Graded Exercise Testing (GXT)

**Purpose of Testing (p 58 G)**
- Educating participants about their present fitness status relative to health-related standards and age- and gender-matched norms
- Providing data that are helpful in development of exercise prescriptions to address all fitness components
- Collecting baseline and follow-up data that allow evaluation of progress by exercise program participants
- Motivating participants by establishing reasonable and attainable fitness goals
- Stratifying risk

**Pretest Instructions (p 58 G)**
- Wear comfortable, loose-fitting clothing consistent with testing.
- Drink plenty of fluids over the 24-hour period preceding the test to ensure normal hydration prior to the testing.
- Avoid food, tobacco, alcohol, and caffeine for at least 3 hours before testing.
- Avoid exercise or strenuous physical activity the day of the test.
- Get an adequate amount of sleep (6 to 8 hours) the night before the test.

**Test Environment/Administration**
- Temperature 70-74 degrees/ventilated
- Order tests appropriately
- Quiet
- Private
- Clean
- Comfortable seat or exam table
- Testing equipment working and calibrated
- Clear explanation of test procedures
- Demeanor – relaxed confidence

**Test Order**
- Resting Measurements
  - HR
  - BP
  - Height
  - Weight
- Cardiorespiratory endurance
- Muscular strength and endurance
- Flexibility

**Maximal or Submaximal Tests?**
- Reason for test
  - Diagnosis/Evaluate S/S of CAD
  - Estimate VO$_2$max for exercise prescription
- Type of subject
  - Risk stratification
- Availability of appropriate equipment
- Personnel
  - Risk stratification
**Factors Affecting Submaximal Tests**
- Heat
- Humidity
- Eating/hydration
- Behavioral factors – smoking, pensive activity
- Medications – RX and OTC

**Submaximal Tests**
- Ideal – test mode consistent with individual’s primary activity
- Largest source of error – estimation of maximal HR

**Box 4-4. General Indications for Stopping an Exercise Test in Low-Risk Adults**
- Onset of angina or angina-like symptoms
- Significant drop (20 mm Hg) in systolic blood pressure or a failure of the systolic blood pressure to rise with an increase in exercise intensity
- Excessive rise in blood pressure: systolic pressure > 260 mm Hg or diastolic pressure > 115 mm Hg
- Signs of poor perfusion: light-headedness, confusion, ataxia, pallor, cyanosis, nausea, or cold and clammy skin

**Assumptions of Submaximal Tests**
- (p. 69 G)
  - A steady-state heart rate is obtained for each exercise work rate.
  - A linear relationship exists between heart rate and work rate.
  - The maximal heart rate for a given age is uniform.
  - Mechanical efficiency (i.e., VO₂ at a given work rate) is the same for everyone.

**Box 4-4. General Indications for Stopping an Exercise Test in Low-Risk Adults Continued**
- Failure of heart rate to increase with increased exercise intensity
- Noticeable change in heart rhythm
- Subject requests to stop
- Physical or verbal manifestations of severe fatigue
- Failure of the testing equipment
Submax Testing

- Perform an active cool down unless symptomatic – sit or in hook position

Mode of Testing

- Survey - 1,400 exercise testing facilities
- 1. Treadmill - 71%
- 2. Cycle Ergometer - 17%
- 3. Step - 12%

Treadmill Protocols

- 1. Bruce - 65.5%
- 2. Balke - 9.7%
- 3. Naughton - 6%
- 4. Ellestad - 3.1%
- 5. Other - 15.7%
- Astrand - speed adjusted to athlete, increase grade 2.5% every 2 minutes after initial 3 minute stage at 0% grade

Advantages of Bicycle Ergometer

- 1. Portable as compared to treadmill
- 2. Quieter - easy to take BP
- 3. Better ECG reception and easier to take BP, less UE movement
- 4. Less expensive than treadmill
- 5. Requires less space than treadmill
- 6. Orthopedic problems, can usually perform

Disadvantages of Bicycle Ergometer

1. Leg fatigue - endpoint - lower HR and VO2 values (5-25%) at max

Advantages of Treadmill

1. Higher VO2max values and heart rates - specificity
2. Leg strength and early fatigue - less of a problem compared to bicycle ergometer
Disadvantages of Treadmill
1. Expensive
2. Not portable
3. Requires more space

Step Test - Advantages
1. Cost
2. Mass testing
3. Limited space requirements
4. Portable

Disadvantages of Step Test
1. Obese individuals
2. Unfit cannot complete the test
3. Orthopedic problems
4. Higher risk individuals
5. High initial MET level - 7.4 METs
6. Inability to measure ECG, BP during test
7. One step height problem - short, unfit
8. Heart rate taken during recovery - not as accurate method to estimate CFR fitness
9. May exceed 85% of MPHR

Selection of Protocol
- Bruce treadmill protocol
  \[ r = 0.98 \text{ active and sedentary males and cardiac males} \]
  \[ r = 0.91 \text{ for active and sedentary females} \]
Criticism
- Initial stage starts at high exercise capacity - 4.6 METs
- Increase in workload in unequal increments which may overestimate exercise capacity
- Stage 3 for women and 4 for men difficult - walk or jog??
Balke, Naughton, and USAFSM Protocols

- Small incremental increases (≤ 1 MET)
- Better for deconditioned or older, or diseased individuals

Biggest source of error
Estimate VO2max on Treadmill

Ramp Protocols

- Alternative to graded or incremental exercise testing
- Work rate increases at a constant and continuous manner
- BE – most common, many treadmills have this controller feature
- Standard - everyone performs standard protocol but in a ramp fashion or
- Individualized – the rate of increase in intensity based on subject

Advantages of Ramp Protocols

- Targeted test duration (select work rate changes so 8-12 minute duration)
  - Elderly – increase BE 10-15 Watts/minute or increase 1-3% grade/minute
- Avoidance of large and unequal increments in workload
- More accurate estimates of exercise capacity
- Facilitates individualizing the test

Considerations for Protocol Selection

1. Population - cardiac, healthy, sedentary vs active
2. Available time -
3. Orthopedic/other limitations
Guidelines for Protocol Selection

1. Start 2-3 MET level with 2-3 minute stages
2. Increase workload 1-3 METs per stage
3. Enough time and stages to allow for incremental measurement of heart rate, blood pressure, ECG and RPE
4. Ideal time - exhaust client in 8-12 minutes
   a. Discomfort
   b. Boredom

Treadmill (p 92 ACSM G)

- Cardiac patients, older, deconditioned - Start 2 METs, increase 1 MET per stage - Naughton, Balke-Ware (modified 3.0 mph for women), USAFSAM
- Active or younger individuals - Bruce and Ellestad, Balke is too long

Bicycle Ergometer 2-3 minute stages, page 92, ACSM

- Healthy, unfit - start at 150-300 kgm/min, increase by 100-150 kgm/min
- Cardiac, less fit or older - start 100-150 kgm/min and increase
- Younger, fit individuals - start 300-600 kgm/min and increase by 150-300 kgm/min

Field Tests

- Advantages
  - Large numbers
  - Little equipment
  - Inexpensive
  - Space
  - Portable
- Disadvantages/Concerns
  - May be maximal
  - Monitor
  - Level of motivation if self-paced
  - Ability to pace
  - Musculoskeletal problems

Active vs Supine CD for max testing

- Active - decreased risk of post exercise hypotension, but attenuates magnitude of ST segment depression
- Supine - maximal sensitivity - % of patients tested who have CAD who show positive or abnormal test results (> 1 mm ST segment depression)
Field Tests

- Running – Cooper 12-minute run test or 1.5 mi run test
  - Vigorous or moderate????
- Walking – Rockport one-mile walking test
- Step test – YMCA protocol
  - Cost

Emergency Procedures

- All personnel CPR certified (locker room attendants, janitors, secretaries)
- Preferably ACLS if conducting stress tests
- Emergency phone numbers and procedures (life-threatening and nonlife-threatening) posted in testing area
- Phone in testing area
- Emergency plan practiced quarterly, document rehearsal and evaluation
- If physician/code blue not immediately available, any concerns regarding patient status – transport
- Complete an accident report and follow-up on client

Respiratory Quotient (RQ)

- Reflects composition of fuels oxidized by cells during exercise at cellular level
- VCO₂/VO₂ (nonprotein)
- Measured at mouth
  - R
  - RER (respiratory exchange ratio)

Chemistry of fats, CHO and protein

- Different amounts of O₂ are required to oxidize the C and H atoms to CO₂ and H₂O
- Hence, quantity of CO₂ produced in relation to O₂ consumed will vary depending on substrate metabolized
- Amount of O₂ necessary to completely oxidize a molecule of CHO or fat is proportional to amount of C in fuel
Respiratory Quotient for CHO

- Glucose $C_6H_{12}O_6$
  - 6 C atoms produce 6 CO$_2$
  - 6 O$_2 + C_6H_{12}O_6 \rightarrow$ 6 CO$_2 + 6$ H$_2$O + 38 ATP
- RER = 6 CO$_2$/6 O$_2$ = 1.0

Respiratory Quotient for Fats

- $C_{12}H_{28}O_2 + 23$ O$_2 \rightarrow$ 16 CO$_2 + 16$ H$_2$O + 129 ATP
- RER = 16 CO$_2$/23 O$_2$ = 0.70

R Values

- Rest on mixed diet = 0.82 (40% CHO/60% fat)
- Starving = 0.70
- Moderate intensity exercise = 0.9 (65% CHO/34% fat)
- Maximal exercise = 1.1 to 1.3 why???????

Zuntz Table

- Look up the caloric expenditure based on your RER vs estimating 5kcal/L
- RER = .8 = 4.801 kcal/L
- RER = 1.0 = 5.047 kcal/L