing/afq034.
2. Keller K, Engelhardt M. Strength and muscle mass loss with aging process. Age and strength loss. *Muscles Ligaments Tendons J.* 2014;3(4):346-350.

Suggested Criteria for Sarcopenia[1]

Diagnosis is based on documentation of criterion 1 plus either criterion 2 or criterion 3

1. Low muscle mass
2. Low muscle strength
3. Low physical performance



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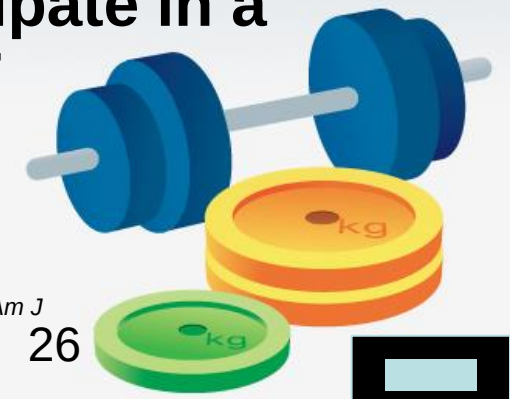
Measuring Lean Mass, Strength, and Functionality

Dimension	Research	Clinical practice
Muscle mass	▪ Anthropometry ▪ CT ▪ MRI ▪ Potassium ▪ DEXA ▪ BIA	▪ Anthropometry ▪ BIA ▪ DEXA
Muscle strength	▪ Handgrip strength ▪ Knee flexion/extension (1RM) ▪ Peak expiratory flow	▪ Handgrip strength ▪ Peak expiratory flow
Physical performance	▪ Short Physical Performance Battery (SPPB) ▪ Gait speed ▪ 6-minute walk ▪ Stair climbing ▪ Timed up and go	▪ SPPB ▪ Gait speed ▪ Timed up and go

What Are the Outcomes?

- Frailty[1]:
  - Sarcopenia **reduces ability** to walk, stair climb, rise from a chair, and carry a load
- Increased risk of falls/broken bones[1]
- Increased risk of depression because of loss of independence[1]
- Reduced aerobic capacity[1]:
  - Sarcopenia contributes to the **decline of aerobic capacity, thus limiting the extent to which older individuals may participate in a variety of activities and retain their independence**



1. Baumgartner R, Koehler KM, Gallagher D, et al. Epidemiology of sarcopenia among the elderly in New Mexico. *Am J Epidemiol.* 1998;147(8):755-763.

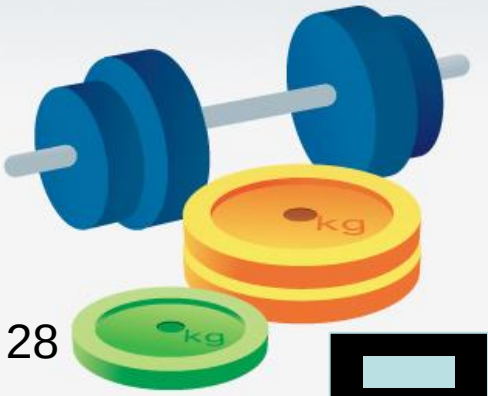
Sarcopenic Obesity[1,2]

- Obesity+sarcopenia= increased disability
- Increased weakness coupled with extra weight to carry:
  - Because of decades of inactivity and too many calories?
- Vicious cycle of increased fat, decreased muscle, chronic disease, and increased disability
- Quality of life drops

1. Roubenoff R. Catabolism of aging: is it an inflammatory process? *Curr Opin Clin Nutr Metab Care.* 2003;6(3):295-299.
2. Roubenoff R. Sarcopenic obesity: the confluence of two epidemics. *Obesity Res.* 2004;12(6):887-888.

Why Does It Occur?[1]

- Physical inactivity
- Motor unit remodeling
- Decreased anabolic stimuli
- Decreased protein synthesis
- Decreased dietary intake
- Infiltration of fat and connective tissue



1. Roubenoff R. Sarcopenia: effects on body composition and function. *J Gerontol A Biol Sci Med Sci.* 2003;58(11):1012-1017.

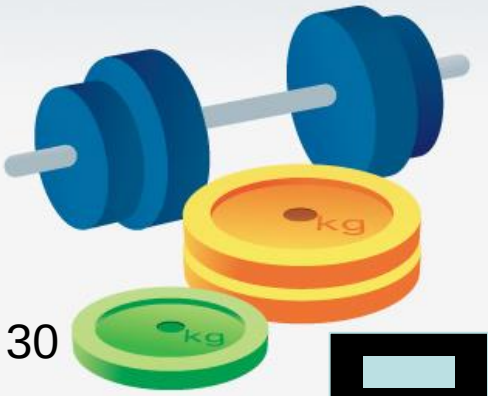
Physical Inactivity[1]

- Sarcopenia is accelerated with physical inactivity
- Physically inactive adults have a faster and greater loss of muscle mass than physically active adults
- Sarcopenia is **not completely prevented by exercise** and is seen but to a lesser degree than in physically active individuals

1. Roubenoff R. Sarcopenia: effects on body composition and function. *J Gerontol A Biol Sci Med Sci.* 2003;58(11):1012-1017.

Motor Unit Remodeling

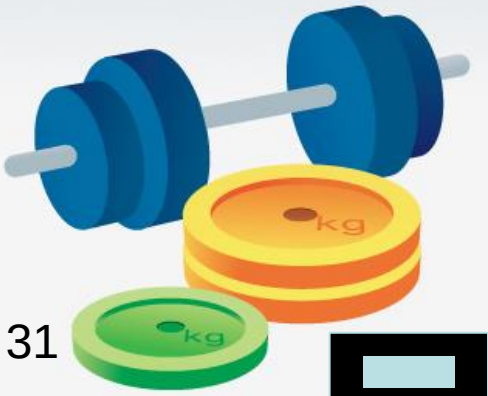
- Loss of muscle begins with the loss of motor neurons[1]
- Motor neurons die with age, resulting in a denervation of the muscle fibers within the motor unit; muscle fibers atrophy and eventually die, leading to a decrease in muscle mass[1]
- Healthy people in their 60s have lost up to one-half of their motor unit neurons compared to people in their 20s[2]



1. Roth SM, Ferrell RF, Hurley BF. Strength training for the prevention and treatment of sarcopenia. *J Nutr Health Aging.* 2000;4(3):143-155.
2. Doherty TJ, Vandervoot AA, Taylor AW, Brown WF. Effects of motor unit losses on strength in older men and women. *J Appl Physiol.* 1993;74(2):868-874.

Hormones[1]

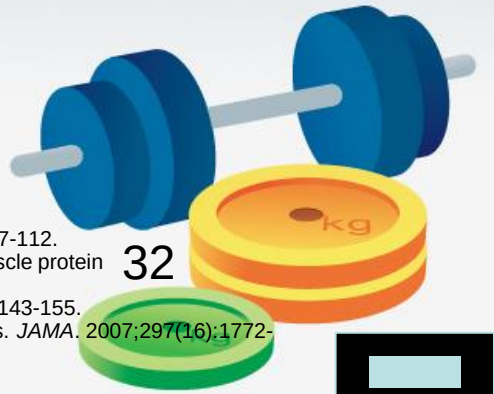
- Aging is associated with decreased concentrations of growth hormone (GH), testosterone (T), and insulin-like growth factor (IGF-1)
- A decrease in the concentrations of these hormones may link to the development of sarcopenia:
  - GH and IGF-1 play a dominant role in the regulation of protein metabolism
  - GH and T are required for protein maintenance
  - IGF-1 levels are positively correlated with muscle protein synthesis rates



1. Roubenoff R. Sarcopenia and its implications for the elderly. *Eur J Clin Nutr.* 2000;54(suppl 3):S40-S47.

Protein Synthesis

- With aging, the changes in whole-body protein turnover reflect a **decreased synthesis rate,** rather than an **increased catabolic rate**[1]
- Research consistently has reported that muscle **protein synthesis rates are lower in older adults** when compared to younger adults[2-4]
- Ability of the muscle to regenerate following injury or overload also is decreased with age[5]



1. Nair KS. Aging muscle. *Am J Clin Nutr.* 2005;81(5):953-963.
2. Nair KS. Muscle protein turnover: methodological issues and the effect of aging. *J Gerontol A Biol Sci Med Sci.* 1995;50: spec 107-112.
3. Yarasheski KE, Pak-Loduca J, Hasten DL, Obert KA, Brown MB, Sinacore DR. Resistance exercise training increases mixed muscle protein synthesis rate in frail women and men >/=76 yr old. *Am J Physiol*. 1999;277(1 pt 1):E118-E125.
4. Roth SM, Ferrell RF, Hurley BF. Strength training for the prevention and treatment of sarcopenia. *J Nutr Health Aging.* 2000;4(3):143-155.
5. Kortebein P, Ferrando A, Lombeida J, Wolfe R, Evans WJ. Effect of 10 days of bed rest on skeletal muscle in healthy older adults. *JAMA*. 2007;297(16):1772-1774.

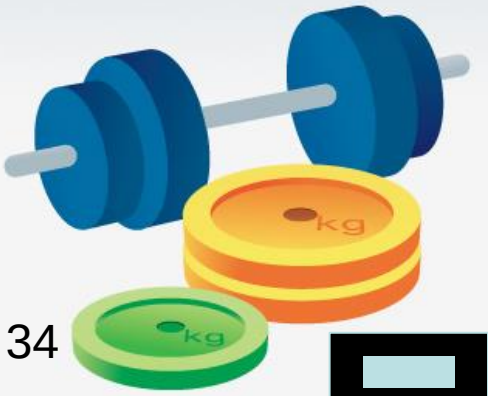
Dietary Intake[1]

- Development of sarcopenia also may relate to **inadequate energy intake**
- Many older individuals **may not take in enough calories and/or protein** to sustain their muscle mass

1. Evans WJ. Protein nutrition, exercise and aging. *J Am Coll Nutr.* 2004;23(6 suppl):601S-609S..

Inflammatory Component[1]

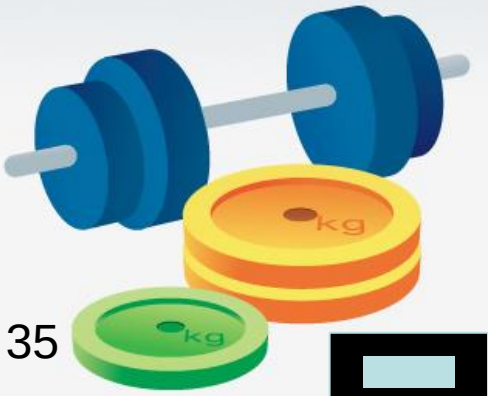
- Catabolic stimuli also may play a role
- Interleukin-6—three possible mechanisms:
  - Direct catabolic effect
  - Reduces appetite
  - Affects hormones:
    - Increased insulin resistance
    - Decreased IGF



1. Roubenoff R. Catabolism of aging: is it an inflammatory process? *Curr Opin Clin Nutr Metab Care.* 2003;6(3):295-299.

Interventions

- Progressive resistance exercise
- Provision of adequate high-quality protein at each meal
- Amino acids to activate mTOR
- The future:
  - Studies on creatine, DHEA, HMB, essential amino acids, protein, and much more!

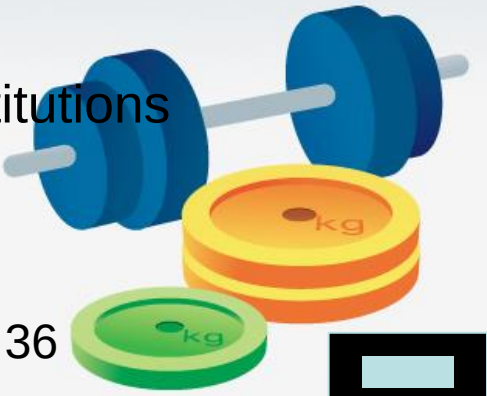


Address Reversibles[1]

M Medication effects
E Emotional problems, especially depression
A Anorexia tardive (nervosa), alcoholism
L Late-life paranoia
S Swallowing disorders

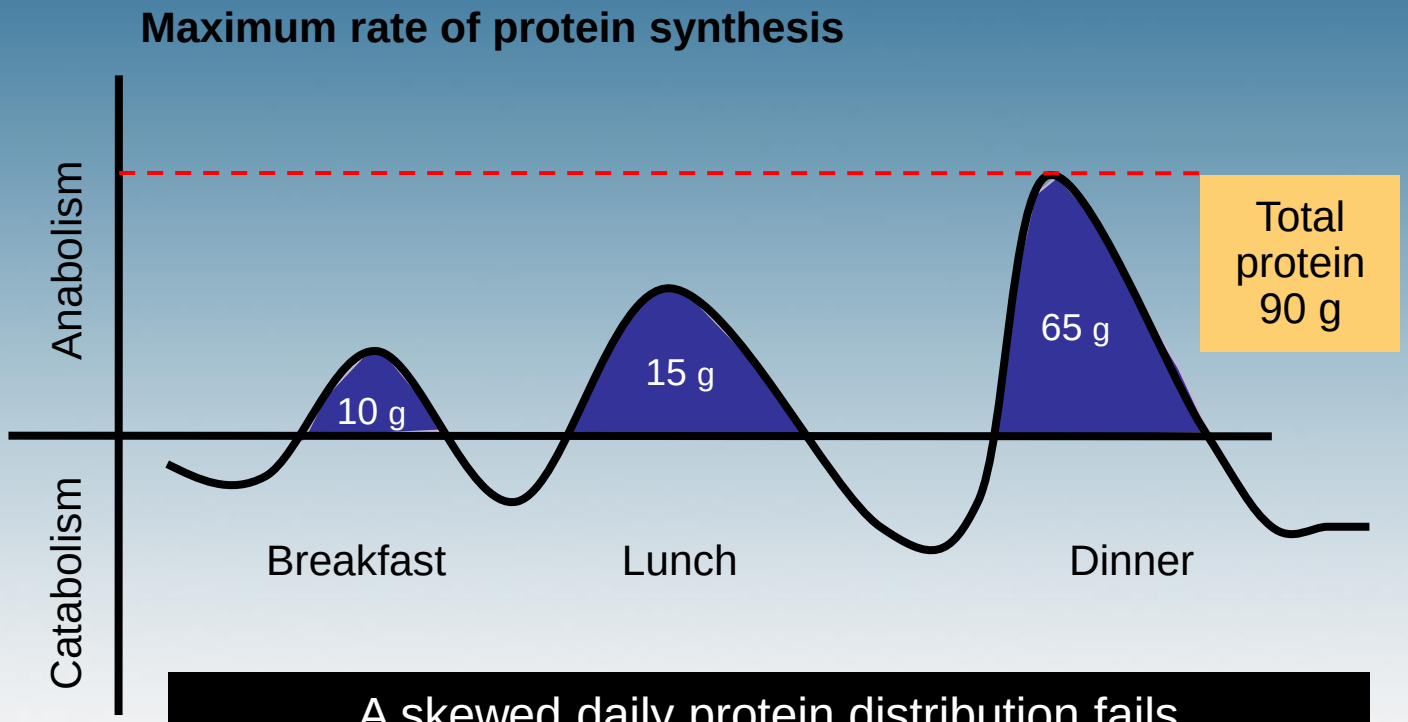
O Oral factors (poor fitting dentures, cavities)
N No money

W Wandering and other dementia-related behaviors
H Hormonal (eg, hyperthyroidism)
E Enteric problems (eg, malabsorption)
E Eating problems (eg, inability to self-feed)
L Low-salt, low-cholesterol diets, especially in institutions
S Social problems (eg, isolation, inability to obtain preferred foods)

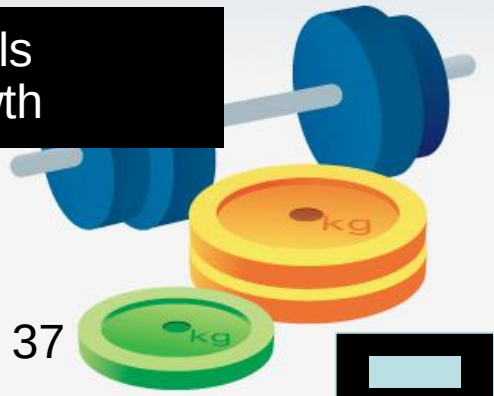


1. Morlley JE, Silver AJ. Nutritional issues in nursing home care. *Ann Intern Med.* 1995;123(11):850-859.

Daily Protein Distribution: Typical[1]

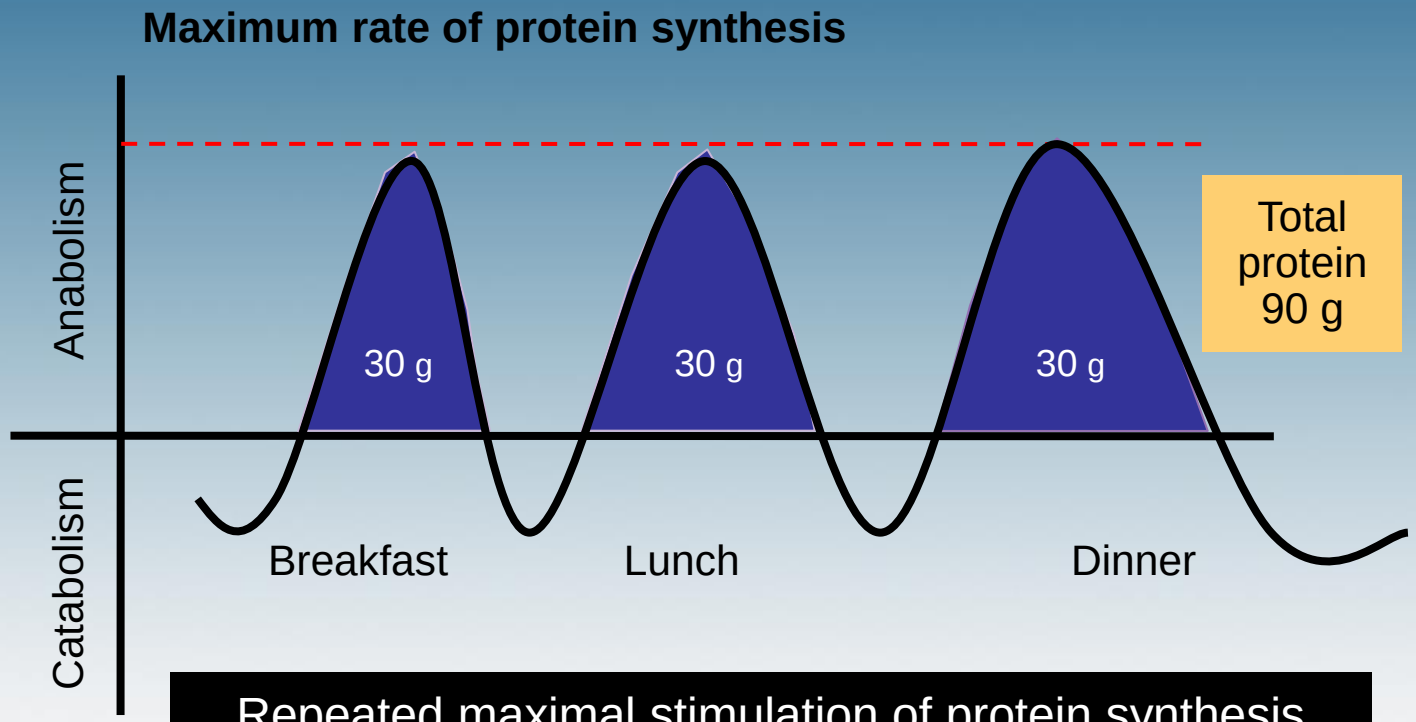


A skewed daily protein distribution fails to maximize potential for muscle growth



1. Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia. *Curr Opin Clin Nutr Metab Care.* 2009;12(1):86-90. doi:10.1097/MCO.0b013e32831cef8b.

Daily Protein Distribution: Proposed[1]

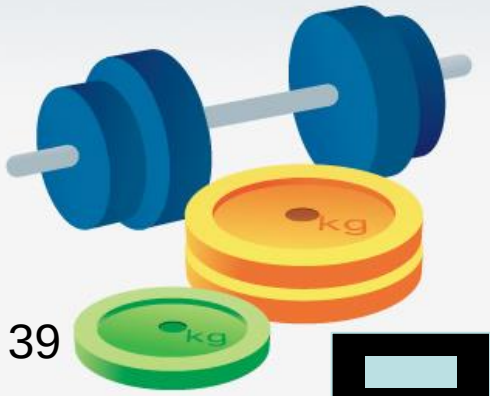


Repeated maximal stimulation of protein synthesis
→ increase/maintenance of muscle mass

1. Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia. *Curr Opin Clin Nutr Metab Care.* 2009;12(1):86-90. doi:10.1097/MCO.0b013e32831cef8b.

Take Home Points

1. Overweight and underweight patients both lose LBM because of aging, immobility, and disease
2. Look beyond scale weight to body composition
3. Encourage timely nutrition interventions: adequate protein, even protein distribution, and amino acid supplements, if needed



Questions?

Thanks for your attention.