Exercise for Frailty and Debility in Injury Recovery and Re-Injury Prevention

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(Unfortunately…….)

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Objectives

- Learning Objective 1: Participants will know the basics principles debility and frailty in injury and recovery
- Learning Objective 2: Participants will know the application of appropriate exercise testing and training, including general and core strengthening, interval, high intensity, and low intensity training
- Learning Objective 3: Participants will know the basics of training programs for sedentary individuals and casual athletes

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Modeling Deconditioning

Astronauts in Space/Low Gravity

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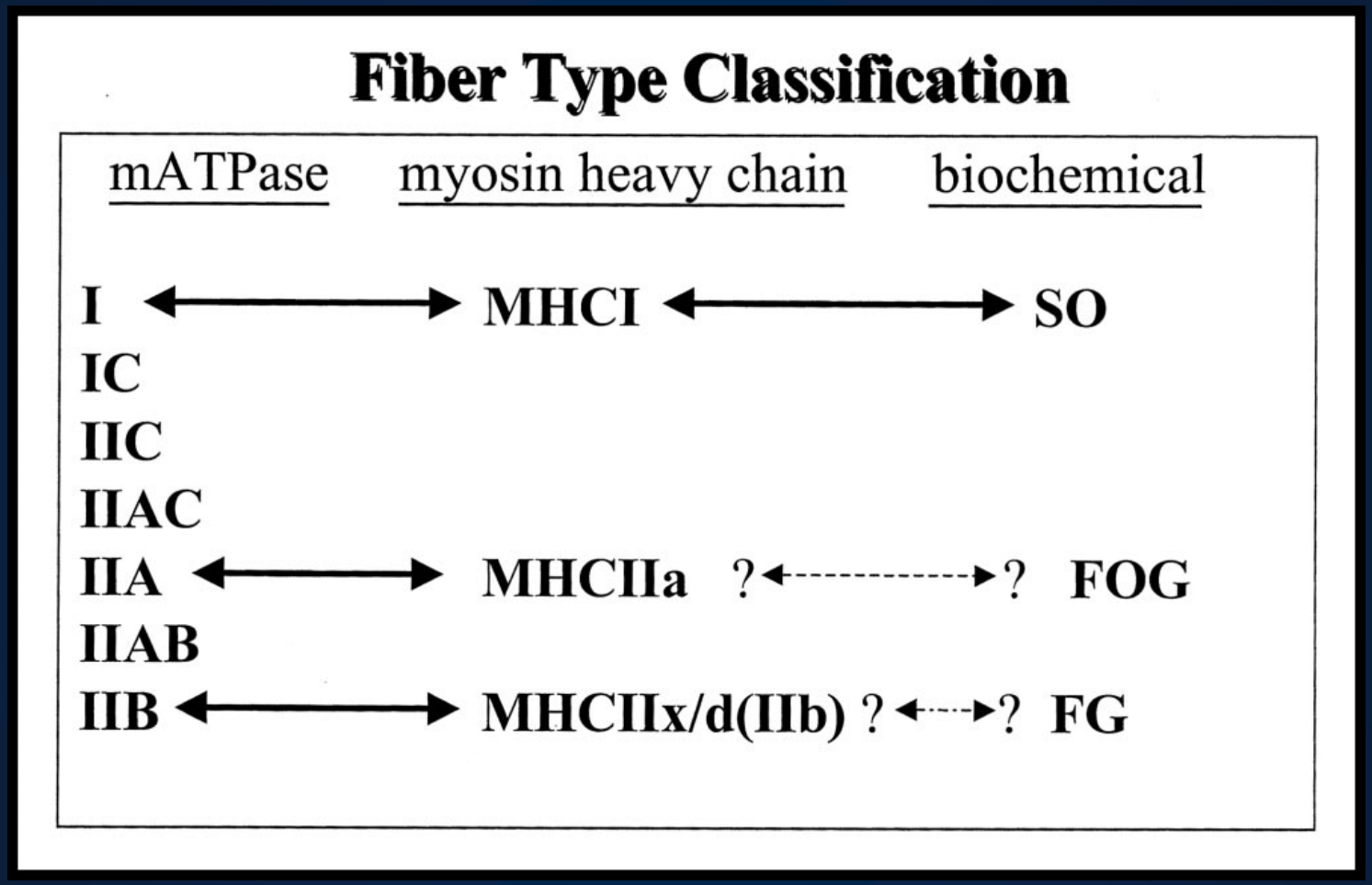
Modeling Deconditioning

- Astronauts are a model of inactivity and debility
- COPD and Heart Failure Patients
  - Model for chronic illness
  - Acute exacerbations
  - Aging and frailty

Review of Fiber Types



SO = Slow Oxidative

FOG = Fast Oxidative/Glycolytic

FG = Fast Glycolytic

? = unclear correlation, still being clarified

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Remember Basic Physiology!

- Endurance activity requires more aerobic fibers
  - This is predominantly Type I fibers
    - Sustain activity for hours, but slow twitch speed and small fiber size, aerobic metabolism
- Short burst activity requires more anaerobic fibers
  - These are predominantly Type II fibers subdivided into:
    - IIa moderately fast – long term anaerobic (<30 min)
    - IIx (IId) fast – intermediate short term aerobic(<5 min)
    - IIb very fast – short term aerobic (<1 min)
- Inactive muscles go to Type IIx fibers
  - Not very capable, but very survivable

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How Fast Does This Happen?

- Very quickly!
  - Acute illness can cause immediate loss of strength
  - Inactivity causes loss of muscle, accelerated with cachexia or a hypermetabolic state
- Healthy younger people lose 500 g of muscle/28 days
- Healthy older people (~67) lose 1 kg of muscle/10 days
  - Can turn a frail older person into an invalid in days
  - Muscle loss can mimic cachexia for hospitalized patients with sarcopenia and muscle loss

Individuals at risk

- Older individuals at higher risk
  - Comorbidities, especially DM, cachexia, cancer
  - Frail at start more likely to progress rapidly
  - Multiple medications
- Still happens to young people
  - Slower loss of muscle, but sarcopenia results
  - Worse with comorbidities
- Can be somewhat attenuated with nutrition
- Exercise best!

Basics of Exercise Training

- Divided into two main categories, dependent upon activity
  - Aerobic conditioning
    - Seen in endurance sports, e.g. long distance running, triathlon, cycling, soccer
    - Critical for daily stamina and function (walk to store, work, prolonged standing, any endurance activity)
  - Strength training
    - Short burst activity/power sports, e.g. sprinting, American Football, Weight lifting
    - Critical for ADL: lifting groceries, housework, and some work
  - Patients recovering from injuries require a balance of the two forms of training

Basic Exercise for Health

	Cardiorespiratory Endurance Exercise										Resistance Exercise
	Relative Intensity				Intensity ($\%\dot{V}O_{2max}$) Relative to Maximal Exercise Capacity in METs			Absolute Intensity	Absolute Intensity (MET) by Age			Relative Intensity
Intensity	%HRR or $\%\dot{V}O_2R$	$\%HR_{max}$	$\%\dot{V}O_{2max}$	Perceived Exertion (Rating on 6–20 RPE Scale)	20 METs $\%\dot{V}O_{2max}$	10 METs $\%\dot{V}O_{2max}$	5 METs $\%\dot{V}O_{2max}$	METs	Young (20–39 yr)	Middle-aged (40–64 yr)	Older (≥65 yr)	% 1RM
Very light	<30	<57	<37	<Very light (RPE < 9)	<34	<37	<44	<2	<2.4	<2.0	<1.6	<30
Light	30–39	57–63	37–45	Very light–fairly light (RPE 9–11)	34–42	37–45	44–51	2.0–2.9	2.4–4.7	2.0–3.9	1.6–3.1	30–49
Moderate	40–59	64–76	46–63	Fairly light to somewhat hard (RPE 12–13)	43–61	46–63	52–67	3.0 to 5.9	4.8–7.1	4.0–5.9	3.2–4.7	50–69
Vigorous	60–89	77–95	64–90	Somewhat hard to very hard (RPE 14–17)	62–90	64–90	68–91	6.0–8.7	7.2–10.1	6.0–8.4	4.8–6.7	70–84
Near–maximal to maximal	≥90	≥96	≥91	≥Very hard (RPE ≥ 18)	≥91	≥91	≥92	≥8.8	≥10.2	≥8.5	≥6.8	≥85

Table adapted from the American College of Sports Medicine (14), Howley (173), Swain and Franklin (344), Swain and Leutholtz (346), Swain et al. (347), and the US Department of Health and Human Services (370).
HR_{max}, maximal HR; $\%HR_{max}$, percent of maximal HR; HRR, HR reserve; $\dot{V}O_{2max}$, maximal oxygen uptake; $\%\dot{V}O_{2max}$, percent of maximal oxygen uptake; $\dot{V}O_2R$, oxygen uptake reserve; RPE, ratings of perceived exertion (48).

Garber, Carol Ewing Ph.D., FACSM, (Chair); ACSM Exercise Position Statement. Medicine & Science in Sports & Exercise. 43(7):1334-1359, July 2011.

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Evidence for Exercise in General

TABLE 1. Summary of the general evidence relevant to the exercise prescription.

	Evidence Statement	Evidence Category
Health benefits	Engaging in regular exercise and reducing sedentary behavior is vital for the health of adults.	A
Reversibility of training effects	Training-induced adaptations are reversed to varying degrees over time upon cessation of a program of regular exercise.	A
Heterogeneity of response	There is considerable variability in individual responses to a standard dose of exercise.	A
Exercise regimen	Cardiorespiratory and resistance exercise training is recommended to improve physical fitness and health.	A
	Flexibility exercises improve and maintain and joint range of movement	A
	Neuromotor exercises and multifaceted activities (such as tai ji and yoga) can improve or maintain physical function, and reduce falls in older persons at risk for falling.	B
	Neuromotor exercises may benefit middle aged and younger adults	D
Exercise adoption and maintenance	Theory-based exercise interventions can be effective in improving adoption and short-term adherence to exercise.	B
	Moderate-intensity exercise and exercise that is enjoyable can enhance the affective responses to exercise, and may improve exercise adherence	B
	Supervision by an experienced health and fitness professional and enhance exercise adherence	C
Risks of exercise	Exercise is associated with an increased risk of musculoskeletal injury and adverse CHD events.	B
	The benefits of exercise far outweigh the risks in most adults.	C
	Warm-up, cool down, flexibility exercise, and gradual progression of exercise volume and intensity may reduce the risk of CVD events and musculoskeletal injury during exercise.	C
	Consultation with a physician and diagnostic exercise testing for CHD may reduce risks of exercise if medically indicated, but are not recommended on a routine basis.	C
	Consultation with a well-trained fitness professional may reduce risks in novice exercisers and in persons with chronic diseases and conditions	D
Preexercise screening	Screening for and educating about the forewarning signs or symptoms of CVD events may reduce the risks of serious untoward events.	C

Table evidence categories: A, randomized controlled trials (rich body of data); B, randomized controlled (limited body of data); C, nonrandomized trials, observational studies; D, panel consensus judgment. From the National Heart Lung and Blood Institute (263).

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Evidence for Aerobic Exercise

	Evidence-Based Recommendation	Evidence Category
Cardiorespiratory ("aerobic") exercise		
Frequency	$\geq$5 d·wk^{-1} of moderate exercise, or $\geq$3 d·wk^{-1} of vigorous exercise, or a combination of moderate and vigorous exercise on $\geq$3–5 d·wk^{-1} is recommended.	A
Intensity	Moderate and/or vigorous intensity is recommended for most adults.	A
	Light- to moderate-intensity exercise may be beneficial in deconditioned persons.	B
Time	30–60 min·d^{-1} (150 min·wk^{-1}) of purposeful moderate exercise, or 20–60 min·d^{-1} (75 min·wk^{-1}) of vigorous exercise, or a combination of moderate and vigorous exercise per day is recommended for most adults.	A
	<20 min·d^{-1} (<150 min·wk^{-1}) of exercise can be beneficial, especially in previously sedentary persons.	B
Type	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature is recommended.	A
Volume	A target volume of $\geq$500–1000 MET·min·wk^{-1} is recommended.	C
	Increasing pedometer step counts by $\geq$2000 steps per day to reach a daily step count $\geq$7000 steps per day is beneficial.	B
	Exercising below these volumes may still be beneficial for persons unable or unwilling to reach this amount of exercise.	C
Pattern	Exercise may be performed in one (continuous) session per day or in multiple sessions of $\geq$10 min to accumulate the desired duration and volume of exercise per day.	A
	Exercise bouts of <10 min may yield favorable adaptations in very deconditioned individuals.	B
	Interval training can be effective in adults.	B
Progression	A gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity is reasonable until the desired exercise goal (maintenance) is attained.	B
	This approach may enhance adherence and reduce risks of musculoskeletal injury and adverse CHD events.	D

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Evidence for Resistance Exercise

Resistance exercise		
Frequency	Each major muscle group should be trained on 2–3 $d \cdot wk^{-1}$.	A
Intensity	60%–70% of the 1RM (moderate to hard intensity) for novice to intermediate exercisers to improve strength.	A
	≥80% of the 1RM (hard to very hard intensity) for experienced strength trainers to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) for older persons beginning exercise to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) may be beneficial for improving strength in sedentary persons beginning a resistance training program.	D
	<50% of the 1RM (light to moderate intensity) to improve muscular endurance.	A
	20%–50% of the 1RM in older adults to improve power.	B
Time	No specific duration of training has been identified for effectiveness.	
Type	Resistance exercises involving each major muscle group are recommended.	A
	A variety of exercise equipment and/or body weight can be used to perform these exercises.	A
Repetitions	8–12 repetitions is recommended to improve strength and power in most adults.	A
	10–15 repetitions is effective in improving strength in middle aged and older persons starting exercise	A
	15–20 repetitions are recommended to improve muscular endurance	A
Sets	Two to four sets are the recommended for most adults to improve strength and power.	A
	A single set of resistance exercise can be effective especially among older and novice exercisers.	A
	≤2 sets are effective in improving muscular endurance.	A
Pattern	Rest intervals of 2–3 min between each set of repetitions are effective.	B
	A rest of ≥48 h between sessions for any single muscle group is recommended.	A
Progression	A gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency is recommended.	A

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Frailty Assessment

- Multiple validated tests
  - Hand grip
  - Gait Speed
  - Get up and Go
- Clinical picture: Weight loss, fatigue
- Clinical Phenotype:
  - Dementia, Disability, Decreased QOL

Basic Terminology of Exercise

- Measurement of exercise capacity
- Aerobic Training
  - VO2 – defined as Liters of O2/minute or mlO2/kg/min
  - MET – one metabolic equivalent - 3.5 mlO2/kg/min
  - Wattage – Resistance on an ergometer – this is power output
  - Heart rate – Used to determine the level of intensity once power at a given heart rate established
  - RPE – can guide exercise once power rates determined
- Resistance Training
  - Maximum Voluntary contraction – one rep max
  - Muscle mass – can be estimated or measured
    - Ultrasound/MRI

Cardiopulmonary Exercise Testing

- CPET is your ally and friend
  - Allows risk assessment in individuals with history of potential health issues
    - Screen for CAD in older individuals and athletes
    - Screen for IHSS or arrhythmia in younger athletes
    - CHF and advanced lung diseases
  - Most important
    - Allows for most efficient aerobic training program
      - Achieve individual specific target heart rates
      - Customize exercise program for recovery or improved performance
      - Assure safety

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Aerobic Exercise

- Use established guidelines – but best with exercise testing to determine true levels of intensity
- Always have appropriate warm up and cool down
  - Some controversy exists on benefits, but nothing that states it is harmful
- Role of CPET (optional)
  - For high level athletes, can help to refine exercise programs and prevent overtraining.
  - Has a role in defining work efficiency/economy
  - Can allow for maximal performance

Aerobic Training – Injury Avoidance

- Principles to avoid injury
  - Avoid overtraining
  - Incorporate multiaxial activity
  - Utilize neuromuscular and proprioceptive training
    - E.g. running on real world surfaces better than on a treadmill, or road cycling better than on a stationary bike
  - Emphasize agility
  - Use well maintained equipment

Aerobic Training – Injury Avoidance

- Consume appropriate nutrients
  - During and in the first hour after exertion
  - Need to have glucose and some protein, fats less critical
- Consume appropriate liquids, especially at high levels of exertion or in high temperature
  - Avoid overhydration – can use thirst as a guide
  - Hyponatremia is the highest risk – can lead to mortality
- Maintain Electroytes
- Use of appropriate protective equipment

Aerobic Exercise Capacity

- For endurance only training
  - Work at or lightly above anaerobic threshold
  - Use as base intensity, build up training sessions
  - Perform daily
- For power combined with endurance
  - Goal is to build burst power in addition to building endurance
  - Interval training is a good way to achieve this
  - Alternate long endurance sessions with interval sessions

To HIIT, or not to HIIT?

- **H**igh **I**ntensity **I**nterval **T**raining (HIIT)
- HIIT is generally more effective at increasing strength/endurance in targeted muscle groups
- Advantages: Adaptation of standard exercises
  - Faster recovery of strength
  - Shorter sessions with less total time spent exercising
- Disadvantages: Hard to do, painful
  - Requires more supervision for some people
  - Needs a more involved individual to perform

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Sample Exercise Program

- Endurance athlete – 40 y/o male runner
  - Had an achilles tendon injury, now going back to exercise
  - HR at peak 188, HR at AT is 165
  - Exercise program should be to maintain HR for one hour at 165 BPM
  - HIIT program 30 minutes with 2 minutes on/off peak exercise HR at 185 BPM, rest at 160 BPM
  - Include some strengthening, agility, and core exercises.

Sample Exercise Program

- Elite Competitive Cyclist– 27 y/o female cyclist
  - Had a shoulder injury and was off her bike for 6 weeks
  - HR at peak 198, HR at AT is 170
  - Endurance exercise program should at 170 BPM for >1 hour several days a week for 30-60 mile road rides
  - HIIT with shorter 30 minute to 60 minute sessions – hill repeats or long ride with multiple sprints for strength building HR to 195 BPM with intervals, base activity at 165 to 170 BPM
  - Include strengthening with weight training focused on thigh muscles, and core along with agility/balance.
  - Focused strengthening of shoulders

Strength Training

- Essential for most individuals
- Can be started even while recovering from injury or in hospital
- Isometric contractures helpful in individuals who can tolerate them
  - Not for Pulmonary hypertension or heart failure patients, likely OK in most others

Strengthening Exercise Basics

- In immobile phase
  - Quad sets
  - Glut sets
    - Preserve leg strength for standing and walking
  - Bridging
    - Some core strengthening
- All together to allow return to ambulation
- Do isometrics for isolated joint injuries, muscle injuries as possible

Sample Exercises

- HIIT applies here as well
  - Aerobic HIIT will allow for more rapid strengthening of exercised muscles
- Question: how hard should strength training be?
  - High intensity/low reps vs low intensity/high reps
  - If not contraindicated, and rapid increase in strength desired, favor higher intensity.
    - Free weights better: proprioceptive open chain training
    - Isometrics may have a role too

Specifics for Strength Training

- Look at core strength => really ***trunk stability***
  - Trunk muscles most likely to atrophy quickly
  - Predominantly Type I, they switch to Type II and then IIX
  - Weak core makes all activity more fatiguing
    - Core muscles fatigue and then all exertion is difficult
  - May need to focus on this first, before starting high levels of any other exercises
  - May be profoundly week in patients even with short immobility/inactivity
- This is not related to back pain => relates to fatigue and muscle strength/endurance
  - Role of “core strength” in back pain controversial/unclear

How to Assess Core Strength

- Not well established how to assess:
  - As a rule evaluation includes: Sit ups, sitting balance and fatigue with sitting, long reaching challenge
- Sample tests:
  - In Sports: Plank tests (R/L), 60 degree Flexion Test, Trunk Extensor Endurance Test
  - In Research: Vertical Jump Test, Margaria-Kalamen anaerobic power test, Standing long jump test, Repeated bounding test, Medicine ball toss test

How to Strengthen the Core

- Abdominal and back exercises
- Reaching exercises
- Just sitting up for increased periods in very weak patients can help
- Medicine ball throwing
- Sustained extra-axial exercises

Strength Training Exercise

- Weight lifter 35 y/o man, recreational/semi-competitive
  - Establish one rep maximum training
  - DO a program of low repetition and high weight training – using reps in the >85% on rep max level
  - Include several bouts of lower intensity free weights for agility and endurance – helps with injury prevention
  - Use spotting, appropriate equipment/protective gear
  - Advise that some aerobic exercise also is important for general fitness – at moderate intensity level 70% peak HR.

Strength Training Exercise

- Football player 20 y/o man, competitive
  - The balance between aerobic and strength will depend on the position – must be tailored to position.
  - Establish maximum training program for strength
  - Include low repetition and high weight training – using reps in the >85% on rep max level
  - Include several bouts of lower intensity free weights for agility and endurance – helps with injury prevention as well as core exercises
  - Use spotting, appropriate equipment/protective gear
  - Include aerobic exercise at moderate intensity level 70% peak HR, with sprints as appropriate.

Exercise for Prevention of Injury

- Must focus on strengthening of past injured muscles
  - They become the “Achilles heel” of patient
    - Subject to re-injury
- Progressive and focused, while maintaining aerobic conditioning and agility/balance
- Initially start with closed chain/isometrics for safety, then go to open chain
- Focus on open chain longer term

Comprehensive View of Exercise and Muscle Health

- Sound muscles in balance prevents re-injury
- Must include both aerobic and anaerobic training to prevent imbalance
- Inquire where an individual has need and focus training there
- Look for HIIT style training where possible, faster results over a shorter time.
- Some endurance also important, alternate HIIT and endurance training for balance

Conclusions

- Gain familiarity with exercise physiology and the specific requirements of patients with ADL and sports
- Remember that application of exercise training can help with both injury prevention and enhancement of exercise performance for individuals in ADL and sports.
- The physiatrist has an important role to play in both debility after an injury (teachable moment) as well as with prevention of re-injury
- Work with families, therapists, and trainers/coaches to improve safety and do the right exercises

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