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Endurance Assessment and Intervention

Pamela Bartlo, PT, DPT, CCS

Learning Outcomes

After this course, participants will be able to:

- Identify at least four endurance tests appropriate for any patient population.
- Describe at least two principles for performing interventions for endurance.
- Apply concepts of endurance testing to at least two patient case examples.

Introduction

Acknowledgments

- I'd like to acknowledge
  - Julie Skzrzat, PT, DPT, PhD, CCS
  - Rachel Pata, PT, DPT, CCS
- We presented at CSM '18 and '19 on Endurance issues and some of the great background work these women did is reflected here.

Definitions

- Endurance: basic definition: the time limit of a person's ability to sustain a particular level of physical effort.[16]
- Fatigue: basic definition: weariness or exhaustion from labor, exertion, or stress[17]

APTA Guide to PT Practice[22]

- Aerobic Capacity/Endurance: The ability to perform work or participate in activities over time using the body's oxygen uptake, delivery, and energy release mechanisms.
- Muscle Endurance: The ability of muscle to sustain forces repeatedly or to generate forces over a period of time.

Importance of Endurance Assessment

Who, What, Where, When, and Why?

Who should perform endurance assessments?

- PTs: can and should do baseline endurance assessment in their initial evaluation and then in sub-sequent re-evals
- PTAs: can and should note endurance throughout sessions even though they are not performing the endurance assessment.

Who Cont'd

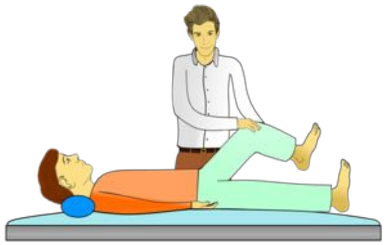
- OTs and COTAs: can and should do endurance assessment during ADLs and note endurance during OT sessions/tasks.
- Other health staff: should note endurance during tasks. *PT can give them the guidelines/scales you would like them to use. Gives you more info on performance outside of PT session*.

What endurance assessments should be used?

- Discussed more fully later in the presentation.

Where should endurance be assessed and treated?

- Clinic, gym, home care setting, long-term care facility, school, or other PT setting.
- Can also be tested in environments specific to that patient
- Endurance interventions will occur anywhere the pt performs activity, but include those listed above.



When should endurance be assessed and treated?

- Assessment:
  - Initial evaluation period
  - Re-eval times
  - D/C from facility or PT care
  - Change in medical status occurs

- Intervention for endurance:
  - Should occur throughout the treatment sessions.
  - Great to do endurance specific interventions, but also incorporate it into other tasks/mobility

Why should endurance be assessed and treated?

- COMPREHENSIVE CARE
- Cardiovascular and respiratory systems contribute so much to function and QoL
- Skeletal muscle impact from conditions impacts demand on CVP systems too
- Metabolic costs – directly impacts functional life and quality of life[30]
- Quantifiable

Factors Affecting Endurance

Factors Effecting Endurance

- Age
- Gender
- Heredity
  - Fiber type
    - Type 1 (slow twitch)
    - Type 2 (fast twitch)
- Elevation and environment
- Body composition
- Endurance training

Age

- Peak VO_2 typically between ages 18-25
- VO_2 max decreases about 0.5-1% per year or 5-10% per decade after age 25.[10,26,44]
- Primary reason for decline with Aging [5]
  - Reduced CO
  - Reduced skeletal muscle oxidative capacity

Gender

- VO_2 max is approximately 200ml/kg/min > in boys than girls in throughout childhood
- An average difference between genders continues throughout the lifespan with males having a VO_2 max of about 15-30% greater than females.
  - % body fat
  - Heart and lung size
  - Hemoglobin

Fiber Type

- Type I fibers: slow twitch – typically better for endurance
- Type II fibers: fast twitch – typically better for power and strength
- As we age, we lose muscle mass including type I and type II fibers.
  - Can lose up to 10% muscle mass by age 50, and 50% loss by age 80 y/o.[27]
- Some studies have shown greater loss of type II cells, but type I are also affected[39]

Altitude

- Atmospheric pressure impacts oxygen in the blood stream and carried on hemoglobin
- At higher altitudes: less O_2 in air and more O_2 dissociates off of Hgb.[47]
- Max O_2 intake also decreased by about 8-10%.
- Compensate by increasing RR and HR
  - As altitude increases or workload increases, RR and HR can't keep up
- Usually will compensate in about 2-5 days
- So, not a long term issue for PTs usually

Temperature

- Cold temps (precaution with ex in <30°)
  - Increase BP
  - Causes vasoconstriction
  - Some bronchoconstriction if breathing cold air without a buffer
  - More work on cardiopulm system = less endurance
- Warm temps (precaution with ex in >80°)
  - Increased metabolism by 5-15x that at rest
  - Higher internal body temp increases HR and BP
  - Thus higher CO and stress on the cardiopulm system = less endurance

Body Mass

- % body fat has direct impact on workload to cardiopulm system
- Also will see increased BP
- Possibly changes in pulmonary capacity
- Overall, increased body fat = decreased aerobic capacity so…. Decreased endurance[36]

Standardized Assessments

Standardized Tools Used to Assess Endurance or Fatigue

Disclaimer

- This section is not meant to be an exhaustive list of tests that can be used.
- It is meant to provide you with the most common assessment tools used and a discussion of their validity and reliability.

Safety Considerations

- General safety recommendations
  - have emergency procedures in place
  - select appropriate exercise protocol
  - perform pre-exercise clinical assessment and testing
  - determine variables to be monitored
  - perform post-exercise eval and monitoring
- More specific indications to limit or stop ex discussed later.

Exercise Testing Measures

- Vitals
- RPE and Subjective Dyspnea Measurement
- VO_2 max
- METS
- Fatigue

Vital Signs

- HR
- BP
- O_2 Sats
- RR
- Signs of Endurance, NOT Strength/Power

RPE and Dyspnea

Borg RPE Scale

6	
7	Very, very light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
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Dyspnea Scale

0 No dyspnea
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Borg Modified Dyspnea Scale

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1	Very Slight
2	Slight
3	Moderate
4	Somewhat Severe
5	Severe
6	
7	Very Severe
8	
9	Extremely Severe (almost maximal)
10	Maximal

VO_2 Max

- VO_2 max: prescribe ex, measure endurance
- *We're not really going to test that*
- Use research that equates test performance to VO_2 max…
- Or, train with intervals in aerobic rates to improve VO_2 max
- Think of oxygen consumption

METs

- Use measures from tests for METs
- Each type of exercise has its calculation to determine METs
- In general, uses power output (Watts or something like that) and pt's weight to determine their METs
- Can use generic MET levels too[1]
- Will discuss more later

Fatigue

- COPD:
  - Manchester COPD Fatigue Scale, FACIT-F Scale, MEMSI[2,3,20]
- MS:
  - MFIS[18,49] and FSS[32]
- PD:
  - Fatigue Impact Scale for Daily Use (D-FIS)[46]
- Many other scales specific to pathology

Standardized Tests

- GXT
- 2 MWT and 6 MWT
- 1 Mile walk
- Step test
- Sit to stand
- Recumbent stepper test
- Timed Up and Go (TUG)
- 6 Minute Arm Test
- Modified Shuttle Run Test

Maximal Graded Exercise Tests

- Strong reliability and validity in regards to endurance via aerobic capacity if pt reaches peak values[23]
- Safe and feasible
  - Provided the pt has pre-test medical screening following ACSM inclusion/exclusion criteria
- *Disadvantage: Not very practical in clinic setting*
- Not actually able to even be done in a PT clinic
- Most patients won't have a GXT (cardiac pt entering phase II rehab really only one.)

Modes of GXT

- Treadmill
- LE cycle ergometry
- UE cycle ergometry
- Recumbent Stepper – not very common
- Body weight supported treadmill
- For SCI, there is some research using w/c propulsion on treadmill[31,21,40]

2 MWT

- Comparable to 6MWT. Same testing procedure, but pt only walks for 2 min.
- Significant correlations between the 2MWT and age, height, weight, and BMI.

2 MWT Cont'd

- Minimum detectable change: 42.5 m.
  - Meaning pt needs to improve 2MWT distance by at least 42.5 m (139.4') to make a clinically significant difference.
- See Bohannon and Wang reference for age norms as they give them across the whole lifespan.[9]

6 MWT

- A sub-maximal test
- Done as a standard test with pulmonary patients, but can also be done with cardiac patients or any other medical patient
- Simple, easy, cheap test
- A good predictor of functional aerobic capacity

6 MWT Cont'd

- Can also correlate to max oxygen consumption (VO_2 max), exercise tolerance, and survival rates among cardiac and pulmonary patients
- *Validity and reliability of the 6-minute walk test in a cardiac rehabilitation population.*[24]
- *Practical interpretation of 6-minute walk data using healthy adult reference equations.*[45]

6 MWT with Neuro Patients

- Pohl et al. showed that in stroke pts, the distance performed was influenced by: LE motor impairment and overall balance[43]
- Kelly et al., showed that poor gait after stroke can be partially attributed to decreased endurance[29]
- Van Hedel et al. showed good correlations between 6 MWT, TUG, and 10 meter walk test in pts with SCI[50]
- Good validity for amb distance, and a physiologic cost index – PCI in pts with TBI

6 MWT Procedures[4]

- Should have a walkway at least 30 meters (98’ 5”)
- Patient should walk at self-selected speed.
  - Can vary speed t/o test.
- Walk as far as they can in 6 minutes.
- Can use assistive device or oxygen.
- Can rest as needed either standing or sitting.
- Can use supervision or be independent.
- * If assistance is needed, you can provide it, but you are now doing a modified 6 MWT for individual performance only

ATS Guidelines for Administration of 6 MWT, 2002

6 MWT Normal Values

- See Steffan et al. reference for age normative distances.[48] Roughly average distances are:
  - Age 60-69 average 555 m (1800')
  - Age 70-79 average 499 m (1622')
  - Age 80-89 average 404 m (1315')
- Also, Bittner et al. showed that[7]
  - Ambulation distances of <300m (~1000ft) predicted poorer prognosis for long-term survival
  - Predicted increased likelihood of death in patients with significant heart and lung diseases.

6MWT using Treadmill

- Performance of 6MWT using treadmill[33]
  - Good predictor of VO_2 max
  - As long as pt uses self selected speed, no significant difference from 6 MWT on floor
  - Has been used in a variety of pt populations now too (adults with ID, fibromayalgia, children, etc.)

1 Mile Walk Test

- Valid test to predict VO_2 max and aerobic capacity.
- Been tested in various populations and ages with some different calculations for each so may want to check them out before using on your population.[11,35,12,42]

1 Mile Walk Test Cont'd

- Need 1 mile course (track, treadmill, or other area).
  - Pt walks 1 mile as fast as they can.
  - At the end, takes HR
  - Calculations based on time to complete and HR. Some calculations use weight too.

1 Mile Walk Test Cont'd

- Pros: multiple pts can be tested at once, cheap, and simple.
- Cons: pacing is sometimes difficult for pts, performance can be affected by motivation, not good for less mobile populations.

Step Tests

- Harvard Step Test – original step test 30 steps/min at height 50.8 cm (1’ 7”)
  - Too tough for many patient populations

- Height adjusted platform step test[19]
  - Height adjusted based on femur length in at a certain hip angle
  - 26 steps/min done at that height for 3 min
  - Immediately post exercise, the subject will remain standing and a pulse will be taken (15 second count)

Step Tests for Patients with Pulmonary Conditions

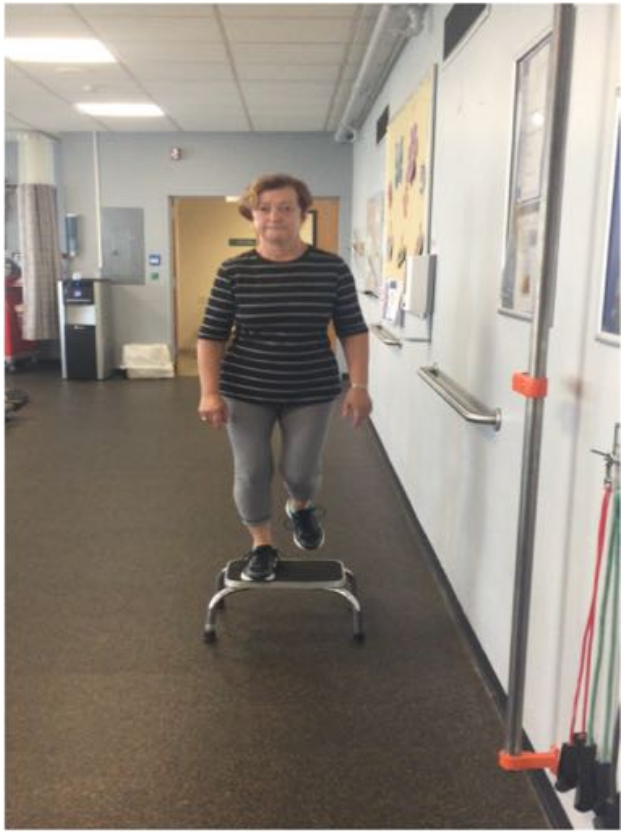
- Astrand and Rhyming Step Test[37]
  - Step height: Females 33cm (13in), Males 40cm (15.7in)
  - Rate: 22.5 steps/min (90 total steps-“up, up, down, down”) for 6 min
  - Take HR at end of each minute (use pulse ox or HR monitor) and average the last two readings

Pulmonary Step Tests Cont'd

- Self paced step test[41]
  - Step height: 7"
  - Rate: 20 steps at varying speeds: first pt instructed to go at slow speed, then at fast speed based on what the patient considered that to be

Step Test Cont'd

- Biggest key is to pick the correct protocol for your pt and WATCH balance.



Sit to Stand Test

- Typically 5x sit to stand
- Standard height chair with a back
- Have pt fold arms across their chest and stand up and sit down 5x as quickly as they can. (Also have 1 min versions)
- You measure how long (in time) it takes them.
  - Stop timing when they stand the 5th time

Sit to Stand Test

- Interpretation:
  - Lower times = better scores = more function
  - Minimum detectable change needed is 2.3 sec
- Age-Matched Norms:[8]
  - 60-69: 11.4 sec
  - 70-79: 12.6 sec
  - 80-89: 14.8 sec

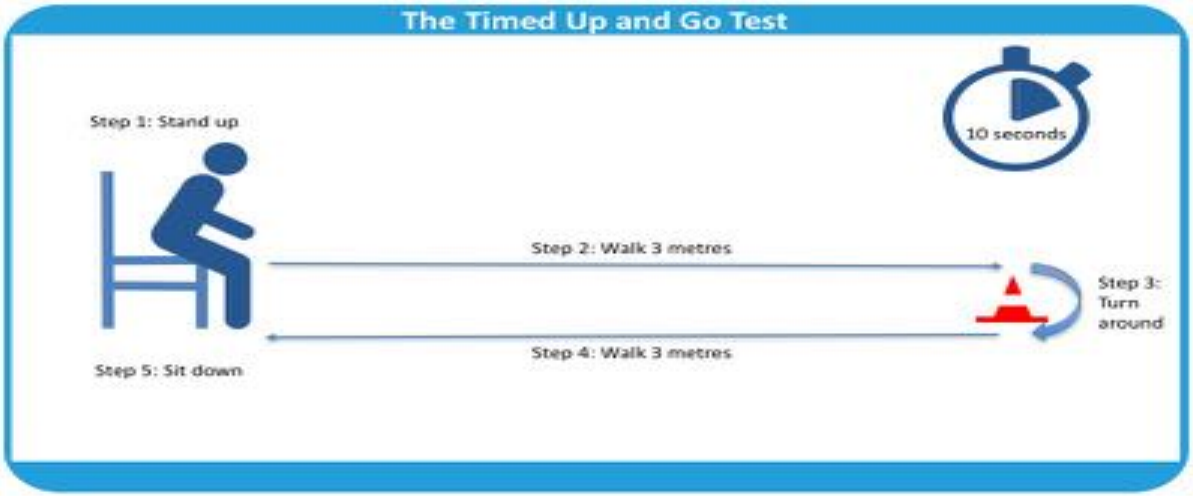
5x Sit to Stand

Recumbent Stepper Exercise Test

- Reliability and Validity: strong to assess peak VO_2 in maximal testing[6,14]
- Testing protocol:
  - Step at 100 steps/min.
  - Increase resistance level by 1 every min
  - Stopped upon fatigue or 85% HR max
- Good test to use as all extremity ex limits LE fatigue
- Good for neuro pts too including those with SCI[38]

Timed Up and Go (TUG) Test

- Benefits
  - Simple, easy, cheap, quick
  - Functional activities
  - Fall risk assessment
- Disadvantages
  - Not really useful for endurance



TUG Cont'd

- Procedure
  - Begin timing
  - Rise from standard chair
  - Walk to a spot/line 3 meters (~10ft) away from the chair
  - Turn around and return to the chair
  - Sit in chair
  - End timing

- Results
  - Low Risk
    - Score of < 14 sec & <3 RF
  - Moderate Risk
    - Score of < 14 sec & ≥ 3 RF or ≥14 sec & < 3 RF
  - High Risk
    - Score of ≥ 14 sec & ≥ 3 RF

TUG Cont'd

- Strong reliability and validity in relation to walking function[48]
- No studies found to assess validity of TUG to endurance/physical fitness
- Not recommended as an endurance test at this time, but good with low level pts in to show overall improvement in functional endurance.

6 Minute Arm Test (6-MAT)

- Reliability and validity: Excellent reliability and validity[28]
- Excellent correlation of 6-MAT to VO_2 peak
- Gives a steady state ex test that is easy to use in clinic
- Hol et al. give a schematic to use to determine the power output setting for each person

Shuttle Run Test

- Symptom limited test with incremental work loads
  - The original protocol[34]
  - The modified version[51]
  - Hassett et al. gives an equation to determine VO2 peak from shuttle run result[25]

Non-Standardized Endurance Assessments

Clinical Tools or Tests Used to Assess Endurance for Various Patient Populations

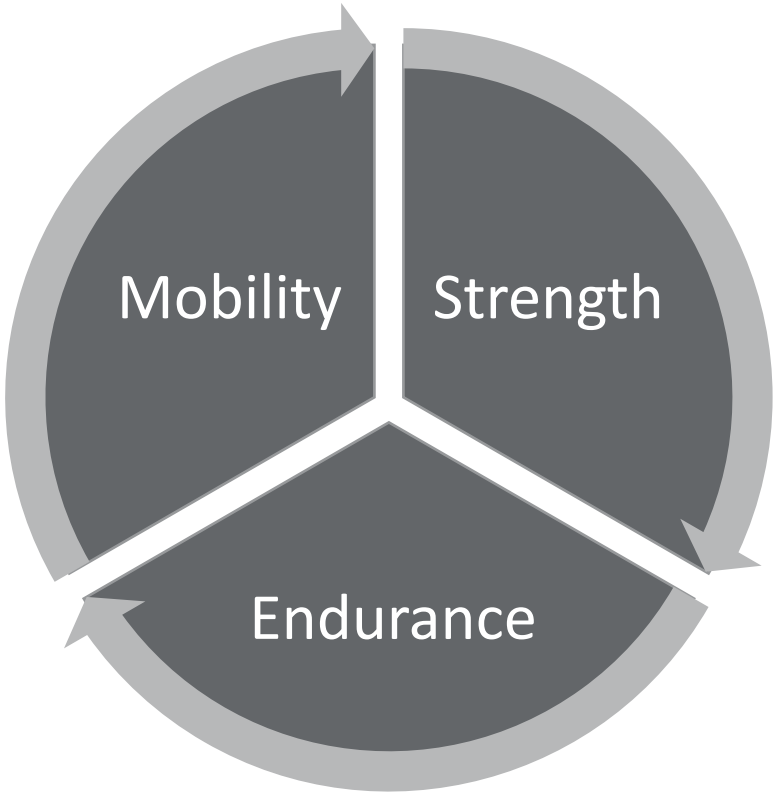
Clinical Methods to Evaluate Endurance

- General Observation
- Positioning / Postural Control
  - Is it requiring a lot of energy just to hold their head or trunk up?
- Toleration to Therapy
  - How many rest breaks do they require?

Clinical Endurance Cont'd

- Breathing Pattern
  - High effort
  - Could it be easier?
- Functional mobility skills
  - Bed Mobility, Transfers, Ambulation, Stairs, W/C Propulsion, ADL's
- Adaptive devices & equipment utilization
  - Looking at the quality & efficiency of their movement
- Environmental accessibility
  - Is their current way the most energy efficient?

Endurance and Mobility



Endurance and Mobility Cont'd

- Too many studies to list.
- Basically
  - We need to improve endurance (muscle and aerobically)
    - That will improve mobility
  - As we work on mobility (balance, positioning, function, etc.)
    - Endurance will improve too

Interventions for Endurance

Parameters

- Low level/Long duration
  - Increases number of type I muscle fibers
  - Increases oxidative abilities of peripheral muscles
  - Will improve pulmonary function
- HIIT (High Intensity Interval Training)
  - Will improve cardiovascular and pulmonary abilities
  - Increase type II fibers and some type I fibers
  - Increase strength to make motions more efficient

Parameters Cont'd

- Increase duration first, then intensity
- Rarely increase both on the same day
- Research shows increasing volume of mod intensity ex greater improvement in cardiovascular health
- Vigorous intensity will cause greater reduction of CAD risk, but not significant
- Take Home: vigorous ex is great if tolerated, but mod intensity is all that is needed[15]

ACSM Standard Ex Guidelines

- "…accumulate 30 minutes or more of moderate-intensity physical activity on most, and preferably all, days of the week." (ACSM, 2006)
- Really need to get our patients active.
- Overload principle:

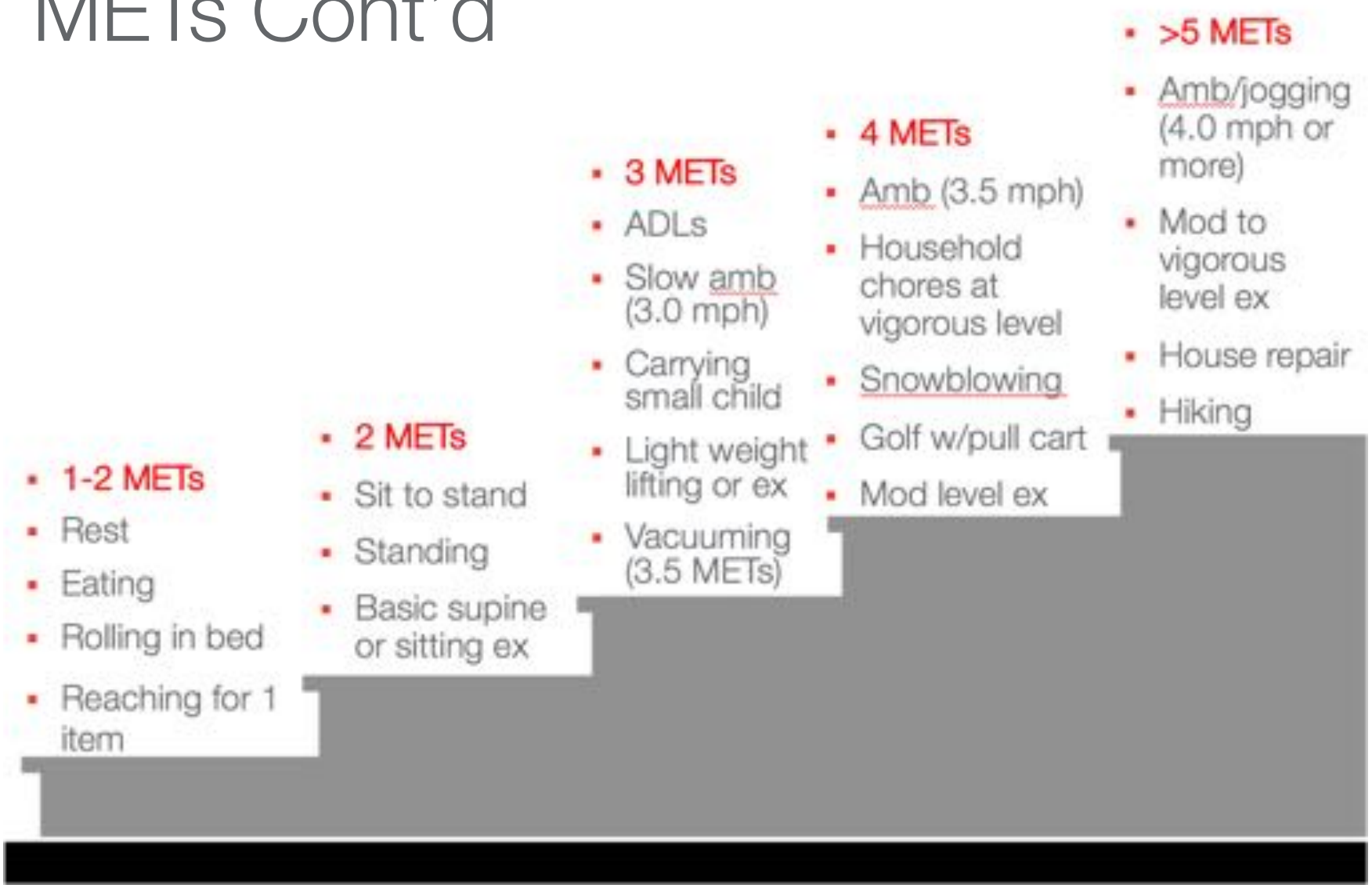
Exercise Prescription:

- Frequency: 3x / wk
- Intensity: 60% - 85% maximal value or age-estimated maximal value
- Time: 30 – 40 minutes / session
- Type: Exercises that use large muscle groups
- **TAKE HOME:** The largest risk reductions occur when patients exercise 3–7 METs-h/wk and less benefit in patients exercising >7 METs-h/wk.
- *Many of our pts may not get that high, so we just maximize what they can get*

METs

- Review: the metabolic equivalent of a task
- It's how much energy a person burns relative to their mass
- At rest, that's about 3.5 ml of O_2/kg/min or 1 MET
- Measure number of METs to complete an activity and then use that for your exercise prescription.
  - Pt does basic ADLs now at 2.5-3 METs
  - 4 weeks from now, they'll perform bike and treadmill at 4 METs

METs Cont'd


1-2 METs
Rest
Eating
Rolling in bed
Reaching for 1 item
2 METs
Sit to stand
Standing
Basic supine or sitting ex
3 METs
ADLs
Slow amb (3.0 mph)
Carrying small child
Light weight lifting or ex
Vacuuming (3.5 METs)
4 METs
Amb (3.5 mph)
Household chores at vigorous level
Snowblowing
Golf w/pull cart
Mod level ex
>5 METs
Amb/jogging (4.0 mph or more)
Mod to vigorous level ex
House repair
Hiking

Subjective scales

- Use subjective scales with METs and other parameters for ex prescription
- General rule of thumb
  - Acute care:
    - RPE 6-10 overall. Up to 11-13 for specific task with rest afterwards
    - Dyspnea: 0-2 overall, 3 for specific task with rest
  - Sub-Acute/Home Health:
    - RPE: 9-11 overall. Up to 13-14 for specific task with rest
    - Dyspnea: 0-2 overall, 3 for specific task with rest
  - Outpt/SNF/School:
    - RPE: initially 11-13, then 12-14 later on outpt as able. SNF and peds may always stay 11-13.
    - Dyspnea: 0-2 overall, 3 for specific task with rest

RPE and Dyspnea – Review

Borg RPE Scale

6	
7	Very, very light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
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Dyspnea Scale

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1	Very Slight
2	Slight
3	Moderate
4	Somewhat Severe
5	Severe
6	
7	Very Severe
8	
9	Extremely Severe (almost maximal)
10	Maximal

Intervention Strategies

- Depending on the level of your patients, you may have to start very basic and progress as needed
- Your patients may be a starting low level: ICU early AROM and mobility… all the way up to outpatient older person with balance deficits due to endurance. (Crazy to think that person is considered high level)
- We have to be prepared to evaluate and treat endurance at various levels

Along the Continuum of Care

- Positioning upright
- Breathing ex:
  - Diaphragmatic
  - Deep breathing
  - IMT as able
- Early Mobility OOB
- General conditioning ex
- Standing, amb, as able

- Functional training: transfers, bed mobility, standing posture
- Ambulation
- General conditioning ex
- Weights and aerobic ex equipment
- Specific muscle targeted ex

- Functional training still: individualized
- Ambulation
- General conditioning ex
- Weights and aerobic ex equipment
- Balance training
- Specific muscle targeted ex

Intervention Strategies: early

- Tolerating Upright
  - May have to begin in the bed and move into the chair
  - Monitor the length of time the pt is able to sit up in their chair without having to be tilted etc
- Tolerating therapy
  - Being able to tolerate the time they are supposed to be in therapy

Intervention Strategies: trunk

- Positioning / Postural Control
  - Using whatever equipment needed to keep the pt in the best position (i.e. lap trays, headrests) so they aren't getting tired trying to hold themselves up before they even begin therapy.

- Breathing Techniques
  - Teaching the pt to breath correctly
  - Incentive Spirometer
  - Inspiratory muscle trainer (P-Flex or Threshold IMT)

Intervention Strategies: functional

- Functional Mobility Skills
  - Breaking down the whole task to parts of the task
- Adaptive Equipment & Equipment utilization
  - Teaching our patients to use equipment the most efficient way & to allow them to utilize equipment to be more independent and to exercise.
- Environmental Accessibility
  - Teaching them independence, efficiency and strength

Intervention Strategies: aerobic

- Gait Training: Basic to high level (treadmill)
- Bike or airdyne
- UE Ergometry (arm bike)
- Recumbent stepper (Nu-Step)
- W/C Propulsion
- For very low level pt - standing program (Stander)
- Circuit Training (weight lifting & aerobic)
  - Cybex or Uppertone
  - The Wii – Endurance games
  - Free weights

Take Home of Intervention Strategies

- There is no perfect answer I can tell you
- Any ex the pt can do, is an ex to have them do
- Any ex the pt will do, is an ex to have them do
- May need to focus on specific component
  - Just on amb **OR** specific muscle(s) strengthening **OR** balance **OR** aerobic capacity
- May need to do a several pronged approach
  - Work on amb **AND** muscle strengthening **AND** balance **AND** aerobic capacity

Importance of Documentation

Documentation

- As clinicians, documentation is very important, now more than ever. Insurances dictate the length of stay of our patients. Insurances rely heavy on the progress shown in our documentation.
- We are good about making our main goals functional, measurable, and attainable.
- For Endurance:
  - Describe the time, weight/resistance, repetition, amount of rests needed, etc.

Use the SMART system

- **S**mart – clear, concise, who/what/when…
- **M**easurable – time, amount, distance…
- **A**chievable – functional and good for time set and pt's ability levels
- **R**elevant – consistent with LTGs of pt and other health care disciplines
- **T**ime-bound – set for appropriate length of time

Documentation Examples: Low Level

- While in short sit, patient will be able to hold proper posture for 30 seconds independently
  - Progress it by upping the time or put it to a functional task
- Pt will be able to speak 5 syllables/letters per breath.
  - Eventually up the number of syllables/letters etc.
- Pt will be able to perform the IMT (inspiratory muscle trainer) for 5 minutes on resistance 1 three times a day.
  - Work up to 15 minutes on each level 4-5 times a day and then increase the resistance

Documentation Examples: Mid Level

- Pt will be able to use the recumbent stepper (or other aerobic ex equipment i.e. bike, AE, etc.) for 10 minutes at ___resistance without a rest.
  - Then up the time and resistance to progress pt
- Pt will tolerate 15 min of amb prior to rest needed. (Or other specific activity)
  - Up the time or decrease the time of rest needed

Documentation Examples: High Level

- Patient will be able to amb 200’ in less than 3 min without rest needed.
- Patient will perform 2 sets of 10 reps of 8 UE and LE resistance exercises with 5# wts.
- Patient will perform cycle ergometer for 12 min at > 80 rpms and resistance level 4.

Documentation Using Time

- Use time in 2 ways:
  - Time pt can perform activity for: pt will perform amb x 200’
  - Efficiency based on performing a task in a certain amount of time: pt will amb x 200’ in less than 3 min

Outcomes

- We do expect endurance to improve based on the our interventions and progress of their functional mobility
- Like other tests and measures, it is important that we re-perform standardized endurance tests after several sessions/weeks of PT
- When endurance doesn't improve
  - Why is that?
  - What do we need to change?

Contraindications to Start Ex

- Unstable angina
- Resting HR >120
- Resting SBP>200, DBP >100 or DPB <60
- Atrial or ventricular tachycardia, frequent PVCs, multi-focal PVCs, PVCs which increase with ex or resting S-T segment depression of >2mm, 3° heart block
- Blood glucose >400
- Significant medical problems
- Unstable blood glucose levels

ACSM, 2018

Relative Indications to Stop Ex

- Drop in SBP > 20 mmHg
- Rapid rise in SBP >180 mmHg, DBP >100 mmHg
- ST or QRS changes such as excessive ST depression
- Arrhythmias including multifocal PVCs, triplets of PVCs, development of new bundle-branch block, supraventricular tachycardia (SVT), heart block, bradycardia [NOT VT]
- Fatigue, SOB, diaphoresis, wheezing, leg cramps or signs of vascular claudication
- Increasing chest pain

ACSM, 2018

Indications to Stop Ex

- Onset of angina or angina-like sx
- Drop in SBP ≥10 mmHg
- Excessive rise in BP: SBP > 250 mmHg and/or DBP > 115 mmHg
- SOB, wheezing, leg cramps, signs of claudication causing pt to want to stop ex
- Signs of poor perfusion: light headedness, confusion, ataxia, pallor, cyanosis, nausea, or cold and clammy skin
- Failure of HR to increase with increased ex intensity
- Noticeable change in heart rhythm by palpation or auscultation

ACSM, 2018

Case Study

Case Study – Roy G. Biv

- Roy is a 72 y/o man who underwent abdominal surgery 2 days ago s/p lower bowel obstruction.
- PMH: Prostate Ca 6 years ago, HTN, MI 4 years ago, COPD, cataract surgery 2018.
- Meds: Colace 100 mg bid, Atenolol 12.5 mg bid, Avapro 150 mg QD, Albuterol 2 puffs Q6 hrs, Percocet 5 mg Q4 hrs.
- Social Hx: retired police officer. Lives with his wife in a 2 story cape and was independent PTA.

Roy Initial Evaluation: Acute Care

- Upon entering room you find Roy supine with HOB elevated to about 45°, 1L O_2 NC, IV, PCA pump, catheter, and abdominal drain in place.
- Pt with c/o 5/10 at incision and increases with movement.
- Vitals: HR – 77, BP – 146/85, RR – 15, O_2 sats – 92%

Roy Eval Cont'd

- Do you general AROM and functional strength tests.

- What endurance test(s) would you like to do?

Roy Treatment: Acute

- What is your plan of treatment intervention for the first PT session?

- How will you progress plan and how will you show endurance improvement?

Roy G. Biv goes to Sub-Acute Rehab

- Day 5 after surgery, Roy is transferred to your sub-acute rehab facility.
- Initial eval: Roy is brought to your PT gym in a wheelchair on RA and no lines in place.
- Pain is 5/10 at abdomen and is fairly constant. He reports that it does increase with amb.
- Vitals: HR – 75, BP – 148/82, RR – 12, O_2 sats – 88%

Roy's Subacute Eval

- Do your full PT sub-acute eval.
- Then, what endurance test(s) would you like to do?

Roy's Treatment: Sub-Acute

- How will you treat Roy's endurance impairments?

- How will you show endurance improvement?

Roy to Outpatient PT

- How would the interventions and assessments used in sub-acute change in outpatient?

Summary

- Describe importance of endurance assessment and intervention
- List factors that impact Endurance
- Explain endurance tests and their administration
- Detail endurance intervention strategies and parameters
- Apply knowledge

Thank You and Questions

References

1. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and met intensities. *Med Sci Sports Exerc*. 2000 Sep;32(9 Suppl):S498-504.
2. Al-shair K, Kolsum U, Berry P, Smith J, Caress A, Singh D, Vestbo J. Development, dimensions, reliability and validity of the novel Manchester COPD fatigue scale. *Thorax*. 2009 Nov; Vol. 64 (11): 950-5.
3. Al-shair K, Muellerova H, Yorke J, et al. Examining fatigue in COPD: development, validity and reliability of a modified version of FACIT-F scale. *Health Qual Life Outcomes*. 2012 Aug 23; Vol. 10: 100.
4. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med*. 2002 Jul 1;166(1):111-7.
5. Betik AC, Russell TH. Determinants of VO2 max decline with aging: an integrated perspective. *Appl Physiol Nutr Metab*. 2008 Feb;33(1):130-40.
6. Billinger SA, VAN Swearingen E, McClain M, Lentz AA, Good MB. Recumbent stepper submaximal exercise test to predict peak oxygen uptake. *Med Sci Sports Exerc*. 2012;44(8):1539-1544.

References Cont'd

7. Bittner V, Weiner DH, Yusuf S, et al. Prediction of mortality and morbidity with a 6-minute walk test in patients with left ventricular dysfunction. *JAMA. 1993;270:1702–1707.*
8. Bohannon RW. Reference values for the five-repetition sit-to-stand test: a descriptive meta analysis of data from elders. *Percept Mot Skills.* 2006; 103(1):215-222.
9. Bohannon RW, Wang YC, Gershon RC. Two-minute walk test performance by adults 18 to 85 years: normative values, reliability, and responsiveness. *Arch Phys Med Rehabil*. 2015 Mar;96(3):472-7.
10. Bortz IV WM, Bortz II WM. How Fast Do We Age? Exercise Performance Over Time as a Biomarker. *J Gerontol A Biol Ci Med Sci*. 1996; 51A (5): M223-5.
11. Burns RD, Hannon JC, Brusseau TA, et al. Development of an aerobic capacity prediction model from one-mile run/walk performance in adolescents aged 13-16 years. *J Sports Sci*. 2016; Vol. 34 (1):18-26.
12. Castro-Pinero J, Mora J, Gonzalez-Montesinos JL, Sjostrom M, Ruiz JR. Criterion-related validity of the one-mile run/walk test in children aged 8-17 years. *J Sports Sci*. 2009 Feb 15; Vol. 27 (4):405-13.

References Cont'd

13. Chung P-K, Zhao Y, Liu J-D, Quach B. A canonical correlation analysis on the relationship between functional fitness and health-related quality of life in older adults. *Arch Gerontol Geriatr*. 2017;68:44-48.
14. Donaldson S, Wright L, Day A, Weiford B. Validity of a Submaximal 6-min Recumbent Stepper Test for Cardiac Rehabilitation. *J Cardiopulm Rehabil Prev*. 2019;39(2):E14-E17.
15. Eijsvogels TMH, Molossi S, Lee DC, Emery MS, Thompson PD. The amount of exercise to reduce cardiovascular events. *JACC*. 2016;67:316-29.
16. Eng JJ, Chu KS, Dawson AS, Kim CM, Hepburn KE. Functional Walk Tests in Individuals With Stroke: Relation to Perceived Exertion and Myocardial Exertion. *Stroke*. 2002;33:756-761.
17. "Fatigue." Merriam-Webster.com. Merriam-Webster, n.d. Web. 20 March. 2019.
18. Flachenecker P, KuÈmpfel T, Kallmann B, et al. Fatigue in multiple sclerosis: a comparison of different rating scales and correlation to clinical parameters. *Mult Scler*. 2002 Dec;8(6):523-26.
19. Francis KT. A new single-stage step test for the clinical assessment of maximal oxygen consumption. *Phys Ther*. 1990;70(11):734-8.

References Cont'd

20. Garrow AP, Khan N, Tyson S, Vestbo J, Singh D, Yorke J. The development and first validation of the Manchester Early Morning Symptoms Index (MEMSI) for patients with COPD. *Thorax*. 2015 Aug; Vol. 70 (8): 757-63.
21. Gauthier C, Arel J, Brosseau R, Hicks AL, Gagnon DH. Reliability and minimal detectable change of a new treadmill-based progressive workload incremental test to measure cardiorespiratory fitness in manual wheelchair users. *J Spinal Cord Med*. 2017;40(6):759-767.
22. *Guide to Physical Therapist Practice 3.0*. Alexandria, VA: American Physical Therapy Association; 2014. Available at: http://guidetoptpractice.apta.org/. Accessed March 12, 2019.
23. Gulati M, Shaw LJ, Thisted RA, Black HR, Bairey Merz CN, Arnsdorf MF. Heart Rate Response to Exercise Stress Testing in Asymptomatic Women The St. James Women Take Heart Project. *Circulation. 2010;122:130-137.*
24. Hamilton DM, Haennel RG. Validity and reliability of the 6-minute walk test in a cardiac rehabilitation population. *J Cardiopulm Rehabil*. 2000 May-Jun;20(3):156-64.

References Cont'd

25. Hassett L, Moseley AM, Tate R, Harmer AR. Fitness training for cardiorespiratory conditioning after traumatic brain injury. *Cochrane Database Syst Rev.* 2008;2. Art. No.: CD006123. DOI:10.1002/14651858.CD006123.pub2.
26. Hawkins SA, Wiswell RA. Rate and Mechanism of Maximal Oxygen Consumption Decline with Aging: Implications for Exercise Training. *Sports Med*. 2003; 33 (12): 877-888
27. Herbst A, Wanagat J, Cheema N, Widjaja K, McKenzie D, Aiken JM. Latent mitochondrial DNA deletion mutations drive muscle fiber loss at old age. *Aging Cell*. 2016;15(6):1132-1139.
28. Hol AT, Eng JJ, Miller WC, Sproule S, Krassioukov AV. Reliability and Validity of the Six-Minute Arm Test for the Evaluation of Cardiovascular Fitness in People With Spinal Cord Injury. *Arch Phys Med Rehabil*. 2007 Apr;88(4):489-95.
29. Kelly JO, Kilbreath SL, Davis GM, Zeman B, Raymond J. Cardiorespiratory Fitness and Walking Ability in Subacute Stroke Patients. *Arch Phys Med Rehabil*. 2003 Dec; 84(12): 1780-5.
30. Kim D. Correlation between physical function, cognitive function, and health-related quality of life in elderly persons. *J Phys Ther Sci*. 2016;28(6):1844-1848.

References Cont'd

31. Kilkens OJ, Dallmeijer AJ, Nene AV, Post MW, van der Woude LH. The Longitudinal Relation Between Physical Capacity and Wheelchair Skill Performance During Inpatient Rehabilitation of People With Spinal Cord Injury. *Arch Phys Med Rehabil.* 2005 Aug;86(8):1575-81.
32. Krupp LB, LaRocca NG, Muir-Nash J, Steinberg AD. The Fatigue Severity Scale Application to Patients With Multiple Sclerosis and Systemic Lupus Erythematosus. *Arch Neurol*. 1989 Oct;46(10):1121-3.
33. Laskin JJ, Bundy S, Marron H, Moore H, Swanson M, Blair M, Humphrey R. Using a treadmill for the 6-minute walk test: reliability and validity. *J Cardiopulm Rehabil Prev*. 2007 Nov-Dec;27(6):407-10.
34. Léger LA, Lambert J. A maximal multistage 20-m shuttle run test to predict VO2 max. *Eur J Appl Physiol Occup Physiol*. 1982;49(1):1-12.
35. Lunt H, Roiz De Sa D, Roiz De Sa J, Allsopp A. Validation of one-mile walk equations for the estimation of aerobic fitness in British military personnel under the age of 40 years. *Mil Med*. 2013 Jul; Vol. 178 (7):753-9.

References Cont'd

36. Maciejczyk M, Więcek M, Szymura J, Szyguła Z, Wiecha S, Cempla J. The influence of increased body fat or lean body mass on aerobic performance. *Plos One*. 2014;9(4):e95797.
37. Marley WP, Linnerud AC, A three-year study of the Astrand-Ryhming step test *Research Quarterly*. 1976 May;47(2):211-7.
38. McCulloch J, Lorenz D, Kloby M, Aslan SC, Love M, DE Paleville DT. Prediction of Maximal Oxygen Consumption from Rating of Perceived Exertion (RPE) using a Modified Total-body Recumbent Stepper. *Int J Exerc Sci*. 2018;8(4):414-424.
39. Miljkovic N, Lim JY, Miljkovic I, Frontera WR. Aging of skeletal muscle fibers. *Ann Rehabil Med*. 2015;39(2):155-62.
40. Morgan KA, Taylor KL, Tucker SM, Cade WT, Klaesner JW. Exercise testing protocol using a roller system for manual wheelchair users with spinal cord injury. *J Spinal Cord Medicine*. March 2018:1-15.
41. Petrella RJ, Koval JJ, Cunningham DA, Paterson DH. A self-paced step test to predict aerobic fitness in older adults in the primary care clinic. *J Am Geriatr Soc.* 2001 May;49(5):632-8.

References Cont'd

42. Pober DM, Freedson PS, Kline GM, McInnis KJ, Rippe JM. Development and validation of a one-mile treadmill walk test to predict peak oxygen uptake in healthy adults ages 40 to 79 years. *Can J Appl Physiol*. 2002 Dec; Vol. 27 (6):575-89.
43. Pohl PS, Duncan PW, Perera S, Liu W, Lai SM, Studenski S, Long J. Influence of stroke-related impairments on performance in 6-minute walk test. *J Rehabil Res Dev*. 2002 Jul-Aug;39(4):439-44.
44. Riebe D, Ehrman JK, Liguori G, et al. *ACSM's Guidelines for Exercise Testing and Prescription, 10th* ed. Philadelphia, PA: Wolters Kluwer; 2018.
45. Sanderson B, Bittner V. Practical interpretation of 6-minute walk data using healthy adult reference equations. *J Cardiopulm Rehabil*. 2006 May-Jun;26(3):167-71.
46. Serrano-Dueñas M, Bravo R, Merchán T, Serrano M. Fatigue in Parkinson's disease: Metric properties of the fatigue impact scale for daily use (D-FIS), and its impact on quality of life. *Clin Neurol Neurosurg*. 2018 Jun; Vol. 169, pp. 12-15.

References Cont'd

47. Shephard RJ. Human endurance and the heart at altitude. *J Sports Med Phys Fitness*. 1970;10(2):72-83.
48. Steffan Nollinger L. Age- and Gender-Related Test Performance in Community-Dwelling Elderly People: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and Gait Speeds. *PhysTher. 2002; 82(2): 128-137.*
49. Tellez N, Rıo J, Tintore M , Nos C, Gala´n I, and Montalban X. Does the Modified Fatigue Impact Scale offer a more comprehensive assessment of fatigue in MS? *Mult Scler*. 2005 Apr;11(2):198-202.
50. van Hedel HJ, Wirz M, Dietz V. Assessing Walking Ability in Subjects With Spinal Cord Injury: Validity and Reliability of 3 Walking Tests. *Arch Phys Med Rehabil*. 2005 Feb;86(2):190-6.
51. Vitale AE, Jankowski LW, Sullivan SJ. Reliability for a walk/run test to estimate aerobic capacity in a brain-injured population. *Brain Inj*. 1997 Jan;11(1):67-76.