Mitigating Age-related Muscle Loss

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Objectivess

1. Describe aging effects on the musculoskeletal system.
2. Discuss the pathophysiology of sarcopenia.
3. Compare and contrast sarcopenia and dynapenia.
4. Identify the relationship of sarcopenia and dynapenia to other conditions commonly seen in older adults.
5. Select sarcopenia screening tools for use in a clinical or home setting.
6. Discuss the role of nutrition, pharmacology, blood flow restriction, whole body vibration, and EMS as interventions for sarcopenia.
7. Determine appropriate exercise and activity interventions to prevent and treat sarcopenia in older adults.

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Musculoskeletal Aging

1) Roberts et al, 2016

- *"The musculoskeletal system is a dynamic environment consisting of a variety of tissues types made up of several different cellular components within complex arrangements of matrices…As we age, the alterations in normal biological responses lead to impaired tissue function, manifest in features we recognize as ageing."*
- Associated with morbidity, mortality, and socioeconomic burden.

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Musculoskeletal Aging

- Bone
  - Decreased mass, increased turnover
  - Dysregulated remodeling
    - Increased osteoclast number and activity
    - Decreased osteoblast activity
    - Decreased osteocyte number and response to mechanical loads
- Cartilage
  - Decreased thickness and tensile strength
  - Increased collagen cross-links
  - Decreased chondrocyte activity

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Musculoskeletal Aging: Osteoporosis

- Defined as bone mineral density of < 2.5 SD below the sex-specific young adult mean (WHO, 1994).
  - ~ 54 million Americans have osteoporosis and osteopenia.
  - 50% of women and up to 25% of men age 50 and older will break a bone due to osteoporosis.
- Worldwide recognition and efforts for prevention, diagnosis, & treatment
  - International Osteoporosis Foundation / National Osteoporosis Foundation
  - NIH Osteoporosis and Related Bone Diseases National Resource Center
  - United States Bone and Joint Initiative (USBJI)

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Musculoskeletal Aging: Muscle

2) Kara et al, 2021

- Skeletal muscle is the largest organ in the body, comprising approximately 40% of total body weight.
- Preservation of muscle mass is determined by the balance between the rates of protein synthesis and proteolysis.
- With aging, a disruption of the balance between anabolic and catabolic processes leads to loss of muscle mass and function.
- Multiple factors: genetic predisposition, inactivity, age-related increase in proinflammatory cytokines, malnutrition, reductions in hormones, mitochondrial dysfunction, metabolic disorders, insulin resistance, and lipodystrophy.

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Musculoskeletal Aging: Sarcopenia

- A "hallmark of aging"
- Loss of 30% of muscle mass between ages 40 and 80
- Muscle is a fundamental organ for:
  - Mobility
  - Metabolism
  - Frailty
  - Endocrine effects
- Implications for physical function, susceptibility to diabetes and resiliency to multiple forms of stress

3) LeBrasseur, 2017

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Sarcopenia

- Geriatric Syndromes

4) Keller, 2019

  - Multifactorial conditions prevalent in older adults
  - Associated with multimorbidity and disability
  - Examples: falls, cognitive decline, depression, polypharmacy, incontinence
- Sarcopenia considered a complex age-related syndrome ICD-10-CM M62.84
- *"Consider sarcopenia in all clinical decision making involving older adults."*

5)Cesari & Kuchel, 2020

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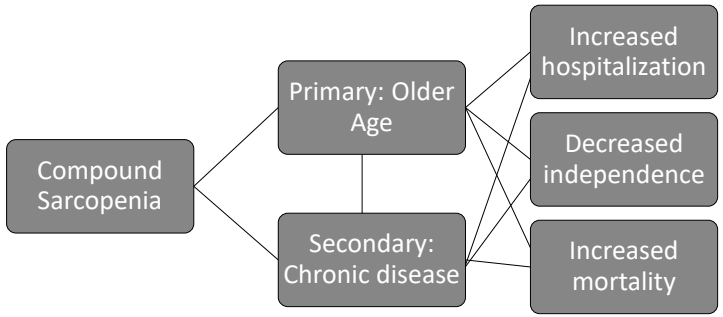
Compound Sarcopenia

6) Attaway et al, 2021



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Endocrine Role of Skeletal Muscle

- Exercise stimulates the release of myokines (proteins)
  - Have autocrine, paracrine, and endocrine functions
  - Primary role is to protect and enhance the exercise capacity of muscle
  - Paracrine regulators of fuel oxidation, hypertrophy, angiogenesis, inflammatory processes, and extracellular matrix regulation
  - Endocrine functions include roles in body weight regulation, low-grade inflammation, insulin sensitivity, suppression of tumor growth, and improvement of cognitive function
  - Myostatin is the myokine with probably the most pronounced effects on muscle mass and body fat composition.

7) Hoffman & Weigert, 2017

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Musculoskeletal Aging: Sarcopenia

- First described by Dr RN Baumgartner in 1998 as loss of appendicular lean mass adjusted for height
- Newer definitions include measures of muscle strength or function because they decline faster than mass during aging and have more impact on function and mortality
- International Working Group on Sarcopenia (IWGS)
  - Combination of low mass and low function
- European Working Group on Sarcopenia in Older People (EWGSOP)
  - Low mass and either low strength or low physical performance
- Asian Working Group for Sarcopenia (AWGS)
  - Low mass plus low strength and/or low physical performance

8) Mayhew et al, 2019

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Musculoskeletal Aging: Sarcopenia

- Sarcopenia Definitions and Outcomes Consortium (SDOC)
- Summary:
  - Low grip strength and low usual gait speed independently predict adverse health-related outcomes
  - Both grip strength and gait speed should be included in the definition and diagnosis of sarcopenia
- Measures:
  - Dominant hand grip strength: <35.5 kg for men; <20.0 kg for women
  - Usual gait speed: 0.8 m/s
  - Gait speed and grip strength vary by age, race/ethnicity, conditions

9) Bhasin et al, 2020

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Sarcopenia: Prevalence

- Problem is increasing as a result of world population aging
- Lack of consistent definition
  - 9.9-40.4% depending on definition used
  - 1-29% of community dwelling older adults
  - Some estimates as high as 60%
- Less common in Asians
  - Combined low strength and quantity in 4.6-14.5%

8) Mayhew et al, 2019; 10) Kim & Won, 2019; 11) Shafiee et al, 2017; 12) Pagotto & Silveira, 2014

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Sarcopenia Matters!

Why no World Sarcopenia Foundation or

National Sarcopenia Awareness Month?

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Muscle Fiber Types

	TYPE I	TYPE IIA	TYPE IIX	TYPE IIB
Contraction Time	Slow	Fast	Fast	Very Fast
Motor Neuron Size	Small	Medium	Large	Very Large
Fatigue Resistance	High	High	Medium	Low
Function	Aerobic	Long-term anaerobic	Short-term anaerobic	Short-term anaerobic
Duration	Hours	<30 min	<5 min	<1 min
Power Production	Low	Medium	High	Very High
Oxidative Capacity	High	High	Medium	Low
Glycolytic Capacity	Low	High	High	High
Predominant Fuel	Triglycerides	Creatine phosphate, Glycogen	Creatine phosphate, Glycogen	Creatine phosphate, Glycogen

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Muscle Fiber Types

13) Talbot & Maves, 2017

Condition	Effect on Muscle Fibers
Obesity and t2DM	Reduced proportions of type 1 and increased proportions of type 2X
Inactivity	Type 1 atrophy; Fiber-type shift from type 1 and 2A to 2X
Aging / sarcopenia	Type 2 loss and atrophy
Heart failure, COPD	Fiber shift from type 1 to type 2 (extremities); Fiber shift from type 2 to type 1 (diaphragm)

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Sarcopenia: Assessment of Muscle Mass

- DXA: Dual Energy X-ray Absorptiometry
- BIA: Bio-electrical Impendence Analysis
- CT
- MRI
- Anthropometry

14) Choi, 2016

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Ultrasound Measurement of Sarcopenia

- Prospective study of 200 patients over age 75 with sarcopenia based on SARC-F, grip strength, and chair stand test.
- Muscle thickness, particularly of the rectus femoris, significantly correlated with sarcopenia severity.
- Ultrasound measurement of the rectus femoris may provide for early identification and management of sarcopenia in older adults.

15) Michael et al, 2025

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Musculoskeletal Aging: Sarcopenia

- Low muscle strength is strong predictor of functional decline
  - 2.6 greater risk of severe mobility limitation
  - 4.3 greater risk for slow gait speed
  - 2.1 greater risk for mortality
- Cannot be entirely attributed to muscle atrophy alone
  - Changes in CNS drive
  - Peripheral nerve dysfunction
  - Alterations in NMJ structure & function
  - Fat infiltration
  - Cellular & molecular changes in single fibers impairing force generation and power production

16) Miljkovic et al, 2015

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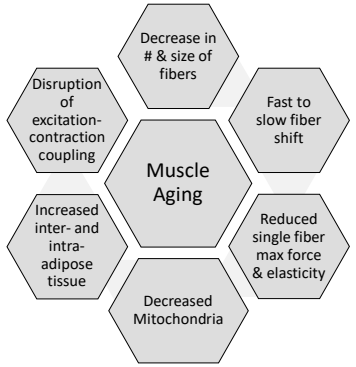
Muscle Mass & Aging

16) Miljkovic et al, 2015 al, 2015



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Musculoskeletal Aging: Sarcopenia

- Progressive loss of muscle strength and function associated with aging
- Increased risk of falls, functional decline, frailty, and mortality
- Influenced by genetic and lifestyle factors across the lifespan
- Recent focus of intense research to improve prevention, diagnosis, and treatment *"with particular interest in the development of biomarkers, nutritional interventions, and drugs to augment the beneficial effects of resistance exercise."*

17) Cruz-Jentoft & Sayer, 2019

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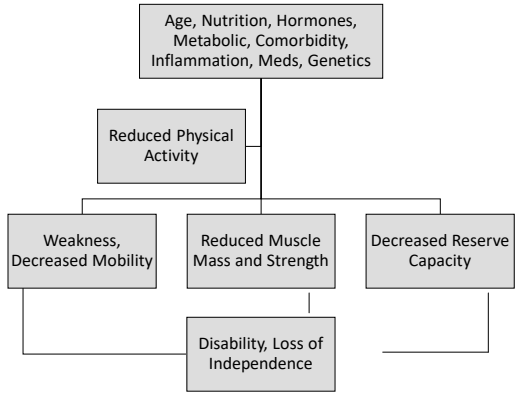

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Meds Associated with Sarcopenia

- Anti-arrhythmics such as amiodarone (Cordarone)
- Anti-thyroid medications, such as methimazole (Tapazole)
- Anti-retroviral medicines, such as zidovudine (Retrovir)
- Chemotherapy medications
- H2 blockers such as cimetidine (Tagamet)
- Corticosteroids
- Lipid-regulators such as gemfibrozil (Lopid)
- Anti-viral meds such as interferon
- Leuprolide acetate (Lupron) used to treat prostate cancer
- NSAIDs
- Penicillin
- Statins
- Sulfonamide antibiotics

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Sarcopenia and Osteoporosis

- Systematic review and meta-analysis, 2018
  - Prevalence of osteosarcopenia varied (5–37%) depending on the classification of sarcopenia
  - Risk of fracture is higher among sarcopenic patients

18) Nielsen et al, 2018

- Cross-sectional analysis from the Sarcopenia in Geriatric Elderly (SAGE) study (84 women, 57 men; mean age 80.6 yrs)
  - Osteosarcopenia common and associated with a higher degree of malnutrition than osteoporosis or sarcopenia alone (Lower BMI and MNA-SF)

19) Reiss et al, 2019

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Sarcopenia and Diabetes

- Systematic review and meta-analysis (54,676 participants, mean age 65.4 yrs)
- Diabetic participants had an increased prevalence of sarcopenia compared to controls (OR = 1.635; 95% CI 1.204–2.220; $p = 0.002$ $I^2 = 67\%$)
- Sarcopenia was associated with an increased odds of having diabetes (OR = 2.067; 95% CI 1.396–3.624; $p < 0.0001$; $I^2 = 0\%$)

20) Veronese et al, 2019

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Sarcopenia and Diabetes

- Sarcopenia may contribute to the development and progression of T2DM through:
  - altered glucose disposal due to low muscle mass, and
  - increased localized inflammation, which can arise through inter- and intramuscular adipose tissue accumulation.-
- Individuals in the lowest skeletal muscle mass relative to body weight quartiles had a 2X greater risk of developing T2DM compared with individuals in the highest quartile
- Skeletal muscle accounts for ~80% of glucose clearance during euglycemic and hyper-insulinemic conditions

21) Mesinovic et al, 2019

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Sarcopenic Obesity

- Recently new concept; critical public health risk in the aging population
- Sarcopenia and obesity share several pathophysiological mechanisms
  - increased proinflammatory cytokines
  - oxidative stress
  - insulin resistance
  - hormonal changes
  - decreased physical activity
- Can lead to metabolic syndrome, t2DM, CVD, HTN, frailty

14) Choi, 2016

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Sarcopenic Obesity

14) Choi, 2016

SARCOPENIA	OBESITY
MECHANISMS	
Decreased physical activity	
Inflammation, oxidative stress	
Myostatin	
Insulin resistance	
CONSEQUENCES	
Dyslipidemia	
Type 2 diabetes	
Cardiovascular disease	
Hypertension	
Frailty	

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Sarcopenia and Arthritis

- Significant associations between physical function and inflammatory measures and sarcopenia were apparent in both OA and RA participants.
- Higher percentage body fat was significantly associated with sarcopenia in both OA and RA participants.
- *"This high percentage of sarcopenia, obesity and SO in both OA and RA identifies a significant comorbidity which is under recognised but may have profound effects on mobility and general health."*

22) Vlietstra et al, 2019

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Sarcopenia and Falls & Fractures

- Systematic review and meta-analysis, 2019
  - 36 studies met all inclusion criteria
    - 52,838 individuals (48.8% females) with a mean age of the study populations ranging from 65.0 - 86.7 yrs
    - Study populations included community-dwelling, hospitalized, out-patients, and nursing home residents
  - Positive association between sarcopenia, falls, and fractures.
  - Findings independent of study design, population, sex, sarcopenia definition, continent, and study quality

23) Yeung et al, 2019

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Sarcopenia and Depression

- Systematic review and meta-analysis, 2017
  - Sarcopenia was independently associated with depression
  - Sarcopenia and depression share several common risk factors
  - Results indicate that sarcopenia might directly cause depression and that the reverse pathogenic pathway is possible

24) Chang et al, 2017

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Sarcopenia and Frailty

- Standardized definitions are lacking for both syndromes
- Study of 1611 participants (mean age 75.4 yrs)
  - 4.5% were frail
  - 20.6-28.1% were sarcopenic (depending on definition)
  - Sarcopenia showed a low sensitivity (<10%) but high specificity (>97%) for the diagnosis of frailty
  - Distinct but related conditions

25) Davies et al, 2018

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Sarcopenia or Dynapenia?

- Dynapenia: age-related loss of muscle strength
- Concept proposed by Clark in 2008
- Longitudinal studies indicate
  - Age-related changes in strength are not due to muscle wasting
  - Strength, but not muscle mass, is associated with negative health outcomes
  - Impairment in neural activation is a key contributor to muscle weakness in older adults

26) Clark, 2019

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Sarcopenia or Dynapenia?

- Dynapenia is prevalent in those with sarcopenia but some older adults have dynapenia without sarcopenia
- Study of 140 community-dwelling older adults
  - 12.5% had dynapenia w/o sarcopenia
  - Higher mean age; women > men; higher BMI
  - Slower gait speed; reduced grip strength
  - Decreased thickness of biceps brachii, rectus femoris, medial gastrocnemius using ultrasonography

27) Chang et al, 2018; 28) Yang et al, 2020

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Sarcopenia or Dynapenia?

- Study of 123 community-dwelling older adults (31 men, 92 women,) (mean age 75.0 ± 5.3 years) who were independent in IADL
- Measurements of muscle mass, grip strength, walking speed, isometric knee extension strength, and unipedal standing
- Dynapenia was associated with sarcopenia and frailty, but those had low sensitivity to dynapenia
- Dynapenia, more than sarcopenia or frailty, was related to IADL difficulties

29) Iwamura & Kanauchi, 2017

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Dynapenia

- 16% - 18% of women and 8% - 10% of men 65 yrs+ cannot lift 10 lbs. or stoop/kneel down 30) CDC, 2008
- 24% of women and 14% of men older than 65 yrs are unable to walk 2-3 blocks
- Mobility disability is a key factor associated with loss of independence

31) Glass et al, 2021

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Dynapenia

- Two primary contributors to dynapenia
  - Neurologic – impaired voluntary activation
    - Decreased CNS excitatory drive
    - Lower motor neurons and/or decreased alpha-motor neuron excitability
    - Fewer functioning motor units
  - Skeletal muscle properties
    - Decreased fiber size and structure
    - Fat infiltration
    - Changes in ratios and interaction of proteins

32) Clark & Manini, 2012

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Dynapenia and Osteoporosis

- 1032 participants (52% women; mean age 62.9 ± 7.4 years) followed for 10 years
- Compared to those without dynapenia or osteopenia, incident fracture risk was significantly higher in participants who were:
  - osteodynapenic (RR = 2.07, 95% CI: 1.26–3.39)
  - dynapenic alone (RR = 1.74, 95% CI: 1.05–2.87)
  - osteopenic alone (RR = 1.63, 95% CI: 1.15–2.31)
- Osteosarcopenia but not osteodynapenia increased the risk of mortality

33) Balogun et al, 2019

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Dynapenia and Diabetes

- Sarcopenia and dynapenia are complications in T2DM
- Prevalence rate of dynapenia is higher than sarcopenia in patients with T2DM

34) Mori et al, 2019

- Uncontrolled diabetes increases the risk of dynapenia in both men and women
- HbA1c ≥6.5% in men and ≥8.0% in women associated with dynapenia

35) Nebuloni C et al, 2020

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Dynapenia and Obesity

- 2025 subjects (56.3 % female), mean age 68.2 yrs, followed 4 years
- Grouped according to obesity and knee strength: dynapenic obesity (24.1%); dynapenia without obesity; obesity without dynapenia; and no dynapenia nor obesity
- Dynapenic obesity associated with reduced gait speed, Late-life Disability and Function Index (LLFDI) limitations, and SF-12 physical score in both sexes and in the 400 m walk in men only
- Odds of ADL limitations in dynapenic obesity was OR 2.23 [1.42:3.50] in men and 2.45 [1.63:3.68] in women

36) Batsis et al, 2015

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Dynapenia and Arthritis

- Secondary analysis of data using The Osteoarthritis Initiative (OAI)
- Sub-cohort assignments: subjects with clinically significant knee OA in at least one knee; subjects asymptomatic but with established OA risk factors; and control group
- Compared to dynapenia alone, dynapenic obese patients had higher WOMAC scores with similar post-hoc comparisons in other baseline variables in both sexes 36) Batsis et al, 2015
- Population-based, cross-sectional study was conducted with 1,168 older adults
- Osteoarthritis associated with dynapenia 37) da Silva Alexandre et al, 2019

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Dynapenia and Falls

- Analysis of data from 1,046 community-dwelling participants of the SABE Study
- Abdominal obesity, dynapenia, and dynapenic-abdominal obesity were all associated with a single fall
  - Dynapenic-abdominal obesity (RRR = 2.06 95% CI: 1.04–4.10) had the strongest association with single fall
  - Dynapenia was the unique condition associated with recurrent falls (RRR = 2.33, 95% CI: 1.13–4.81)

38) de Oliveria Maximo et al, 2019

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Dynapenia and Depression

- Prospective cohort study of 5271 community-living older adults aged >50 yrs (51.1% females; mean age = 63.2)
- After controlling for age, sex, education, marital status, employment status, smoking, BMI, number of chronic conditions, physical activity, and cognitive function, dynapenia was associated with greater likelihood for:
  - incident depression (OR = 1.44; 95%CI: 1.08–1.92)
  - persistent depression (OR = 1.61; 95% CI: 1.01–2.58)
  - anxiety (OR = 1.61; 95% CI: 1.20–2.14)

39) Carvalho et al, 2021

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Dynapenia and Dementia

- 1175 nondemented older adults (77.2% female, mean age 80.9 (SD 7.1 yrs) followed for average of 5.6 years
- More severe sarcopenia at baseline associated with higher risk of Alzheimer's dementia
  - 13.2% of those with no CI at baseline developed AD; 46.7% of those with MCI at baseline developed AD
- Also associated with mild cognitive impairment and faster rate of decline
  - 38.7% NCI at baseline developed MCI
- *"Poor muscle function* [grip strength], *but not reduced lean muscle mass, drives the association of sarcopenia with late-life cognitive impairment."*

40) Beeri et al, 2021

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Dynapenia and Frailty

- Population-based cross-sectional study of 126 subjects (47% women, ≥75 yrs)
  - Prefrail 35.7%; Frail 29.4%
  - Fried's criteria for frailty:
    - Poor muscle strength 50%
    - Low physical activity 29%
    - Slow gait 28%
    - Exhaustion 27%
    - Weight loss 5%
  - Poor muscle strength most prevalent frailty component and closely associated with physical activity

41) Papiol et al, 2016

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Dynapenia and Frailty

- Cross-sectional study of 353 older adults (74.8% women; mean age 75.4 yrs)
- Social frailty: poor social activity and other participation
- 14.7% showed social frailty; men 11.2% and women 15.9%
- Social frailty status associated with muscle weakness more than loss of skeletal muscle mass

42) Makizako et al, 2018

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Sarcopenia Screening Tools

SARC-F 43) Ida et al, 2018

- 2018 meta-analysis including 7 studies (12,800 subjects)
- Sensitivity: 21% (95% CI, 13–31),
- Specificity: 90% (95% CI, 83–94)
- Odds Ratio with the EWGSOP2: 2.47 (95% CI, 1.64–3.74)

Cut-off score of 4 identified those at high risk 44) Li et al, 2019

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SARC-F

5-item Screening Tool for Sarcopenia

COMPONENT	QUESTION: How much difficulty?	SCORING
Strength	Lifting/carrying 10 lbs	None = 0 Some = 1 A lot or unable = 2
Walking	Walking across room	
Rise from chair	Transferring from chair or bed	
Stairs	Climb a flight of 10 stairs	
Falls	How many falls in past year?	

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Sarcopenia Screening Tools

- SARC-F + CalF
  - 5-component questionnaire combined with calf circumference
  - Study of 384 participants, age 60 yrs + (58.3% women)
  - SARC-CalF had a sensitivity of 60.7% and a specificity of 94.7%
  - SARC-F had a sensitivity of 29.5% and a specificity of 98.1%
  - SARC-F + CalF significantly improved sensitivity and overall diagnostic value for screening community-dwelling older adults

45) Yang et al, 2018

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Sarcopenia Screening Tools

46) Krzymińska-Siemaszko et al, 2020

- SARC-F + CalF
  - Maximal score of the SARC-CalF is 20 points
    - Usual scoring of questionnaire
    - Calf circumference scored 0 if above cut-off and 10 if below
    - **Recommended cut-off values for predicting low muscle mass ≤34 cm in men, and ≤33 cm in women**
    - Total score of ≥11 points indicates the risk of sarcopenia
  - Important considerations
    - Obesity or Edema – higher calf circumference may mask sarcopenia
    - Other medical condition (e.g. Parkinson's, cancer, etc.)

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Sarcopenia Screening Tools

46) Krzymińska-Siemaszko et al, 2020

- SARC-F+EBM (elderly + body mass)
  - 7 domains
  - Usual SARC-F 5 items
  - Age: score 10 if age ≥ 75 years and 0 if age < 75
  - BMI score 10 if BMI ≤ 21 kg/m^2 and 0 if BMI > 21 kg/m^2
  - Maximum score = 30 points
  - Score $\geq$12 indicates risk of sarcopenia
  - Sensitivity 55%, Specificity 70.7%, PPV 23.7% (CI 95%,15.5–34.5)

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ISarcoPRM* Diagnostic Algorithm for Sarcopenia

- 5X Chair stand test (CST) $\geq$12s
- Grip strength (GS) <32 kg for males and <19 kg for females
- Sonographic Anterior Thigh Ratio (STAR), <1.0 (F) and <1.4 (M)
- Severe sarcopenia in the presence of mobility limitation:
  - Gait speed $\leq$0.8 m/s
    and/or
  - Inability to rise from a chair without support

*Sarcopenia Special Interest Group of the International Society of Physical and Rehabilitation Medicine

47) Ikemoto et al, 2025

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Impact of Sarcopenia on Gait

- Prospective observational study of 153 orthopedic patients (78.4% female, avg age 79.3 yrs) during hospitalization.
- Functional ambulation categories assessed gait independence before admission and on discharge.
- Sarcopenia assessed using the ISarcoPRM algorithm was associated with worsened gait independence on discharge in older orthopedic patients.

47) Ikemoto et al, 2025

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Dynapenia Screening Tools

(EWGSOP2 cut-off points)

- Handgrip dynamometer measurements
  - Overall strength
  - < 27 kg for men and <16 kg for women (59.5 & 35 lbs)
- 5X Chair Stand Test (CST)
  - Lower body strength
  - > 15 s for both sexes
- 4-m usual walking speed test
  - Physical performance
  - ≤0.8 m/s both sexes

46) Krzymińska-Siemaszko et al, 2020

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Tools for Assessing Strength and Physical Perfor

Tools for Assessing Strength and Physical Performance

- Recommendations based on the availability, time for the test, and the availability of robust cut-off points
- Strength
  - Handgrip
  - Repeated chair stands
  - LE (quad) strength
- Physical Performance
  - Gait speed or SPPB
  - TUG, 6MWT, 400 m walk test

48) Beaudart et al, 2016

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Dynapenia Screening Tools

- Observational cross-sectional study of 30 **SNF residents** (76.7% female; 85.6±7.1 yrs)
- Dependence in ADL was negatively correlated with
  - physical activity (r_s = -0.44, p = .015)
  - handgrip (r_s = -0.38, p = .038)
  - elbow-flexor (r_s = -0.42, p = .032)
  - quadriceps strength (r_s = -0.67, p < .001)
  - Only quadriceps strength remained significant with logistic regression
    - 11 kg (24 lb) quad strength predicted performance in ADL (sensitivity of 100% and a specificity of 79%)
    - 1 kg (2 lb) increase lowered the risk of becoming dependent by 65%

49) Wearing et al, 2019

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Handgrip Strength (HGS)

- Cross-sectional study of 45 healthy adult subjects ages 18-64
  - 21 men (avg age 32.9 ±11.4 yrs); 24 women (avg age 35.5 ±14.0 yrs)
- Primary finding was that HGS has a strong relationship with leg strength, leg power, lean body mass, and thigh muscle mass.
- HGS has been associated with various aspects of physical performance, activities of daily living (ADL), health, and mortality.
- "Thus, it could be argued that muscle strength and power, and not necessarily cardiovascular endurance, are the key foundation for longevity and overall health and quality of life."
- **HGS simple clinical measure of leg strength, power, and muscle mass.**

McBride et al, 2025

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Sources for Normative Data

- Shirley Ryan Ability Lab / Rehabilitation Measures Database
  - https://www.sralab.org/rehabilitation-measures
  - Includes cut-offs for falls, norms for various diagnoses/conditions, MDC, etc.
- Rikli RE, Jones CJ. *Senior Fitness Test Manual*, 2nd ed. Human Kinetics. 2013. ISBN-13: 978-1450411189
  - Norms for community-dwelling, ages 60+

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Potential Alternative Test for Dynapenia

- Cross-sectional study of 355 out-patients ≥ 65 yrs (71.5% female)
- 15 second blink rate positively correlated with grip strength
- Independent of age, sex, ADL (Katz), IADL (Lawton), nutritional status (MNA), cognitive function (MMSE), creatinine, hemoglobin, C reactive protein, vitamin D
- Cut-off of ≤40 blinks in 15 sec with 79.3% sensitivity and 43.3% specificity

51) Bahsi et al, 2021

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Pharmacological Interventions

- Currently no FDA-approved medications for sarcopenia
- Variety of drugs under investigation
  - Myostatin/ActR2 signaling inhibitors
  - Exercise mimetics
  - Anabolic hormones
  - Natural compounds
    - Ursolic acid in apples
    - Tomatidine in unripe green tomatoes
    - Urolithin A in pomegranates, nuts, berries

53) Kwak and Kwon, 2019

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Interventions: Nutrition

- RTC of 34 LTC patients (65% female; mean age 66.5 yrs) over 3 months
  - Groups
    - Regular resistance muscle training by PT
    - PT combined with nutrition therapy (whey protein and vitamin D)
  - Results:
    - Exercise alone did not result in significant increase in muscle mass or strength
    - Combined exercise and nutrition significantly increased strength

54) Molnar et al, 2016

- *"Evidence suggests that nutrition intervention alone does have benefit and certainly enhances the impact of exercise."* 55) Woo, 2018

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Interventions: Nutrition

Recommended nutrients to combat sarcopenia:

- Protein
- Vitamin D
- Leucine
- Beta-hydroxy-beta-methylbutyrate (HMB)

56) Rizzoli, 2015

- Resistance exercise and enhanced protein intake and vitamin D may help offset sarcopenia in non-obese older adults

57) Oh et al, 2017

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Interventions: Nutrition

- **Protein**
  - 25 - 30 g of high quality protein per meal 56) Rizzoli, 2015
  - Intake levels upwards of 1.2 g/kg recommended 59) Traylor et al, 2018
- **Vitamin D**
  - 15 µg/day (600 IU) for people <70 yrs; 20 µg/day (800 IU) for 71+ yrs
  - International Osteoporosis Foundation, recommends 20 to 25 µg/day (800 to 1000 IU/day) to prevent both falls and bone fractures in older women

60) Uchitomi et al, 2020

63

Nutrition: Protein

- At least .45 grams per pound. (e.g. 67.5 grams for a 150-pound person.)
- Examples:
  - Chicken breast (25g/3oz)
  - Seafood and soybeans (29g/4oz)
  - Red meat (22g/3oz)
  - Beans (15g/cup)
  - Greek yogurt (20g/cup)
  - Large egg (6g)
  - Peanut butter (4g/T)
  - Milk (8g/cup)

Moninger J. Get the protein you need. WebMD. Published Feb 22, 2022. https://www.webmd.com/healthy-aging/ss/slideshow-how-to-get-protein

64

Interventions: Nutrition

- **Leucine**
  - Amino acid that stimulates protein synthesis and increases insulin response of muscle cells
  - Recommended intake of 3g of leucine at the three main meals together with 25–30g of protein
  - High leucine foods include chicken, beef, pork, tuna, tofu, beans, milk, cheese, seeds (i.e. squash, pumpkin, chia), eggs

61) Rondanelli et al, 2021

- **Beta-hydroxy-beta-methylbutyrate (HMB)**
  - Metabolite derived from leucine
  - Modulates muscle protein degradation

62) Cruz-Jentoft, 2018

65

Malnutrition & Sarcopenia in In-patient Rehab

- Multi-center cross-sectional prevalence and longitudinal observational study (558 pts, 51.8% male, median age 73.0 yrs)
- Bodyweight (BW), hand grip strength (HGS), and functional independence measure (FIM) were assessed within 3 days of admission and after 21 days of rehab
- Overall prevalence of malnutrition was 35.5% and sarcopenia was 32.7%
- At the end of rehab, malnourished or sarcopenic patients had a significantly lower BW, HGS, and FIM
- Dieticians were not involved in >1/3 of patients at risk of or with malnutrition

64) Lehman et al, 2025

66

Pro/Prebiotics Effects on Muscle

- Systematic Review (8) and Meta-Analysis (4) of RCTs
- Results:
  - Probiotics supplementation improved muscle strength (grip strength) and physical performance and function (gait speed)
  - Probiotics suggested to be beneficial effect on muscle mass
  - Prebiotics suggested to be effective on muscle strength

65) Besora-Moreno M et al, 2025

67

PT & Nutrition: *Screen, Refer, Educate*

"Diet and nutrition are key components of many conditions managed by physical therapists."

"Nutrition can directly affect recovery and function while an individual is under a physical therapist's care. Thus, PTs should be concerned with and address nutritional intake and eating patterns of their patients and clients."

https://www.apta.org/patient-care/public-health-population-care/nutrition

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Nutrition: Screening

- Mini-Nutritional Assessment (MNA)
- 18 items, short form consists of 6 items
  - Evaluates the risk of malnutrition among older adults and to identify those who may benefit from early intervention

- https://www.mna-elderly.com/forms/mini/mna_mini_english.pdf

- Free online calculator: https://www.freeonlinecalc.com/mini-nutritional-assessment-mna-short-and-full-form-calculator.html

69

My Plate / Older Adults

https://www.myplate.gov/life-stages/older-adults

- Designed to encourage healthy eating in people ages 60 and up.
  - Unique needs
  - Nutrition tips
  - Be active
  - My Plate on Alexa
  - Resources
  - Tip Sheet

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Intervention: Exercise

*"Without question exercise is the most powerful intervention that we have to improve muscle health…**Exercise is the powerful, magical silver bullet for muscle loss**."*

Dr. Nathan K LeBrasseur, MS, PhD

Dept of PM&R, Mayo Clinic, Rochester, MN

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Intervention: Exercise

"While many of these **[*rehabilitation*] facilities** offer 60 minutes of therapy twice per day, they **commonly use low-intensity exercise** (e.g., seated in a wheelchair performing knee extension exercises with ankle weights) in conjunction with some functional training (e.g., wheelchair transfers) and aerobic activity. …**they are not likely a sufficient stimulus to promote positive muscle growth and adaptation."**

58) Law TD et al, 2016

72

Aerobic Training is Not Enough

- Cross-sectional study of 115 older women (60 yrs+)
- Divided into 3 groups:
  - 47 sedentary (CON)
  - 30 exercise with emphasis on resistance (RES)
  - 38 exercise with emphasis on aerobics (AER)
- Prevalence of sarcopenia:
  - 46.8% CON
  - 6.6% RES
  - 37.3% AER
- No significant difference in muscle mass between groups.
- Strength and performance showed a statistically significant difference in favor of the resistance group. 65) Ferreira et al, 2023

73

Systematic Umbrella Review

66) Beckwee et al, 2019

- 14 systematic reviews or meta-analyses
- Four exercise categories:
  - resistance training
  - resistance training + nutritional supplementation
  - multimodal exercise programs (resistance, aerobic, balance)
  - bloodflow restriction training
- *"High quality evidence for a positive and significant effect of resistance training on muscle mass, muscle strength, and physical performance.*

74

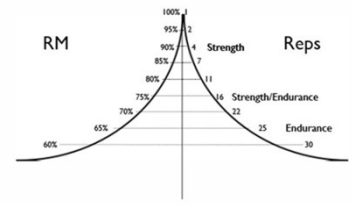
Systematic Umbrella Review 66) Beckwee et al, 2019

- Types of Exercise
  - Circuit resistance training
  - High-speed resistance vs normal strength training
  - Isokinetic leg exercises
  - Elastic resistance
- Higher intensity training was associated with greater improvement
  - Low intensity: <60 1RM
  - Moderate intensity: 60-79% 1RM
  - High intensity: >80% 1 RM
- Large muscle groups, 8-15 reps, 2-3 X week, 6-12 weeks

75

Calculating 1RM

Oddvar Holton Diagram



1RM Online Calculator

https://www.ptpioneer.com/personal-training/tools/one-rep-max-calculator/#:~:text=There%20are%20a%20variety%20of,1%20%2B%200.0333%20%C3%97%20reps).

76

Exercise for Men with Osteosarcopenia

- RCT of 43 sedentary community-dwelling men (mean 77.8; 73-91 yrs) with osteosarcopenia
  - Exercise group (n=21)
  - Control group (n=22)
- Dynamic resistance exercise on machines with high intensity effort and velocity 2 X week, progressing over 12 months

67) Kemmler et al, 2020

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Exercise for Men with Osteosarcopenia

- Phase 1
  - 14 exercises: leg press, extension, curls, adduction, abduction, latissimus front pulleys, rowing, back extension, inverse fly, bench press, military press, lateral raises, butterfly with extended arms, crunches conducted on resistance devices (MedX)
  - 1-2 sets of 8-15 reps; 2-sec concentric, 1-sec isometric, 2-sec eccentric
  - 90-120 sec rests between exercises
  - 4 weeks familiarization, 8 weeks conditioning

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Exercise for Men with Osteosarcopenia

- Phase 2
  - Single-set, intensity-based, 4-week phases with 4th week a recovery week (low intensity and effort)
  - Four new exercises added: calf raises, hip extension, pull-overs, lateral crunches
  - Repetition range (e.g. 5–7 or 8–10 reps)
  - Velocity varied between sessions from slow (4-1-4) to fast (1-1-2)
  - 90 sec rest between exercises

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Exercise for Men with Osteosarcopenia

- Phase 3:
  - One-third of sets included explosive movement in concentric phase (not back extension)
  - Rest breaks 90 sec
- Phase 4:
  - Introduced superset approach (same or related muscle groups or agonist/antagonist)
  - 2-3 exercises in superset sequence (10 exercises)
  - Rest breaks 30-45 sec within superset and 2 min between supersets

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Exercise for Men with Osteosarcopenia

- Phase 5
  - Introduced drop sets
    - After work to RM (≤10 reps), load decreased 10-20% to complete more reps
    - Applied to 7 exercises included in the supersets
    - Rest breaks 1 min within and 2 min between supersets
- Supplementation of protein, vitamin D, and calcium (exercise and control groups)

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Exercise for Men with Osteosarcopenia

- Average of 102/108 scheduled exercise sessions completed
- Average session 47 minutes
- Two men in each group lost to 1 year follow-up
- No unintended side effects or negative effects other than DOMS reported
- Outcomes:
  - Bone mineral density – significant increase in EG, maintained in CG
  - Skeletal muscle mass – significant increase in EG and significant decrease in CG
  - Max hip and knee extensor strength – significant increase EG, maintained in CG

66) Kemmler et al, 2020

82

High-Intensity Functional Training

- Pilot study with 8 participants (75% female, mean age 71 yrs)
- Two 60 min group sessions per week X 8 weeks
- Followed CrossFit exercise template
  - Gymnastic: pull-ups, push-ups, squats
  - Weightlifting: kettlebell swings, deadlifts, overhead press
  - Aerobic: rowing, walking, cycling
- Modified as needed for pain and lack of mobility, coordination and/or strength

68) Heinrich et al, 2021

83

High-Intensity Functional Training

- Outcomes
  - 87.5% adherence
  - Improved physical function scores:
    - TUG +6%
    - Lift and Carry +10%
    - Chair stands +7%
    - Stair climb test +7%
    - 6MWT +9%
  - No change in self-reported ADL difficulty or confidence
  - Participants liked the supervised program that included peers
  - Self-reported increased participation in leisure and structured physical activities

68) Heinrich et al, 2021

84

High-Intensity Interval Training (Resistance)

- 2024 Systematic Review (ages 60-75; avg 69.4 yrs)
- HIIT for prevention and treatment of sarcopenia in older adults
- HIIT training showed improvements in body composition and functional and cardiorespiratory capacity, has benefits on muscle strength, increases muscle quality and architecture, and is associated with muscle hypertrophy in healthy older adults.
- Evidence for the efficacy of HIIT in adults over the age of 70, but studies are scarce when subjects are over the age of 90.

69) Morcillo-Losa JA et al, 2024

85

High-Intensity Interval Training (Resistance)

- Discontinuous, alternating periods of short-term work (6sec-4min)
- Intensity 80% 1RM or 80-85% MHR or Borg RPE 8 (0-10 scale)
- Duration of the interval usually 90-150 sec
- Recovery periods of 1-5 min at 60% MHR based on RPE (3-4/10)
- Number of intervals based on exercise intensity and person's physical condition
- Average training session duration 30-50 min
- Frequency 2-3 days/week
- Significant improvements in STS, TUG, stair climbing at 16 weeks

69) Morcillo-Losa JA et al, 2024

86

High-Intensity Interval Training (Resistance)

- High-intensity strength exercises at 80% of 1RM have the greatest benefits in improving muscle strength and size, showing increases of 11% in muscle area, 34% in type I fibers, and 28% in type II fibers, with a decrease in body fat, and an increase in bone mineral density and oxygen consumption, as well as an optimization of glucose uptake and utilization.
- Individualized prescription considering the individual's health status and gradually progressing the intensity can contribute to a safe and effective HIIT program for older adults.

69) Morcillo-Losa JA et al, 2024

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Home-based Tele-exercise

- RCT of 23 community-dwelling older adults (69-93 yrs)
  - Exercise group (n=11)
  - Control group (n=12)
- Supervised resistance exercise, 1:1, 20-40 min, 3 X week X 12 weeks
- Significant improvements in LE muscle mass, appendicular lean mass, total muscle mass, and chair sit-and-reach length
- No group X time effects for the 2 min step test and chair stand test

70) Hong et al, 2017

88

Exercise Program Study

71) Fanning et al 2020

- Lifestyle Interventions and Independence for Elders (LIFE) study
- Single-blind randomized clinical trial: physical activity (PA) and health education (HE) groups
- PA group had 818 subjects at risk for major mobility disability
  - 64.5% female, 26% racial minorities
  - Mean age 78.1 yrs (70-89)
  - Mean BMI 30.4
  - Comorbidities: HTN 69.7%, CVD 28.6%, Lung disease 16.1%, Arthritis 17.2%
  - SPPB ≤9; mean gait speed 0.83 m/s; <20 m/w structured PA

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Exercise Program

71) Fanning et al 2020

- Structured individualized physical activity intervention
  - 2 center-based and 3-4 home-based exercise sessions per week
  - Primary goal was walking 150 minutes per week
    - Progressed to 30 min/day at moderate intensity
  - Included balance, flexibility, and LE strengthening
    - 10 min/session of balance and flexibility
    - 10 min/session of LE strengthening with ankle weights
  - Progressed to 13/20 RPE during walking and 16/20 during strength training

90

Exercise Program

71) Fanning et al 2020

- Structured individualized physical activity intervention
  - Noted older adults with limited function may achieve 3.0 METs at slow walking speeds (1.5 mph)
  - 48.4% had a hospitalization unrelated to the intervention
  - 58.6% went on medical leave at least once (median 49 days)
    - Focus on strength and balance to assist return to extended walking
  - 71% median attendance rate; 14.5% drop out rate
  - Both pre-frail and frail participants showed improvement in SPPB and 400-m walk

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Exercise Program

71) Fanning et al 2020

- Structured individualized physical activity intervention
  - Followed for 2 years
  - Engaged in additional 40 m/w of moderate PA at 6, 12, and 24 months
- *"Our results add to a building **'movement is medicine'** approach to PA prescription for older adults, one that considers the individual's specific needs and desired outcomes when crafting clinical activity recommendations."*

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Exercise Program

71) Fanning et al 2020

FRAIL (SPPB <8)	PRE-FRAIL (SPPB 8-9)
Focus: 1. Function First: Strength and balance 2. Biggest Return: Concurrently increase total volume of higher intensity activity	**Focus:** Move More: increase volume of lower intensity activity Move More Often: Increase frequency of lower intensity activity
Examples: Seated UE exercises Frequent, brief bouts of higher-intensity lifestyle activity (e.g. parking further away, climbing steps) Participate in structured aerobic exercise as tolerated	**Examples:** Standing activities/hobbies Use a step counter and work on increasing steps during the day

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Physical Activity

- 2017 SR & MA looked at the relationship between sarcopenia and physical activity in older adults
  - A statistically significant association between PA and sarcopenia was found in most studies reviewed
  - PA included housework, gardening, occupational activity involving the carrying of light or heavy objects, moderate exercise (e.g. walking, swimming, cycling) and some did vigorous exercise (e.g. tennis, basketball, rope jumping)
  - Participants who did some form of PA had lower odds of developing sarcopenia
  - Results support regular PA (occupational activities, aerobic sports, and muscle-strengthening) as protection against sarcopenia

72) Steffi et al, 2017

94

Co-morbidity Exercise/Activity Precautions

- Osteoporosis, Arthritis, Obesity, Falls/Fractures, Frailty
- Multi-morbidity and Polypharmacy
- Type 2 diabetes mellitus
  - Older adults at high risk of recurring hypoglycemia
  - Signs often mistaken for neurological symptoms or dementia

73) Freeman, 2019

95

Co-morbidity Exercise/Activity Precautions

- Cardiovascular disease
  - Significant positive relationship between skeletal muscle mass and left ventricular mass

74) Pela et al, 2021

- Oral anticoagulants and A fib
  - Supra-therapeutic levels independently associated with low appendicular muscle mass
  - Increased bleeding risk

75) Bendayan et al, 2021

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Co-morbidity Exercise/Activity Precautions

- Risk of Urinary Incontinence
- 802 female out-patients, age 60+
  - 48.9% prevalence of UI
- Sarcopenic associated factors:
  - Higher age and BMI
  - Lower grip strength
  - Low muscle mass adjusted by weight and body mass index

76) Erdogan et al, 2019

97

Resistance Exercise / Sarcopenia

- Guidelines:
  - Frequency: 2-3 sessions per week on alternating days
  - Exercises: "major muscle groups" chest, back, arms, shoulders, upper legs (quadriceps, hamstrings, and gluteals), and lower legs (calves).
  - Sets: 1-3 with 1-2 minutes rest between sets
  - Intensity: 65-80+% of 1RM
  - Reps: to "task failure"
    - 60% 1RM: 18-32 reps
    - 80% 1RM: 8-15 reps

77) Law TD et al, 2016

98

Resistance Exercise/Sarcopenia

77) Law TD, et al, 2016

- Guidelines:
  - Progression
    - Gradual with adjustments made on a monthly basis commonly recommended
    - By increasing the frequency, duration, exercises performed, number of exercises for each muscle group, sets, and repetitions.
    - Consider the patient's comorbidities to prescribe and progress the most appropriate training variables on a case-by-case basis

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Blood Flow Restriction

Systematic Umbrella Review

66) Beckwee et al, 2019

- *"Blood flow restriction training is a novel training method that has a significant impact on muscle strength."*
- Blood flow restriction (resistance training maintaining arterial blood inflow and restricting venous blood outflow)
- Meta-analysis of 8 studies reported low intensity (10-30% 1RM)
  - More effective to increase strength than low intensity training alone
  - Less effective than heavy-load training with no BFR
  - Did not report presence or absence of adverse events – close supervision recommended

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Low-load resistance training with blood flow restriction (LRT-BFR)

- RCT of 21 sedentary older adults (avg age 71.25 yrs) diagnosed with sarcopenia
  - LRT-BFR (20-30% 1RM, n+10) / CRT (60-70% 1RM, n=11)
- PT Supervised exercise 3Xw for 12 wks
  - CRT group: 3 sets of 15 reps at 60% 1RM X 4wks, progressed to 3 sets of 12 reps at 65% 1RM X 4 weeks, progressed to 3 sets of 10 reps at 70% 1RM X 4 wks. 60 sec interval between sets.

78) Zhang et al, 2024

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Low-load resistance training with blood flow restriction (LRT-BFR)

78) Zhang et al, 2024

- PT Supervised exercise 3Xw for 12 wks
  - LRT-BFR: Individualized occlusion pressure (LOP) was determined and used.
    - Cuff positioned on inguinal fold area for LEs and axilla area for UEs
    - 50% LOP throughout exercise session, including intervals between sets
    - 3 sets of 30-15-15 reps for each exercise with increasing intensity from 20-30% 1RM using elastic bands. 20 sec rest between sets and 30 sec between exercises.
    - Intensity progressed every 4 wks by reevaluating the 1RM of each participant.

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Low-load resistance training with blood flow restriction (LRT-BFR)

78) Zhang et al, 2024

- Both groups improved in knee extension strength, 6-M walk
  - Only CRT showed additional benefits in SPPB
- Both significantly improved various health markers, including body composition (BM, BMI and BFP), blood lipid level (TG) and blood pressure (SBP).
  - Positive effect on resting HR found in LRT-BFR group
- Both improved sarcopenia-related biomarkers (e.g. increased growth hormone (GH), decreased Furosemide Stress Test (FST) levels, decreased inflammatory markers)

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Low-load resistance training with blood flow restriction (LRT-BFR)

78) Zhang et al, 2024

- Changes appear to be due to growth hormone and fat metabolism.
- Both beneficial to the clinical muscle outcomes, CVD risk factors and certain sarcopenia-related biomarkers of older people with sarcopenia.
  - CRT seems more effective in improving muscle mass and strength
  - LRT-BFR may be more beneficial for improving cardiovascular health

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Vibration Therapy

- Systematic review and meta-analysis examined the effect of local and whole-body vibration therapy
  - 6 studies with 223 participants
  - Muscle strength significantly increased after whole-body vibration therapy (SMD 0.69, 95% CI) and local vibration therapy (SMD 3.78, 95% CI)
    - LE strength increased ~40% in both; maintained better with local vibration
  - Physical performance measured by the sit-to-stand test and the TUG were significantly improved

79) Wu et al, 2020

105

Whole-body Vibration vs Resistance Training

- 12-week, 3-times-weekly RCT of 27 older people with sarcopenia aged ≥ 65 years.
- Subjects randomized into SBVT group (n=14) and RT group (n=13)
- WBVT group
  - Each intervention lasted 30 min (5 min warm-up, 20 min vibration, 5 min relaxation).
  - Subjects stood barefoot with knees bent at 30 deg on a vertically vibrating platform; hands could grasp vibrating rope for balance.
  - Vibration frequency 12Hx with an inter-peak amplitude of 4 mm.
  - Hedl 1 min, rest 1 min, repeated 10 reps

80) Min Zhuang et al, 2025

106

Whole-body Vibration vs Resistance Training

- RT group
  - Each intervention lasted 30 min (5 min warm-up, 20 min vibration, 5 min cool-down).
  - Shoulder external rotation, elbow extension, elbow flexion, leg squat abduction, lunge and bend, shoulder abduction, half-squat stand-up all with elastic band resistance based on 1RM.
    - week 1–4: 60% 1 RM
    - week 5–8: 65% 1RM
    - week 9–12: 70% 1RM

80) Min Zhuang et al, 2025

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Whole-body Vibration vs Resistance Training

- Outcomes: knee ext strength (KES), body composition (Wt, BMI, PBF), handgrip strength, physical performance (GS, 5XCST, SPPB), blood biomarkers, QOL questionnaire.
  - WBVT and RT both improved the physical condition of older people with sarcopenia.
  - KES significantly higher in RT group
  - Only WBVT group showed significant increase in 5XCST
- WBVT group had significant improvements in body composition, KES, physical performance, blood biomarkers, and QOL.
- RT excelled in muscle strength, but WBVT offers a low-risk alternative for those with exercise restrictions.

80) Min Zhuang et al, 2025

108

Whole-Body Vibration Frequencies

- 2025 SR and MA
- Reviewed 27 RTCs (1608 participants) regarding effects of whole-body vibration training (WBVT) and traditional training (TT) on strength, balance, and gait in healthy older adults.
- Avg duration of single session 17.4 min
- Mean training frequency 2.93 sessions/week
- Avg total training duration 25.07 weeks

81) Xing K et al, 2025

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Whole-Body Vibration Frequencies, con't.

- Conclusions (ranking probability analysis):
  - HF-WBVT (30 Hz $\leq$ f $\leq$ 40 Hz) optimal for improving dynamic balance and gait performance
  - MF-WBVT (20 Hz $\leq$ f $\leq$ 30 Hz) recommended for improving static balance
  - Traditional training optimal for improving muscle strength

81) Xing K et al, 2025

110

Whole-Body Vibration Effects on LEs

- SR of 18 RTCs of older adults
- WBVT parameters:
  - Duration of intervention: 6-48 wks / Session duration: 15 sec – 2 min
  - Frequencies: 12-45 Hz
  - Amplitude: 0.5-8 mm
  - Time: 1.25 – 17 minutes
- WBVT significantly improved:
  - Knee strength and power
  - Physical performance measured by: STS, TUG, Gait speed, Walking endurance

82) Tan X et al, 2023

111

Interventions: EMS

- EMS should not be regarded as a replacement of exercise training since the beneficial effect of exercise training is not just building muscle mass but also for its positive effects on endothelial, myocardial, and cognitive function.
- EMS is an alternative for individuals with limited mobility
- Two types: whole-body (WB-EMS) and local EMS
- Human studies have shown that EMS can increase muscle mass ~1% and improve muscle function ~10–15% after 5–6 weeks of treatment.

83) Paillard, 2018

112

Interventions: EMS

- Study results recommend the following criteria with respect to efficiency and comfort:
  - Biphasic current, large pulses (300–450 µs), high frequency (50–100 Hz in young and around 30 Hz in older)
  - Relaxation time should be at least equal to the stimulation time
  - Intensity as high as individually tolerated
  - Minimum of TIW for at least 5–6 weeks
  - Usual EMS contraindications and precautions
  - Possible risk of rhabdomyolysis

83) Paillard, 2018

113

Future Research

- Effects of Kinesio taping and extracorporeal shock wave therapy in combination with exercise in sarcopenic older adults
- Design of an intervention app for sarcopenia in older adults

85) Lu J et al, 2025

114

Summary

- Muscle mass and strength decrease with age, and those losses can negatively impact health, function, and quality of life.
- Resistance exercise has a profound effect on the neuromuscular mechanisms that influence strength in older adults.
- All clinicians should use resistance exercise for treating, slowing, and/or preventing sarcopenia and dynapenia.

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Summary

- Higher intensity resistance exercise is associated with greater improvements and is well tolerated by most older adults.
- Nutrition screening and education and/or referral recommended.
- Blood-flow restriction therapy, Vibration and EMS are optional interventions in combination with resistance exercise or alternative for those with limited mobility.

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THANK YOU!

"In the end we retain from our studies only that which we practically apply."

Johann Wolfgang Von Goethe

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