Objectives

1. Compare and contrast the concepts of measurement, evaluation, and prediction.

2. Explain the specificity and generality applied to exercise performance and physiologic function.

3. Describe the procedures to administer two practical “field tests” to evaluate anaerobic capacity of the intramuscular high-energy phosphates.

4. Identify a commonly used laboratory test to evaluate the power output capacity of glycolysis.

5. Explain the differences between direct and indirect calorimetry.

6. Explain the differences between open- and closed-circuit spirometry.

7. Describe the different measurement systems used in open-circuit spirometry.
8. Define the term respiratory quotient (RQ) including its use and importance.

9. Explain the factors that influence RQ and respiratory exchange ratio.

10. Define the maximal oxygen uptake \( (VO_{2\text{max}}) \), including its physiological significance.

11. Define the graded exercise stress test.

12. List the criteria that indicate when a person reaches “true” \( VO_{2\text{max}} \) and \( VO_{2\text{peak}} \) during a graded exercise test.

13. Identify at least three commonly used treadmill protocols to assess \( VO_{2\text{max}} \).

14. Explain how each of the following affects \( VO_{2\text{max}} \): (1) mode of exercise, (2) heredity, (3) state of training, (4) gender, (5) body composition, and (6) age.
Objectives (Cont.)

15. Describe the procedures to administer a submaximal walking “field test” to predict VO$_{2\text{max}}$.

16. Outline the procedure to administer a bicycle test to predict VO$_{2\text{max}}$.

17. List three assumptions when predicting VO$_{2\text{max}}$ from submaximal exercise heart rate.
Measurement, Evaluation, and Prediction of Human Performance Variables

- **Measurement** takes place when a score attaches to a performance.

- **Evaluation** involves interpretation of test scores.
  - Measuring represents an objective, nonjudgmental process; evaluating requires that judgments be made.

- **Prediction** is a process whereby test scores estimate or predict another function, or attribute from the same individual.
  - The strength of any prediction comes from the degree of relationship between the test scores and the estimated function.
Individual Differences and Specificity

- The concepts of individual differences and specificity help explain differences in capacity for anaerobic and aerobic power.

  - **Individual differences** refer to real differences among individuals, which contrasts to variation in physiologic response that characterizes the individual.

  - **Specificity** says that the effects of systematic exercise training remain highly specific for neurologic, physiologic, and metabolic responses.
Assessing Anaerobic Power

- Two general approaches assess the anaerobic power and capacity responses of individuals:
  1. Measure changes in ATP and PCr levels metabolized or lactate produced from anaerobic metabolism
  2. Quantify the amount of external work performed or power generated during short-duration, intense activity
Performance Tests of Anaerobic Power

• Maximal tests for 1-10 seconds reflect energy transfer of the immediate energy system.

• Maximal tests of longer duration reflect utilization of the slow-glycolytic system bioenergetic system.

• Types of Immediate Energy Power Tests:
  1. Jumping power test
  2. Sprint running or cycling (Wingate p.210)
  3. Shuttle runs
  4. Arm cranking
  5. Simulated stair climbing, rowing, or skiing
Physiologic Indicators of the Short-Term Energy System

- **Blood lactate levels**
  - Considerable blood lactate accumulates from glycolytic energy pathway activation in maximal exercise.
  - Establishing blood lactate levels reflect the capacity of the short-term energy system.

- **Glycogen depletion**
  - Because the short-term energy system largely depends on glycogen stored within specific muscles activated by exercise, the pattern of glycogen depletion in these muscles provides an indication of the contribution of glycolysis to exercise.
Performance Tests of Glycolytic Power

- Activities that require substantial activation of the short-term energy system demand maximal work for up to 3 minutes or longer in some individuals.

- Considered within the framework of exercise specificity, the performance test must be similar to the activity or sport for which energy capacity is evaluated.

- Three Types
  1. Cycle ergometer tests (Katch and Wingate)
  2. All-out runs from 200-800 meters
  3. Sport-specific run tests
Factors Affecting Anaerobic Exercise Performance

- Specific training
- Buffering of acid metabolites
- Motivation
Anaerobic Fatigue

In the Wingate test, anaerobic fatigue \(\text{(percentage of decline in power relative to the peak value)}\) provides an index of anaerobic endurance; it represents the maximal capacity for ATP production via a combination of intramuscular phosphagen breakdown and glycolytic reactions (ATP/PCr and Anaerobic Glycolytic systems).
Measuring and Evaluating the Aerobic System: Direct Calorimetry

- **Direct calorimetry**: Assesses human energy metabolism by measuring heat production similarly to the method for determining the energy value of foods in the bomb calorimeter
  - Human calorimeter
Measuring and Evaluating the Aerobic System: Direct Calorimetry

• By measuring a person’s oxygen uptake, an indirect yet accurate estimate of energy expenditure can be obtained.

  ▪ **Closed-circuit spirometry**
    • Unsuitable for use during exercise where subject movement is required and large volumes of air are exchanged (used only for measuring resting energy expenditures)

  ▪ **Open-circuit spirometry**
    • Bag technique, portable spirometry, and computerized instrumentation
Measuring and Evaluating the Aerobic System: Direct Calorimetry (Cont.)
Measuring and Evaluating the Aerobic System: Direct Calorimetry (Cont.)
Respiratory Quotient (RQ)

• RQ = CO$_2$ produced/O$_2$ consumed

• Helps approximate the nutrient mixture catabolized for energy during rest and aerobic exercise
  ▪ RQ for Carbohydrate: 1.00
  ▪ RQ for Lipid: 0.70 but can range between 0.69-0.73, depending on the oxidized fatty acid’s carbon chain length
  ▪ RQ for Protein: 0.82
  ▪ RQ for a Mixed Diet: 0.82 from the metabolism of a mixture of 40% carbohydrate and 60% fat
Maximal Oxygen Uptake ($\text{VO}_{2\text{max}}$)

- Represents the greatest amount of oxygen a person can use to produce ATP aerobically on a per minute basis.

- A fundamental measure in exercise physiology, and serves as a standard to compare performance estimates of aerobic capacity and endurance fitness.

- Types of tests:
  - Treadmill walking or running
  - Bench stepping
  - Cycling
  - Swimming
Maximal Oxygen Uptake ($VO_{2\text{max}}$) by Gender
Criteria for VO$_{2\text{max}}$

- A leveling-off or peaking-over in oxygen uptake during increasing exercise intensity
  - **Peak oxygen uptake (VO$_{2\text{peak}}$):** When max criterion is not met or local muscle fatigue rather than central circulatory dynamics limits test performance

- Failure for oxygen uptake versus exercise intensity to increase by some value usually expected from previous observations with the particular test

- Blood lactate levels that attain at least 70 or 80 mg per 100 mL of blood or about 8 to 10 mmol

- Attainment of near age-predicted maximum heart rate, or an RQ in excess of 1.00
Criteria for $\dot{V}O_{2}\text{max} \ (\text{Cont.})$
Six Factors Affecting \( VO_{2\text{max}} \)

1. **Exercise mode:** Reflect the quantity of activated muscle mass (cycling underestimates \( VO_{2\text{max}} \) by approximately 10%)

2. **Heredity:** Current estimates ascribe 30% for \( VO_{2\text{max}} \), 50% for \( HR_{\text{max}} \), 70% for physical working capacity.

3. **Training state:** Aerobic capacity with training improves 6%-20%; largest improvement occurs among the most sedentary individuals.

4. **Gender:** \( VO_{2\text{max}} \) for women is 15%-30% below men.

5. **Body composition:** Differences in body mass explain roughly 70% of the differences in \( VO_{2\text{max}} \).

6. **Age:** Average values decrease with age.
Six Common Treadmill Protocols (pg 226)

1. Bruce (most common)
2. Balke
3. Naughton
4. Ellestad
5. Astrand
6. Harbor
Other Test Protocols

- **Stationary Ergometer**
  - YMCA
  - Astrand-Rhyming
- **Step Test** (pg 224)
- **Field Tests**
  - Rockport walk test (pg 221)
  - 1.5 mile run test
  - 12 minute swim test
**VO₂max Predictions**

- Tests that predict VO₂max from submaximal performances
- The most popular use walking and running performance
  - Easily administered, can be used for large groups, no need for a formal laboratory setting
- Factors that contribute to final VO₂max predicted score:
  - Body mass
  - Body fatness
  - Walking/Running economy
  - Percentage of aerobic capacity sustainable without blood lactate buildup
Heart Rate Predictions

- Prediction tests utilize the linear relationship between heart rate and oxygen uptake for various intensities of light to moderately intense exercise.
- Falls within 10-20% of the person’s actual VO$_{2}\text{max}$
- Suitable for screening and classification of aerobic fitness

**Limitations**

- Linearity of the HR–VO$_2$ relationship
- Similar maximum heart rates for all subjects
- Assumed constant exercise economy
- Day-to-day variation in exercise heart rate
Heart Rate Predictions (Cont.)
The End