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› *KNOWLEDGE*
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CONFLICT OF INTEREST STATEMENT

I have no actual or potential conflict of interest
in relation to this presentation.

SARCOPENIA IN THE AGING ADULT

HEALTH AND FITNESS PROGRAMMING IMPLICATIONS

Objectives

- Define sarcopenia
- Identify the cellular mechanisms that may contribute to sarcopenia and how these may impact health and fitness programming
- Design programs that will help offset the consequences of sarcopenia
- Summarize the relevant sarcopenia literature related to health and fitness

Successful Aging

- Regular exercise
- Social interactions
- Positive attitude

Age-Related Changes in Health

- Reduced functional capacity
 - Decreased VO_2 Max
- Altered body composition
 - Greater accumulation of body fat
 - Central and visceral
 - Gut microbiota
 - Protein absorption kinetics attenuated
 - Sarcopenia- loss of muscle/strength
- Decreased bone mineral density (BMD)
 - Osteopenia
 - Osteoporosis
- Increased risk for chronic disease and injury
 - Cardiovascular
 - Arthritis
 - Diabetes

Sarcopenia (*“flesh deficiency”*)

- Considered a disease since 2016
- Consequences are vast, serious and life-changing
 - Morbidity
 - Disability
 - Health care costs
 - Mortality
- Positive correlation with falls and fractures (Yeung et al., 2019)
- Physical exercise as the cornerstone
- Decrease on quality of life, self-sufficiency, well-being
- Multi-factorial onset
 - Neurological factors
 - Endocrine alterations
 - Loss of muscle motor units
 - Lifestyle changes

Sarcopenia Prevalence Rates (Paintin 2018)

- Prevalence difficult to assess given variable cut-off scores and definitions
- Wide range estimated 5-13% for adults 60-70 yo and 11-50% for adults >80 yo
- Affects >50 million worldwide and expected to rise to >200 million over next 40 years
- Economic burden with direct hc costs ~\$18.5 billion in 2000
 - Increased fall risk and fracture

Sarcopenia Prevalence Rates (Papadopoulou et al., 2020))

- 9-10% in community-dwelling individuals
- 30-50% in nursing-home individuals
- 23-24% in hospitalized individuals
- Associated with
 - Falls and secondary fractures
 - Pulmonary insufficiency
 - Sleep disorders
 - Cognitive impairment
 - Poor quality of life
 - Premature mortality
 - Medical and economic burden

Sarcopenia Guidelines

- European Working Group on Sarcopenia in Older Persons (EWGSOP)
 - Three Stages
 - Presarcopenia
 - Sarcopenia
 - Severe sarcopenia
- Belgian Society of Gerontology and Geriatrics (BSGG)
- The Society of Sarcopenia, Cachexia, and Wasting Disorders (SCWD)
- International Clinical Practice Guidelines for Sarcopenia (ICFSR)

Sarcopenia

(Malafarina et al, 2012; DiGiulio et al, 2009; Koopman et al, 2009; Bijlsma et al 2012; Pascual-Fernandez et al., 2020)

- Gradual decline in skeletal muscle mass and strength
 - Fifth decade – 0.8% per year
 - Age 45, decline 1% per year/Age 60, 2% per year, up to 3% as age
 - Age 30-50 decrease ½# per year, after 50 1# per year
 - 15/15/30/30 principle
 - Between 20-60, total cross sectional mm area decreases approximately 40%
 - Age 30-80 50% muscle mass decrease
 - 10% strength loss per decade
- Fat free mass 2 SD below the mean (Baumgartner, 1998)
 - Men: 7.23 kg/m²
 - Women: 5.67 kg/m²

Sarcopenia (Shaw et al., 2017; Billot et al., 2020; Cruz-Jentoft and Sayer, 2019)

- Must relate to function
 - Part of definition – describes the severity
 - Gait speed, grip strength, SPPB as example
- Syndrome
 - Progressive and generalized
 - Change in muscle mass, muscle quality, strength and physical function
- Relationship between health conditions and muscle health

Sarcopenia

- Gross circumference
 - Muscle reduction, fat increase
 - Cortical bone thinning too
- Lack of physical activity often with unbalanced diet rich in saturated fats
- Relationship to functional ability and disability
 - Gait speed, sit to stand, fall risk
 - Walking distance, LE strength, grip strength

Cellular Age-Related Changes Skeletal Muscle (Liguori et al., 2018)

- Decrease in muscle mass
 - Shrink in size, loss in contractile proteins
 - Loss of # fibers
- Decrease in type I and II fiber numbers
 - Selective loss type II (de-enervation)
 - Conversion FT to ST
- Atrophy of muscle fibers
 - Especially type II fibers
- Decrease motor unit number
 - De-enervate and spread out
- Progressive neuron loss
 - Involves motor neurons
 - Denervation of m. fibers that fail to contribute to muscle contraction
- Nerve conduction velocity slowed
- Fat content and CT increase
 - Deposition of fat between myofibrils (adipocytes) + fibrosis

Changes, cont. (Liguori et al., 2018)

- Chronic oxidative stress
- 'Inflammaging' (TNF- α , IL-6, IL-1, CRP)
- Reduced mitochondria volume
 - Less ATP
- Imbalance of protein metabolism
 - Synthesis and degradation out of balance
 - mTOR
- Decrease in anabolic stimuli
 - GH, testosterone, estrogen, IGF-1
 - Insulin resistance
- Increase in catabolic stimuli
 - Cortisol
 - Cytokines

Satellite Cells (SC) (Pascual-Fernandez et al., 2020)

- Responsible for post-exercise muscle repair and regeneration processes
- With physical inactivity and unbalanced diet alters hepatic growth factor (HGF) signaling pathway
- NO production increases with PA and is key signal in HGF activation
- Altering results in lack of SC activation and incorrect repair of muscle fibers and myogenesis

Myostatin (Pascual-Fernandez et al., 2020)

- Extracellular messenger which inhibits muscle growth
- Controls cell cycle, inhibiting factors that regulate myogenesis
- Aged muscle expresses increased myostatin signaling and initiates progressive atrophy

Sarcopenia (Pascual-Fernandez et al., 2020)

- Lack of SC activity
- Increase in intramuscular proteolytic activity
- Inhibited myogenesis
- =decrease in strength and muscle mass with aging

Oxidative Stress (Pascual-Fernandez et al., 2020)

- Reactive Oxidative Stress (ROS)
- Nitrogen Species (RNS)
- =RONS
- Overproduction of RONS together with decreased response from antioxidant systems contribute to sarcopenia and delay of muscle regeneration in the elderly

Neuronal Factors (Pascual-Fernandez et al., 2020)

- Lost motor neurons starting at 60 – leads to denervation of muscle fibers
 - Occurs more often in large motor neurons that connect to fast fibers
- Reduction in axonal size and its myelination at peripheral nerve level with loss of nerve conduction velocities
- Neural plasticity and remodeling but reinnervation by small motor neurons that turn fast muscle fibers into slow ones
- BDNF stimulated by muscle contraction; reduced with age

Inflammatory Processes (Pascual-Fernandez et al., 2020)

- Immune system plays an important role in skeletal muscle regeneration
- Sarcopenia leads to reduced muscle regenerations capacity caused by local inflammatory mechanisms
- Induces alteration of the neuro-hormonal response, which results in an imbalance in protein synthesis and degradation
- $\text{TNF-}\alpha$, IL-15, IGF-1
- Decreases number of SCs
- Sarcopenia accelerated in chronic inflammatory pathological states

Behavioral Changes

- Decrease in physical activity, exercise
 - 60 min increase in daily sedentary behavior of the elderly related to 33% greater risk of reduction in muscle volume and strength during aging
 - Intensifies muscular anabolic resistance through pro-inflammatory markers and reduction of insulin sensitivity
- Decreases nutritional status
 - Inadequate intake of dietary energy and protein
- Gender differences
 - Testosterone
 - Role of fat

Sarcopenia

- Multi-factorial
 - Pro-anabolic decrease
 - Growth factors
 - Androgen
 - Exercise
 - Nutrition
 - Catabolic increase
 - Chronic disease (sarcopenia worse)
 - Inflammation
 - Inactivity
 - Inadequate nutrition

Results

- Decrease in:
 - Strength and power
 - Fast and strong movements
 - Fine dexterity
 - Excitability
 - Endurance and sustained power
 - Movement speed
 - Coordination
 - Balance
- Increased injury
- Muscle cell function disrupted
- Impaired ability to use fat as energy and other physiologic processes
- Insulin sensitivity disrupted

Consequences

- Balance issues
- Depression
- Declining activity
- Compromised ADLs and function
- Reduced quality of life
- Increased risk of falls
- Frailty
- Increased mortality

Consequences

- May increase risk of diabetes, insulin resistance or chronic metabolic disease
 - Glucose intolerance
- Increase risk of osteoporosis
- Impaired thermoregulation
- Decreased protection for bones, organs, nerves, blood vessels
- Decreased resting metabolic rate

Related Concepts

- Sarcopenia vs. Cachexia (Sakuma and Yamaguchi, 2012)
 - Aging vs. inflammatory state
 - Illness such as HIV as example
- Frailty (Fried, Watson, Rockwood; Roubenoff, 2000; Vanitallie, 2003; Lee et al, 2011)
 - Impaired capacity to respond to stress
 - Slowed motor performance (gait speed)
 - Poor endurance and energy (“exhausted”)
 - Weakness: grip strength
 - Weight loss
 - Low physical activity
 - Elevated cytokines, IL-6, TNF- α , CRP

Osteosarcopenia (Paintin 2018)

- Increasing body of evidence demonstrates considerable overlap in pathophysiology of osteoporosis and sarcopenia
- Bone and muscle interact mechanically and biochemically
- Osteosarcopenia prevalence 37%, with patients having higher comorbidities, impaired mobility and depression
 - Increased mortality

Health and Fitness Programming

Screening: F-Sarc (Malmstrom et al., 2013)

- A symptom score to predict persons with sarcopenia at risk for poor functional outcomes
- Similar to FRAX
 - Can predict persons with elevated risk of osteoporotic fracture without the requirement of measuring bone mineral density

SARC-F Components

- SARC-F includes five components:
 - Strength,
 - Assistance walking
 - Rise from a chair
 - Climb stairs
 - Falls
- SARC-F items were selected to reflect health status changes associated with the consequences of sarcopenia
- SARC-F scale scores range from 0 to 10 (i.e. 0–2 points for each component; 0 = best to 10 = worst)
 - Dichotomized to represent symptomatic(4+) vs. healthy (0–3) status
 - A score of 4 or more indicates sarcopenia

SARC-F Questionnaire

Date :

Name :

Test administered by :

Component	Question	Scoring	Score
Strength	How much difficulty do you have in lifting and carrying 10 pounds?	None = 0 Some = 1 A lot or unable = 2	
Assistance in walking	How much difficulty do you have walking across a room?	None = 0 Some = 1 A lot, use aids, or unable = 2	
Rise from a chair	How much difficulty do you have transferring from a chair or bed?	None = 0 Some = 1 A lot or unable without help = 2	
Climb stairs	How much difficulty do you have climbing a flight of 10 stairs?	None = 0 Some = 1 A lot or unable = 2	
Falls	How many times have you fallen in the past year?	None = 0 Some = 1 A lot or unable = 2	
TOTAL SCORE			

A score equal to or greater than 4 is predictive of sarcopenia and poor outcomes.

Measurement Properties

- SARC-F exhibited good internal consistency reliability and factorial, criterion, and construct validity (Malmstrom et al., 2015)
- High specificity and low to moderate sensitivity

Benefits of Physical Activity

- Body composition
 - Less body fat
 - Greater muscle mass
- Increased muscle force output and endurance
- Higher bone mineral density
- Higher stroke volume
 - Less cardiovascular stress
- Better insulin sensitivity and glucose homeostasis
- Lower triglycerides, LDL, and total cholesterol
 - Higher HDL
- Faster nerve conduction velocity
- Quality of life
 - Influence on chronic disease
 - Mitigation of age-related biological changes
 - Preservation of functional capacity
 - Slower development of disability

Exercise – First Line Intervention

- Compensates for harmful effects caused by aging
 - Modulates all factors
 - Oxidative stress
 - Neural dysfunction
 - Inflammation
 - Prevent obesity and mitochondrial dysfunction
- *Most efficient exercise type in delaying sarcopenia?

Exercise Modality Guidelines (Beckwe'e et al., 2019)

- Resistance Training
 - Promotes SC activation and proliferation
 - Improve muscle mass and strength (Proper load, CS, KES; Lu et al., 2021)
 - Improve physical performance (gait speed, TUG, Functional Reach)
 - Higher training volume results in more lean body mass
 - Better results when introduced earlier in life

Exercise Modality Guidelines (Beckwe'e et al., 2019)

- Resistance Training
 - Hypertrophy blunted at older age (anabolic resistance)
 - Upper and lower body benefits
 - Higher intensity better ($\geq 80\%1RM$)
 - Greater training volumes may compensate for lower intensities
 - 70-80% 1RM 1-4 sets of 8-15 reps during 2-3 sessions per week for 6-12 weeks
 - Gains lost if stop, so needs to be part of weekly routine

Exercise Modality Guidelines (Beckwe'e et al., 2019)

- Multimodal/Mixed Exercise
 - Strength, Cardio, Balance
 - Recommended to improve muscle mass and strength, physical performance
 - KES, TUG, GS
 - Combo of resistance training, walking, aerobic training, balance training and other types of training
 - Especially frail individuals (Lieberman et al., 2017)

Exercise Modality Guidelines (Beckwe'e et al., 2019)

- Resistance Training + Nutritional Supplementation
 - Not recommended
 - Creatine, anti-oxidants, HMB, omega-3 FFA (Liguori et al., 2018)
- Nutrition – ESPEN recommends 1-1.5 g/kg/day for older adults to delay increased risk of sarcopenia; consider sources
 - Leucine

Exercise Modalities

- Agility-based Training (Forte et al., 2021)
 - Performance of complex motor skills improves ability to navigate complex environmental conditions (stepping over objects, carrying items while walking, etc.)
 - Increases vestibular-driven signals needed for postural changes and the ability to maintain balance during postural changes
 - Important for gait speed
- Whole Body Vibration Training (WBVT) (Lu et al., 2021)
 - Frequency-based outcomes?
 - Improved TUG times
 - Need sufficient duration of training for improvement?
 - Minimal studies on individuals with sarcopenia

Guidelines (Beckwe'e et al., 2019)

- Blood Flow Restriction
 - Recommended to improve muscle strength
 - Performed under supervision
 - Muscle resistance training with maintenance of arterial inflow but restricted venous outflow
 - Low intensity (10-30% 1RM) BFR training more effective in increasing muscle strength than low intensity alone
 - Low intensity BFR not as effective as high intensity/heavy load training alone
- Influence of Circadian Rhythms (Vitale et al., 2019)
- Testosterone – questionable help for someone with sarcopenia

ACSM Guidelines (Garber et al, 2011)

- Aerobic
 - Moderate intensity (40-60% VO_2 Max)
 - ≥ 30 min/d, ≥ 5 d/wk (≥ 150 min/wk)
 - Vigorous intensity (60-90% VO_2 Max)
 - ≥ 20 min/d, ≥ 3 d/wk (≥ 75 min/wk)
- Resistance training
 - 2-3d/wk, 3 sets, 8-12 repetitions, 60-80% 1RM
 - Older, very deconditioned, or frail individuals (initially)
 - ≥ 2 d/wk, 40-50% 1RM, 10–20 repetitions
- Balance, agility, coordination, flexibility

Program Design: General

- Prescreen all participants
- Proper supervision and instruction
- Warm-up 5-10 min
- Gradual progression
- Avoid the Valsalva Maneuver
- Allow 48-72 hours between sessions
- Train within a pain free ROM

Program Design: General Principles

- Specificity
 - Reproduce similar movements
 - Consider goals, ADLs, recreational activities
- Overload
 - Greater intensity than athlete or client accustomed to
 - Increasing loads, frequency of sessions, add exercises or sets, complex vs. simple exercises, decrease rest or combination
- Progression
 - Promotes long term training benefits
 - Systematic and gradual

Training Variables

- Same as for adults with additional emphasis on positioning, quality of movement/technique and nutritional implications
 - Ensure targeting correct muscle/muscle groups
 - Pain free ROM
 - Stabilization components
 - Use of mirror for technique feedback
 - Reduce injury risk
 - Ensure correct technique on own
 - Compliance
 - Controlled movement
 - Frequency – 2-3 times per week
 - Initial neuromuscular adaption

Program Design: Considerations

- Older adults
 - Medical status, training range, volume, experience
 - Comorbidities
 - Compliance
 - Motivation
 - Cardiovascular, core, strength, balance, and flexibility, agility
 - Functional mobility
 - Goals

Background Information

- Description (medical and exercise history)
- Gender
- Body composition (weight and body fat percentage)
- Age
- Past/present injuries
- Any other pertinent information

How Much Weight?

- Self-selected loads usually **too low** (38-58% 1 RM)
- Determine 1 RM
 - Estimate the 1RM
 - “Nearly all” individuals
 - “Nearly all” exercises (concern for fatigue)
 - 10RM → 1RM procedure (prediction equation)
 - Best if pain is a problem with higher joint forces (OA)

Determine Number of Sets

- Overall goal of program AND
 - Multiple (3) sets are likely superior to single sets
 - 1 set for novice- initially
- Type of exercise AND
- Training status

What About Intensity?

- 60-80% of 1RM (estimated- based on target range of 8-12 reps)
 - 60% = RPE 12-13 for 15 reps
 - 80%= RPE 15-17 10 reps with form loss in last 1-2 reps
- Need to feel fatigue by end of each set (multiple sets optimal)
- Rest period options unchanged (30 sec- 2 min)
- May need to lower intensity based on health condition
 - Neuro disease/NM dysfunction
 - Cardiac disease
 - Osteoporosis
- Use of Borg Scale (1-10)
 - Goal is to have 8-12 reps rated as 'somewhat hard' to 'hard'

Program Progression

Timing and quantity

- “2 for 2” rule
 - Do 2 or more reps over last assigned rep goal in the last set of 2 consecutive workouts for the exercise, add weight
- 2.5-10% load increases



Specific Concepts/Concerns

- Power training vs. traditional strength training
- High intensity training vs. low intensity training
- % 1RM and exercise choice
- Frail individuals
- Very old individuals
- Sarcopenia and co-morbidities
- Pain
- Postural fault
- Balance issues and fall risk

Research

- Strength training vs. power training (Balachandran et al., 2022)
- Eccentrics vs. concentrics (Granacher et al., 2011; Lim 2016; Kim et al., 2022)
- High-Speed Resistance Training (Martins et al., 2022)
- Role of nervous system in sarcopenia, strength training as a countermeasure (Aagaard et al, 2010)

Power vs. Strength

- Power
 - Faster, higher reps
 - 60%-80% 1 RM for LE exercises
 - 30-60% 1 RM for UE exercises
 - Better mobility outcomes
 - Strength increases occur
 - Facilitate neural adaptation, faster force production
 - Less hypertrophy
 - Inconclusive whether one better over other
 - Due to functional measurements and variability of study design and parameters

Frail Elderly

- Use very low resistance
- May have to reduce or eliminate gravity
- Try eccentric first before concentric
- Functional movement focus

Balance and Fall Risk

- Movement outside of COM
 - Stable surface with perturbation above
 - Base of support modifications
 - Translate to function
- Ankle power training (Webber and Porter, 2010)
- Reaction training (mirror drills)
- Agility training
- Dual and triple tasking is KEY (Granacher et al, 2011)
 - Carryover to life
 - Example – march, catch ball, and recite list of words
 - Tai chi

Key Concepts

- Proper form and technique
- Add strength training at any age but preferably prior to age 80
- High intensity based on Borg scale is perfectly acceptable and results are positive
- Attempt 80% of 1 RM (8-12 reps)
- Increase velocity concentric portion
- Dual and triple task
- 2-3 sets; 30 sec to 2 min rest; 2-3 x per week
- Combine power exercises with other assistive exercises
 - Dumbbells, broomsticks, kettlebells
 - Use machines only if necessary

Thank You!

Questions?

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