ACE Personal Trainer Manual, 4th edition

Chapter 8: Physiological Assessments

Learning Objectives

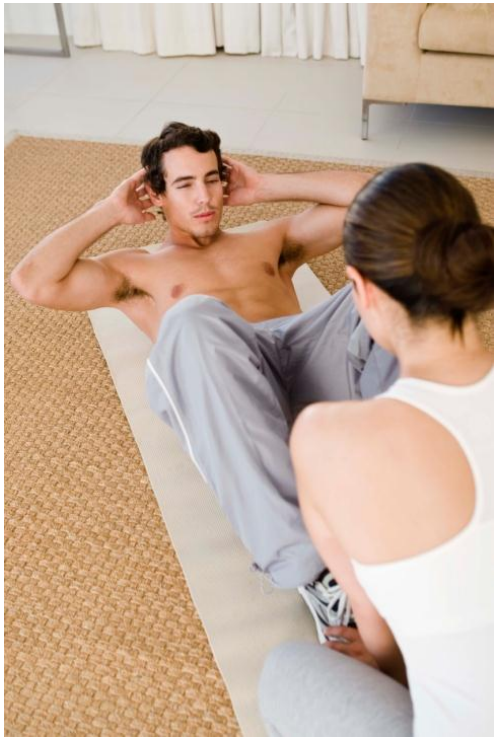
- This session, which is based on Chapter 8 of the *ACE Personal Trainer Manual* (4th ed.), covers the various physiological assessments that a personal trainer must be able to conduct and interpret.
- After completing this session, you will have a better understanding of:
  - Body-composition assessments and anthropometric measurements
  - Cardiorespiratory fitness assessments, including ventilatory threshold testing and field testing
  - Muscular-strength and muscular-endurance testing
  - Sports-skill assessments, including tests of power, speed, agility, and quickness

Introduction

- This session describes common health- and fitness-related assessments.
- The selected modalities follow the sequence outlined in the ACE Integrated Fitness Training™ (ACE IFT™) Model.
- The personal trainer will select and administer tests according to:
  - Each client's needs and desires
  - Availability of equipment
  - Time allotment
  - The trainer's level of comfort with the assessment procedures

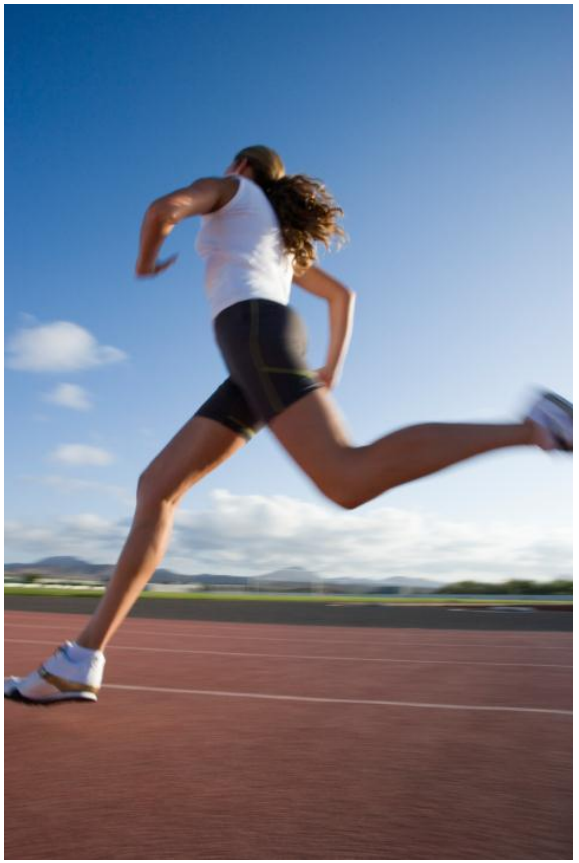
Health-related Assessments

- Cardiorespiratory fitness
- Body composition and anthropometry
- Muscular endurance
- Muscular strength
- Flexibility



Skill-related Assessments

- Anaerobic power
- Anaerobic capacity
- Speed
- Agility
- Reactivity
- Coordination



Testing and Measurement

- Personal trainers must act professionally and be competent when evaluating a client's level of fitness.
- There are a number of resources for gaining hands-on training in fitness assessments, including:
  - ACE-sponsored workshops
  - Local colleges or universities with exercise science departments
  - Experienced personal trainers, athletic trainers, or rehabilitation specialists
  - Repeated practice, using friends, family members, or other trainers

Signs and Symptoms for Fitness Test Termination

- These signs or symptoms merit immediate test termination and possible referral to a qualified healthcare professional:
  - Onset of angina, chest pain, or angina-like symptoms
  - Significant drop (>10 mmHg) in systolic blood pressure (SBP) despite an increase in exercise intensity
  - Excessive rise in blood pressure (BP): SBP >250 mmHg or diastolic blood pressure (DBP) >115 mmHg
  - Excess fatigue, shortness of breath, or wheezing (does not include heavy breathing due to intense exercise)
  - Signs of poor perfusion: lightheadedness, pallor, cyanosis, nausea, or cold and clammy skin
  - Increased nervous system symptoms
  - Leg cramping or claudication
  - Subject requests to stop
  - Physical or verbal manifestations of severe fatigue
  - Failure of testing equipment

Anthropometric Measurements: Body Composition

- There are many methods for assessing body composition, though some prove to be impractical in a fitness setting.
- Skinfold measurement determines body composition via the measurement of select subcutaneous adipose tissue sites.
- Anthropometric measures include measurements of height, weight, and/or circumference to assess body size or dimension.

Anthropometric/Body Composition Techniques

Body Composition and Body Size Measurement Techniques	
Body Composition	**Body Size**
Bioelectrical impedance	Body mass index
DEXA scans	Girth measurements, including waist-to-hip ratio
Hydrostatic weighing or underwater weighing	Height
Near-infrared interactance	Weight
Skinfold measurements	
Whole-body air displacement plethysmography	

Components of Body Composition

- Body composition refers to the proportion of lean tissue to body-fat tissue.
  - Lean body mass
  - Body fat
- Just as lean tissue contributes to athletic performance, an appropriate percentage of body fat can also be related to successful athletic performance.
  - A certain amount of body fat is necessary for overall health and well-being, though too much body fat can be detrimental to health.

Appropriate Use/Clientele

- Many clients are concerned with body composition and desire to decrease their body fat.
- When working with clients who are concerned with weight loss, focus primarily on fat loss, without sacrificing lean muscle tissue.
- The same holds true when working with clients who are interested in weight gain where the focus should generally be on increasing lean mass.

Overweight versus Overfat

- Overweight is defined as an upward deviation in body weight, based on the subject's height.
- Overfat indicates an excess amount of body fat.
- To get a more accurate picture of lean and fat mass, it is usually necessary to perform tests that involve more than just height and weight.

Practical Implications of Body Composition

- Personal trainers should conduct body-composition assessments in a private area to put the client at ease.
  - Clients should be instructed on appropriate attire to promote easy access to measurement sites.
  - Testing accuracy is improved by proper hydration.
  - Between measurements, a client may notice changes in the way his or her clothes fit.

Contraindications and Considerations

- If a client is extremely obese, some of the body-composition techniques will not be accurate.
- In some cases, it may be more appropriate to utilize only BMI and girth measurements.
- Many clients, especially those who are not comfortable with their weight, will not want their body composition measured

Body-composition Assessments

- The assessments presented on the following slide are used to assess body composition.
- Due to the cost and limited availability of the equipment needed, not all are practical in a fitness setting.

Body-composition Assessment Table

Method	Description
Bioelectrical impedance analysis (BIA)* Whole-body BIA machines are found primarily in laboratory settings. Less-sophisticated BIA devices are found in fitness settings.	BIA measures electrical signals as they pass through fat, lean mass, and water in the body. In essence, this method assumes leanness, but calculations can be made based primarily on the sophistication of the machine. Many fitness centers utilize BIA due to the simplicity of use. Optimal hydration is necessary for accurate results.
Air displacement plethysmography (ADP) Example: Bod Pod® (or Pea Pod® for children) Cost-prohibitive for most facilities	The Bod Pod is an egg-shaped chamber that measures the amount of air that is displaced when a person sits in the machine. Two values are needed to determine body fat: air displacement and body weight. ADP has a high accuracy rate but the equipment is expensive.
Dual energy x-ray absorptiometry (DEXA)* Found in exercise physiology departments at colleges and universities	DEXA ranks among the most accurate and precise methods. DEXA is a whole-body scanning system that delivers a low-dose x-ray that reads bone and soft-tissue mass. DEXA has the ability to identify regional body-fat distribution.
Hydrostatic weighing (underwater weighing) The gold standard: Many later methods of body-fat assessment are based on calculations derived from hydrostatic weighing Found in exercise physiology departments at colleges and universities	This method measures the amount of water a person displaces when completely submerged, thereby indirectly measuring body fat. It is not practical in a fitness setting due to the size of the apparatus and the complexity of the technique required for accurate measurements, which involves the individual going down to the bottom of a tank, exhaling all air from the lungs (expiratory quotient), and then holding the breath until the scale settles and records an accurate weight. The assessment must them be repeated to ensure accuracy.
Magnetic resonance imaging (MRI) Found in hospitals and diagnostic centers	MRI uses magnetic fields to assess how much fat a person has and where it is deposited. Since MRIs are located in clinical settings, using an MRI solely for calculation of body fat is not practical.
Near-infrared interactance (NIR)* Example: Futrex®	NIR uses a fiber optic probe connected to a digital analyzer that indirectly measures tissue composition (fat and water). Typically, the biceps are the assessment site. Calculations are then plugged into an equation that includes height, weight, frame size, and level of activity. This method is relatively inexpensive and fast, but not as accurate as most.
Skinfold measurement Very commonly used in fitness settings	Skinfold calipers are used to “pinch” a fold of skin and fat. Several sites on the body are typically measured. The measurements are plugged into an equation that calculates body-fat percentage.
Total body electrical conductivity (TOBEC) Found in clinical and research settings	TOBEC uses an electromagnetic force field to assess relative body fat. Much like the MRI, it is impractical and too expensive for the fitness setting.

**These body-composition assessment techniques are not accurate when used with obese clients.*

Hydrostatic Weighing

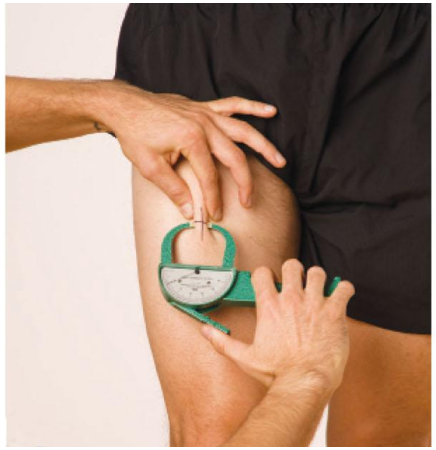
- Hydrostatic weighing, also called underwater weighing, is considered the benchmark for computing body composition.
- The body is weighed on an underwater scale.
  - Measures the amount of water a person displaces when completely submerged, thereby indirectly measuring body fat by determining body density.
  - Individuals with greater body densities (i.e., more lean tissue and less fat) will weigh more under water.
- Hydrostatic weighing is not a practical approach for the standard fitness center.
  - This evaluation tool is often found in elite clinical settings and in many colleges and universities.

Skinfold Measurements

- In an average person, approximately 50% of body fat is distributed just below the skin.
- In general, the skinfold caliper method produces a measurement that is ±2.0 to 3.5% of that obtained in hydrostatic weighing.
- Further measurement error is likely if the:
  - Trainer is inexperienced or uses poor technique
  - Client is obese or extremely thin
  - Caliper is not properly calibrated
- Most research supports using at least three sites when assessing body fat.

Jackson and Pollock Three-site Skinfold for Men

- Chest
  - A diagonal skinfold taken midway between the anterior axillary line and the nipple
- Thigh
  - A vertical skinfold taken on the anterior midline of the thigh between the inguinal crease and the proximal border of the patella
- Abdomen
  - A vertical skinfold taken 2 cm (~1 inch) to the right of the umbilicus


Jackson and Pollock Three-site Skinfold for Women

- Triceps
  - A vertical fold on the posterior midline of the upper arm taken halfway between the acromion and olecranon processes
- Thigh
  - A vertical skinfold taken on the anterior midline of the thigh between the inguinal crease and the proximal border of the patella
- Suprailium
  - A diagonal fold following the natural line of the iliac crest taken immediately superior to the crest of the ilium and in line with the anterior axillary line

Determining Body Composition

- Body composition can be determined by summing the three skinfold measurements and then using conversion tables to determine body composition.
- It can also be determined by calculating body density, from which body composition can be computed.
- ACE also provides valuable fitness calculators and assessment support materials on its website.
  - www.acefitness.org/calculators

Body-composition Evaluation

- The table below presents acceptable body-fat norms for both men and women.
- Vanity is a fundamental reason for lowering body fat.
  - The trainer should also point out that personal health and physical performance are negatively impacted when body-fat stores are high.

General Body-fat Percentage Categories		
Classification	**Women (% fat)**	**Men (% fat)**
Essential fat	10–13%	2–5%
Athletes	14–20%	6–13%
Fitness	21–24%	14–17%
Average	25–31%	18–24%
Obese	32% and higher	25% and higher

Body-composition Reassessment

- There are no true recommendations for reassessment of body composition.
  - Since time and significant energy expenditure are necessary to reduce body fat, assessments should not be conducted too frequently.
  - Monthly or bimonthly assessments are appropriate.

Programming Considerations for Body Composition

- Reducing excess adipose tissue is important for decreasing the risk of major disease and dysfunction.
- To enhance program effectiveness, appropriate exercise should be used in conjunction with following healthful dietary recommendations (e.g., USDA, DASH).
- Body-composition values can also be used to determine a goal weight.
- With any weight loss or gain, there is typically a change in the amount of lean body mass and fat mass.

Sample Desired Body Weight Calculation

- Desired body weight = [Lean body weight / (100% – Desired % fat)] x 100
- Starting information:
  - Female client's current weight is 168 pounds, with 28% body fat
  - Initial goal: To achieve 24% body fat without losing lean tissue
- Determine fat weight in pounds:
  - Body weight x Body-fat percentage (BF%): 168 lb x 28% = 47 lb of fat
- Determine lean body weight (LBW):
  - Total weight – Fat weight: 168 lb – 47 lb = 121 lb of lean tissue
- Calculate %LBW at desired %Fat:
  - Desired %LBW at 24% body fat = 100% – 24% = 76% (or 0.76)
- Calculate goal weight:
  - Divide current LBW by desired %LBW = 121 lb/0.76 = 159 lb

Measurement of Body Size

- Anthropometry is the measurement of the size and proportions of the human body.
  - The most frequently used anthropometric measures are height, weight, and circumference measures.
- Body mass index (BMI) provides an objective ratio describing the relationship between body weight and height.
- BMI measurement cannot determine actual body composition.

Calculating BMI

- BMI is relatively easy and inexpensive to measure and calculate using the following formulas:
- BMI = Weight (kg)/Height^2 (m)

or

- BMI = Weight (lb) x 703/Height (inches)/Height (inches)
- Rather than calculating BMI, the table presented on the following slide can be used as a quick reference.
- ACE also provides valuable fitness calculators and assessment support materials on its website.
  - www.acefitness.org/calculators

BMI Reference Table

Body Mass Index														
	19	20	21	22	23	24	25	26	27	28	29	30	35	40
Height (inches)	Weight (pounds)													
58	91	95	100	105	110	115	119	124	129	134	138	143	167	191
59	94	99	104	109	114	119	124	128	133	138	143	148	173	198
60	97	102	107	112	118	123	128	133	138	143	148	153	179	204
61	100	106	111	116	121	127	132	137	143	148	153	158	185	211
62	104	109	115	120	125	131	136	142	147	153	158	164	191	218
63	107	113	118	124	130	135	141	146	152	158	163	169	197	225
64	110	116	122	128	134	140	145	151	157	163	169	174	203	233
65	114	120	126	132	138	144	150	156	162	168	174	180	210	240
66	117	124	130	136	142	148	155	161	167	173	179	185	216	247
67	121	127	134	140	147	153	159	166	172	178	185	191	223	255
68	125	131	138	144	151	158	164	171	177	184	190	197	230	263
69	128	135	142	149	155	162	169	176	182	189	196	203	237	270
70	132	139	146	153	160	167	174	181	188	195	202	209	243	278
71	136	143	150	157	165	172	179	186	193	200	207	215	250	286
72	140	147	155	162	169	177	184	191	199	206	213	221	258	294
73	144	151	159	166	174	182	189	197	204	212	219	227	265	303
74	148	155	163	171	179	187	194	202	210	218	225	233	272	311
75	152	160	168	176	184	192	200	208	216	224	232	240	279	319
76	156	164	172	180	189	197	205	213	221	230	238	246	287	328

Note: Find your client's height in the far left column and move across the row to the weight that is closest to the client's weight. His or her body mass index will be at the top of that column.

BMI and Health Risks

- As BMI increases, so do health risks.
- A BMI >25 increases a person's risk for:
  - Cardiovascular disease
  - Metabolic syndrome
  - Hypertension
  - Type 2 diabetes
- The BMI reference chart can be used to:
  - Discuss the health risks of being overweight or obese
  - Set long-term weight-loss goals for clients
- Clients with high lean body mass (LBM) may be categorized as overweight using BMI alone; even though their % body fat may well be within the normal or even athletic ranges.

BMI Reference Chart	
Weight Range	**BMI Category**
Underweight	<18.5
Normal weight	18.5–24.9
Overweight	25.0–29.9
Grade I Obesity	30.0–34.9
Grade II Obesity	35.0–39.9
Grade III Obesity	>40

Practical Implications of Determining BMI

- Calculating BMI is quick and inexpensive.
- BMI charts are used by many healthcare agencies to assess body mass and associated risks.
- If BMI charts are the only method of assessing body structure, the results could be misinterpreted.
- A simple visual inspection can prompt a personal trainer to proceed with a body-composition assessment to gain a more accurate indicator of health risk.

Girth Measurements

- Girth measurements are good predictors of health problems.
  - They also provide motivation as clients see changes in their body dimensions.
  - When taking girth measurements, precision is necessary to validate the results.
  - To ensure accuracy, the personal trainer must use exact anatomical landmarks for taking each measurement.


Abdominal circumference


Hip circumference


Waist circumference

Waist-to-Hip Ratio

- The location of the fat deposits is a good indicator of disease risk.
- The waist-to-hip ratio (WHR) helps differentiate individuals who have an android shape from those who have a gynoid shape.
  - Though any extra fat weight is detrimental to a person's health, those who are android and have a high WHR have a greater health risk.
  - To determine a client's WHR, the waist measurement is divided by the hip measurement.
  - The table below illustrates the relative risk ratings for waist-to-hip ratios.

Waist-to-Hip Ratio (WHR) Norms				
Gender	**Excellent**	**Good**	**Average**	**At Risk**
Males	<0.85	0.85–0.89	0.90–0.95	≥0.95
Females	<0.75	0.75–0.79	0.80–0.86	≥0.86

Bray, G.A. & Gray, D.S. (1988). Obesity: Part I: Pathogenesis. *Western Journal of Medicine,* 149, 429–441.

Waist Circumference

- Excess visceral fat contributes to android fat distribution and is associated with insulin resistance.
- For every 1-inch (2.5-cm) increase in waist circumference in men, the following associated health risks are found:
  - Blood pressure increases by 10%
  - Blood cholesterol level increases by 8%
  - High-density lipoprotein (HDL) decreases by 15%
  - Triglycerides increase by 18%
  - Metabolic syndrome risk increases by 18%
- The table presented on the following slide lists the risk categories associated with various waist circumferences for men and women.

Criteria for Waist Circumference in Adults

Criteria for Waist Circumference in Adults		
	Waist Circumference	
Risk Category	Females	Males
Very low	<27.5 in (<70 cm)	<31.5 in (<80 cm)
Low	27.5–35.0 in (70–89 cm)	31.5–39.0 in (80–99 cm)
High	35.5–43.0 in (90–109 cm)	39.5–47.0 in (100–120 cm)
Very high	>43.5 in (>110 cm)	>47.0 in (>120 cm)

Bray, G.A. (2004). Don't throw the baby out with the bath water. *American Journal of Clinical Nutrition*, 70, 3, 347–349.

Resting vs. Physical-fitness Assessments

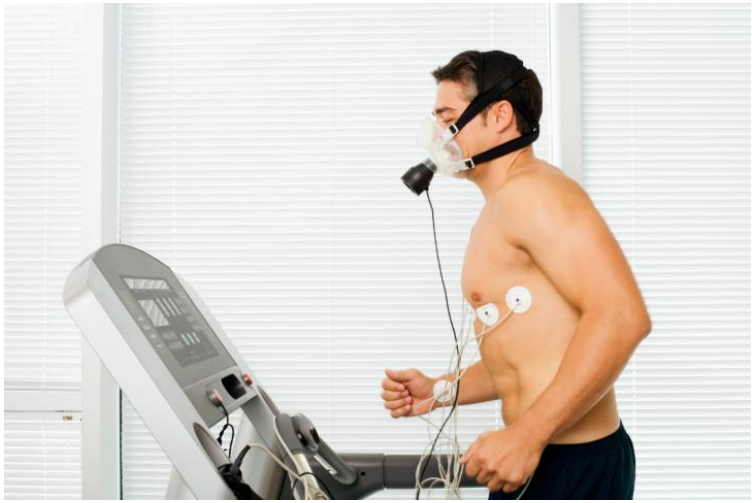
- The previous sections in this session were devoted to resting measurements.
- Subsequent sections focus on physical-fitness assessments that are active and require submaximal to maximal effort.
- Not all tests are suitable for all populations.

Cardiorespiratory Fitness Testing

- Cardiorespiratory fitness is defined by how well the body can perform dynamic activity using large muscle groups at a moderate to high intensity for extended periods.
- Exercise testing for cardiorespiratory fitness is useful to:
  - Determine functional capacity
  - Determine a level of cardiorespiratory function that serves as a starting point for developing goals for aerobic conditioning
  - Identify metabolic markers (e.g., VT1 and VT2) that can be utilized to design individualized exercise programs
  - Determine any underlying cardiorespiratory abnormalities that signify progressive stages of cardiovascular disease
  - Periodically reassess progress following a structured fitness program

Maximal Oxygen Uptake

- Maximal oxygen uptake (VO_2max) is an:
  - Excellent measure of cardiorespiratory efficiency
  - Estimation of the body's ability to use oxygen for energy at maximal exertion
- Measuring VO_2max in a laboratory involves the collection and analysis of exhaled air during maximal exercise.
  - Measured in L/min = Absolute VO_2max
  - Divide by body weight (kg) to determine relative VO_2max (mL/kg/min)
- Conducting a cardiorespiratory assessment at maximal effort is not always feasible and can actually be harmful to certain populations.



Submaximal Cardiorespiratory Assessments

- Submaximal cardiorespiratory assessments can provide relatively accurate values at a workload that can be extrapolated to determine expected O_2 uptake during maximal efforts.
  - As workload increases, so do heart rate and oxygen uptake.
  - In fact, heart rate and oxygen uptake exhibit a fairly linear relationship to workload.
  - This allows for VO_2max estimates based on MHR (generally predicted).

Inaccuracies: Submaximal Cardiorespiratory Testing

- Many estimation calculations are based on the calculation of 220 – age for estimating maximum heart rate (MHR).
- Maximal oxygen uptake is determined by measuring HR at submaximal workloads and then extrapolating the workload and HR data to the predicted MHR to determine predicted VO_2max.
- A submaximal test is likely to underestimate the true maximum for an individual who is very deconditioned, and overestimate VO_2max for a very fit individual.

Cardiorespiratory Fitness Assessments

- Treadmill tests
  - Bruce submaximal treadmill exercise test
  - Balke & Ware treadmill exercise test
  - Ebbeling single-stage treadmill test
- Cycle ergometer tests
  - YMCA bike test
  - Astrand-Ryhming cycle ergometer test
- Ventilatory threshold testing
  - Submaximal talk test for VT1
  - VT2 threshold test
- Field tests
  - Rockport fitness walking test (1 mile)
  - 1.5-mile run test
- Step tests
  - YMCA submaximal step test (12 inches)
  - McArdle step test (16 inches)

Graded Exercise Tests

- Graded exercise tests (GXT) conducted in laboratory and fitness settings typically use a treadmill, cycle ergometer, or arm ergometer to measure cardiorespiratory fitness.
  - Some of the tests are administered in stages that incorporate gradual increases in exercise intensity.
  - Other tests measure the heart-rate response to a single-stage bout of exercise.
  - In the clinical setting, a GXT is typically performed to maximal, or near maximal, exertion.

Submaximal Graded Exercise Tests

- Submaximal exercise testing is safer and, in many cases, provides a reliable indicator of maximal effort.
  - The workload can be measured in metabolic equivalents (METs).
- Workload is a reflection of oxygen consumption and, hence, energy use.
  - 1 MET is the equivalent of oxygen consumption at rest, or approximately 3.5 mL/kg/min.
  - For example: If a person is exercising at a workload of 7 METs, he or she is consuming oxygen at a rate of 24.5 mL/kg/min (7 MET x 3.5 mL/kg/min).
  - Most activities of daily living (ADL) require a functional capacity of 5 METs.

Indicators of Heart Disease Risk

- A GXT is also a valuable tool in identifying those who are at risk of a coronary event.
- The major indicators include:
  - A decrease—or a significant increase—in blood pressure with exercise
  - An inadequate HR response to exercise
  - Exercise duration (the longer the individual can tolerate the treadmill test, the less likely he or she is to die soon of CAD—or of any cause)
  - Heart-rate recovery

Monitoring the Client

- It is essential to monitor the client before, during, and after any GXT.
  - Heart rate
  - Blood pressure
  - Ratings of perceived exertion (RPE)
  - Signs and symptoms (S/S)

Ratings of Perceived Exertion (RPE)

Ratings of Perceived Exertion (RPE)	
RPE	**Category Ratio Scale**
6	0 Nothing at all
7 Very, very light	0.5 Very, very weak
8	1 Very weak
9 Very light	2 Weak
10	3 Moderate
11 Fairly light	4 Somewhat strong
12	5 Strong
13 Somewhat hard	6
14	7 Very strong
15 Hard	8
16	9
17 Very hard	10 Very, very strong
18	* Maximal
19 Very, very hard	
20	

Source: Adapted, with permission, from American College of Sports Medicine (2010a). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.

Test Termination

- There are a number of reasons to terminate an exercise test, ranging from chest pain to a drop in SBP.
- Additionally, a GXT must be terminated if the client requests to stop or fails to comply with testing protocol.
- Trainers must always be aware of signs or symptoms that merit immediate termination and referral to a more qualified professional.

Key Pre-test Information and Procedures

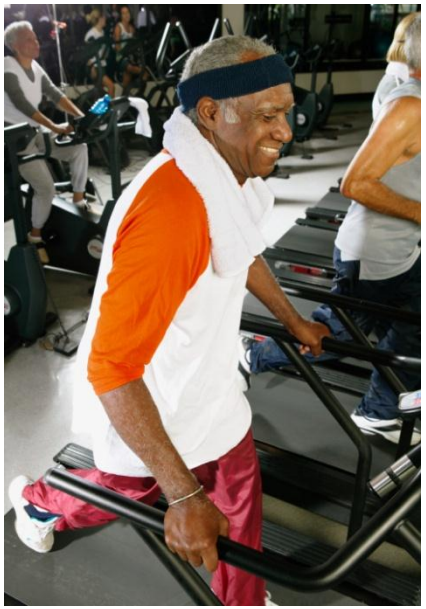
- Medication/supplement usage
- Recent musculoskeletal injury or limiting orthopedic problem(s)
- Any sickness or illness
- Time of last meal or snack
- Inform the client that the validity of fitness testing is based on precise protocols being followed.
- Clients should provide RPE when requested, as well as information on personal signs and symptoms.
- The personal trainer will assess HR and BP at specific intervals throughout the test.
- Inform the client that the test will immediately cease if the client reports any significant discomfort at any point during the test.

Treadmill Exercise Testing

- Walking on a treadmill may make some clients uneasy.
  - A submaximal graded fitness test should take between eight and 12 minutes.
  - The Bruce submaximal treadmill protocol is the most widely used.
  - The Balke & Ware treadmill test is preferred for older and deconditioned clients.

Contraindications for Treadmill Tests

- Treadmill exercise testing should not be conducted when working with a client with:
  - Visual or balance problems, or who cannot walk on a treadmill without using the handrails
  - Orthopedic problems that create pain with prolonged walking.
  - Foot neuropathy
- Obese individuals may suffer from both balance and orthopedic issues.



Bruce Submaximal Treadmill Exercise Test

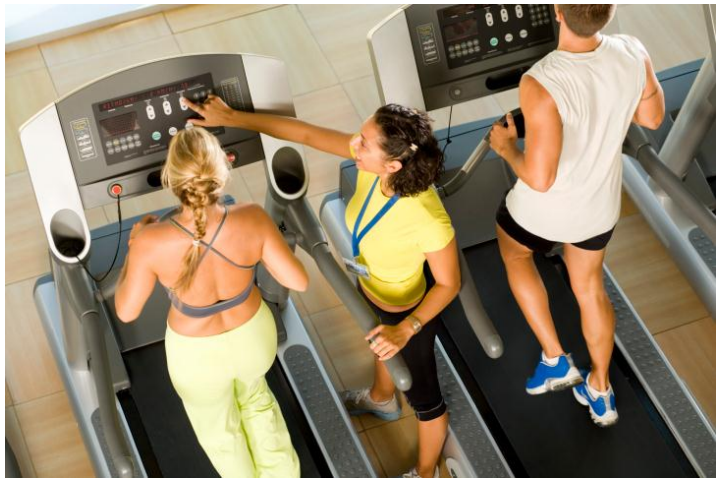
- The Bruce submaximal treadmill test is perhaps the most common test used to assess cardiorespiratory fitness, especially in clinical settings.
  - The test is administered in three-minute stages until the client achieves 85% of his or her age-predicted MHR.
  - In a clinical setting, the test is typically performed to maximal effort, to evaluate both fitness and cardiac function.
  - Given the degree of difficulty, this test is generally not appropriate for deconditioned individuals or the elderly.

Balke & Ware Treadmill Exercise Test

- The Balke & Ware treadmill test is another common treadmill test used in both clinical and fitness settings.
  - The test is administered in one- to three-minute stages until the desired HR is achieved or symptoms limit test completion.
  - When performed in a fitness setting, this test should be terminated when the client achieves 85% of his or her age-predicted MHR.
  - This test is more appropriate for deconditioned individuals, the elderly, and those with a history of cardiovascular disease.

Ebbeling Single-stage Treadmill Test

- This single-stage treadmill test is an appropriate option for low-risk, apparently healthy, non-athletic adults aged 20 to 59 years.
  - This test estimates VO_2max using a single-stage, four-minute submaximal treadmill walking protocol.



Cycle Ergometer Testing

- Submaximal cycle ergometer tests are useful assessment tools to estimate VO_2max without maximal effort.
- As long as the heart rate has achieved a steady state at an appropriate workload, exercise HR can be used to predict VO_2max.
- Cycle ergometer testing has many advantages in assessing cardiorespiratory fitness.

Cycle Ergometer Testing Disadvantages

- The cycle ergometer test may underestimate the client's actual cardiorespiratory fitness.
  - The exercise BP may also be higher than if the client was tested using a treadmill test.
  - The accuracy of these tests is based on an initial MHR prediction calculated using the formula [208 – (0.7 x Age)].

Cycle Ergometer Testing Contraindications

- Cycle ergometer testing should be avoided when working with:
  - Obese individuals who are not comfortable on the standard seats or are physically unable to pedal at the appropriate cadence
  - Individuals with orthopedic problems that limit knee range of motion (ROM) to less than 110 degrees
  - Individuals with neuromuscular problems who cannot maintain a cadence of 50 rotations per minute (rpm)

YMCA Bike Test

- This test measures the steady-state HR (HRss) response to incremental three-minute workloads that progressively elicit higher heart-rate responses.
  - The HRss responses are then plotted on a graph against workloads performed.
  - As exercise HR correlates to a VO_2 score, the HR response line is extended to determine maximal effort and estimate the individual's absolute VO_2max (L/min).

VO_2max Conversion

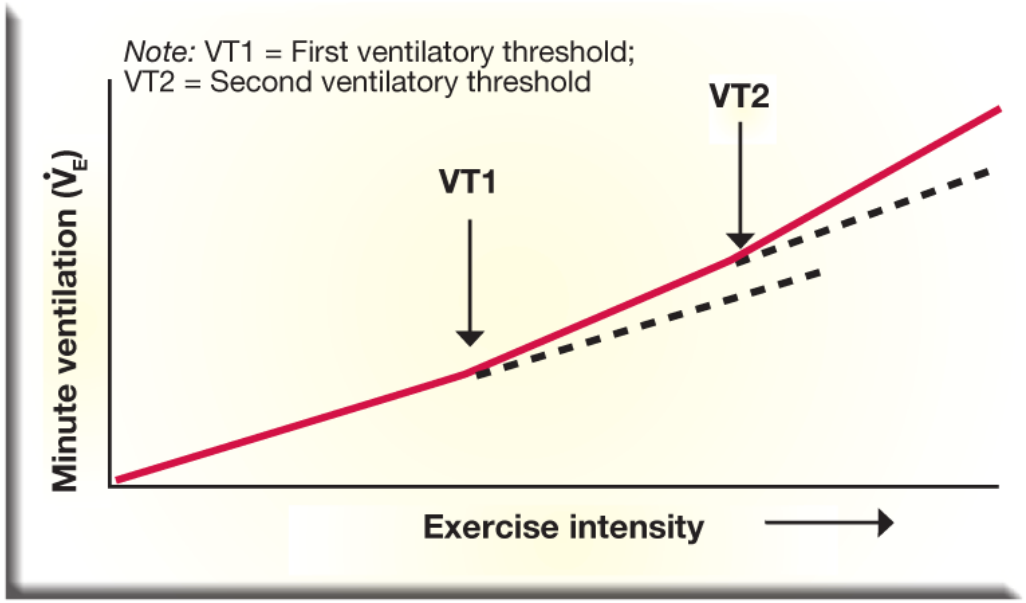
- Oxygen uptake is dependent on the size of the individual being tested.
- To compare VO_2max among individuals of different weights, oxygen uptake must be divided by body weight.
- Oxygen uptake expressed in relative terms (i.e., in relation to body weight) is mL/kg/min.

Astrand-Ryhming Cycle Ergometer Test

- This test estimates VO_2max using a single-stage, six-minute submaximal cycling protocol.
  - Because it is easier to administer than the YMCA bike test, this test may be a more appropriate choice for trainers who are new to cycle ergometer testing.
  - However, inexperienced riders might find riding at a moderate-to-hard intensity for six minutes fatiguing.

Ventilatory Threshold Testing

- Ventilatory threshold testing is based on the physiological principle of ventilation.
  - As exercise intensity increases, ventilation increases in a somewhat linear manner.
  - The “crossover” point, or the first ventilatory threshold (VT1), represents a level of intensity where lactic acid begins to accumulate within the blood.
  - Past the crossover point, ventilation increases exponentially as oxygen demands outpace the oxygen-delivery system and lactic acid begins to accumulate in the blood.



Metabolic Analyzers

- Metabolic analyzers identify VT1 and VT2 using the respiratory exchange ratio (RER) scores.
  - Approximately 0.85 to 0.87 for VT1 and approximately 1.00 for VT2
- However, the majority of trainers will not have access to metabolic analyzers and will need valid field tests to identify these markers.
- This section reviews field tests for measuring HR at VT1 and VT2.
  - This type of testing is also useful for athletes interested in estimating their lactate threshold (LT).

Ventilatory Threshold Testing Contraindications

- This type of testing is not recommended for:
  - Individuals with certain breathing problems [asthma or other chronic obstructive pulmonary disease (COPD)]
  - Individuals prone to panic/anxiety attacks, as the labored breathing may create discomfort or precipitate an attack
  - Those recovering from a recent respiratory infection

Submaximal Talk Test for VT1

- This test is best performed using HR telemetry for continuous monitoring (e.g., HR monitoring with chest strap).
  - To avoid missing VT1, the exercise increments need to be small.
    - This test requires preparation to determine the appropriate increments that elicit a 5 bpm increase.
  - Once the increments are determined, the time needed to reach steady-state HR during a stage must also be determined.
  - The end-point of the test is determined by the client's ability to recite the Pledge of Allegiance, or another memorized group of phrases.
- The submaximal talk test for VT1 is recommended in cardiorespiratory training phases 2, 3, and 4 of the ACE IFT Model.

Submaximal Talk Test for VT1 Objectives

- The objectives of the test are to:
  - Measure the HR response at VT1 by progressively increasing exercise intensity and achieving steady state at each stage
  - Identify the HR where the ability to talk continuously becomes compromised
    - This point represents the intensity at which an associated increase in tidal volume should not compromise breathing rate or the ability to talk.
    - Progressing beyond this point where breathing rate increases significantly, making continuous talking difficult, is not necessary and will render the test inaccurate.

VT2 Threshold Test

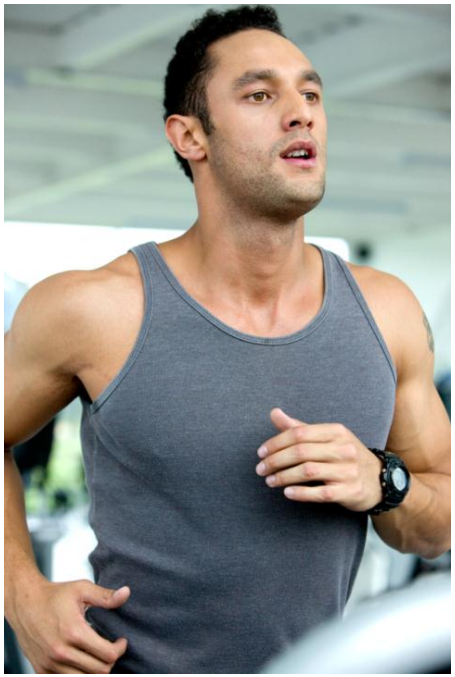
- Onset of blood lactate accumulation (OBLA) is the point at which lactic acid accumulates at rates faster than the body can buffer and remove it.
  - Represents an exponential increase in the concentration of blood lactate, indicating an exercise intensity that can no longer be sustained
  - Historically referred to as the lactate or anaerobic threshold
  - Corresponds with a second noticeable increase in respiration called the second ventilatory threshold (VT2)
  - Represents the highest sustainable level of exercise intensity, a strong marker of exercise performance
- Field tests challenge an individual's ability to sustain high intensities of exercise for a predetermined duration to estimate VT2.
  - Requires sustaining the highest intensity possible during a single bout of steady-state exercise
  - Mandates high levels of conditioning and experience with pacing
  - VT2 testing is only recommended for well-conditioned individuals with performance goals.

VT2 Threshold Test Disadvantages

- The major disadvantages associated with field tests are that they:
  - Do not assess any direct metabolic responses beyond heart rate
  - Can be influenced by environmental variables that may potentially impact the scores obtained
- While several laboratory protocols have been validated through research over the past 30 years, relatively little research has evaluated or validated field-testing protocols.

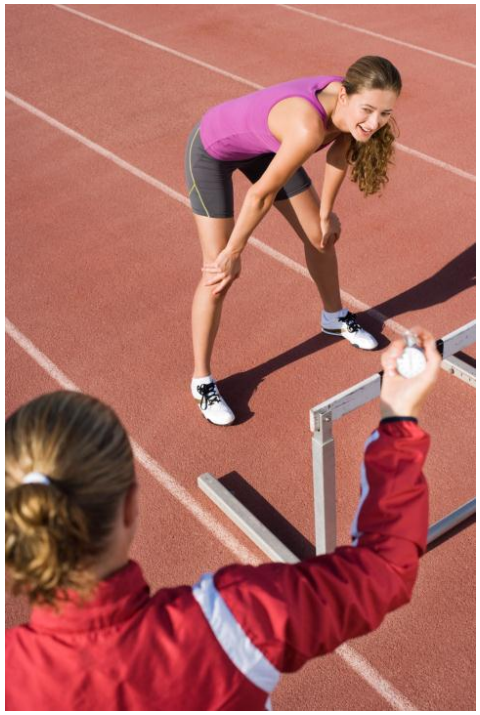
VT2 Threshold Test Objective

- To measure HR response at VT2 using a single-stage, sustainable, high-intensity 15- to 20-minute bout of exercise.
- The VT2 threshold test is recommended only in cardiorespiratory training phases 3 and 4 of the ACE IFT Model.



Field Testing

- Most field tests:
  - Are simple to administer
  - Involve very little expense
  - Can be used for testing multiple clients
- These assessments offer reliable testing methods for those without access to traditional testing equipment found in a fitness center or health club.



- Since many of the field tests can be performed outside, it is important to be mindful of extreme weather conditions.

Field Testing Contraindications

- Outdoor walk/run testing is not appropriate:
  - In extreme weather conditions
  - For individuals with health challenges that would preclude continuous walking
  - For individuals with breathing difficulties exacerbated by pollution or outdoor allergens
- Running tests are not recommended for those who are deconditioned or have lower-extremity orthopedic issues.

Rockport Fitness Walking Test

- The purpose of the Rockport fitness walking test is to estimate VO_2max from a client's HRss response.
  - This test involves the completion of a 1-mile (1.6-km) walking course as fast as possible.
  - The VO_2max is calculated using the client's HRss, or immediate post-exercise HR, and his or her 1-mile walk time.
  - This test is suitable for many individuals, easy to administer, and inexpensive to conduct.
  - This test is also suitable for testing large groups of people.
  - This method of testing would also be preferred for a client who intends to walk/run outdoors as his or her mode of fitness training.

1.5-mile Run Test

- The 1.5-mile (2.4-km) run test is used by the U.S. Navy to evaluate cardiovascular fitness levels of its personnel.
  - Due to the intense nature of running, this test is not suitable for less-conditioned individuals.
  - The goal of the test is to run as fast as possible for 1.5 miles (2.4 km).
  - Effective pacing is important for a successful outcome.

Step Tests

- Step tests require stepping continuously at a specific cadence or pace for a predetermined timeframe (usually three minutes).
  - Fitness level is determined by the immediate post-exercise recovery heart rate.
- More fit individuals will:
  - Not work as hard during exercise and require less effort from their heart
  - Recover from exercise faster than those who are less fit
- The lower the exercising or recovery HR, the higher the level of fitness.
- Step tests are very simple to administer, require very little investment in supplies, take very little time, and can be administered to large groups.

Step Test Contraindications

- Due to the nature of step testing, this assessment may not be appropriate for:
  - Individuals who are extremely overweight
  - Individuals with balance concerns
  - Individuals with orthopedic problems
  - Individuals who are extremely deconditioned, as the intensity of the test may require near-maximal effort
  - Individuals who are short in stature, as they may have trouble with the step height

YMCA Submaximal Step Test

- The YMCA submaximal step test is considered suitable for low-risk, apparently healthy, non-athletic individuals between the ages of 20 and 59.
  - This particular test uses any 12-inch (30.5-cm) step.
    - The Reebok® step is utilized most frequently in fitness settings (four risers plus the platform).

McArdle Step Test

- Unlike the YMCA submaximal step test that evaluates recovery HR, this test measures exercising HR, from which VO_2max can be estimated.
  - This is a useful test for clients with higher levels of aerobic fitness.
  - Individuals who are short in stature may struggle with this test given that the step height is 16.25 inches (41.3 cm).

Application From Cardiorespiratory Fitness Testing

- If the cardiorespiratory testing was unremarkable, an appropriate fitness program can be initiated.
- For novice exercisers and those who score in the lowest percentiles, improving cardiorespiratory fitness should be addressed in a twofold manner.
  - The first goal is to gradually increase exercise duration.
  - Initially, training volume can be increased by 10 to 20% per week, until the desired training volume is achieved.
- For those who already have a solid cardiorespiratory fitness base, training should focus on increasing exercise intensity.

Muscular Fitness

- Muscular fitness encompasses both muscular endurance and muscular strength.
- The following list describes the many health-related benefits of muscular fitness:
  - Enhances the ability to carry out ADL, which translates to an increase in self-esteem and fosters a sense of independence
  - Provides for musculoskeletal integrity, which translates to a reduction in common musculoskeletal injuries
  - Enhances or maintains fat-free mass and ultimately positively impacts RMR, which is an important aspect of weight management
  - Guards against osteoporosis by protecting or enhancing bone density
  - Enhances glucose tolerance, which can protect against type 2 diabetes

Muscular-endurance Testing

- Muscular-endurance testing assesses the ability of a specific muscle group, or groups, to perform repeated or sustained contractions.
- Muscular endurance of the trunk and lower extremity is most relevant to optimal function.
- The following are some important things to consider prior to any muscle-endurance testing:
  - Always screen for low-back pain before performing any of these assessments.
  - Any indication of pain during a test merits immediate termination of the test and referral to a more qualified professional.
  - If a client has a history of diagnosed low-back pain or is currently experiencing pain and/or discomfort, these tests should not be performed until he or she has consulted with a doctor.
- The client must maintain the integrity of the repetition and/or the recommended posture for the specific exercise movement.

Select Muscular-endurance Tests

- The following tests are described in this section:
  - Push-up test
  - Curl-up test
  - McGill's torso muscular endurance test battery
  - Bodyweight squat test

Push-up Test

- The push-up test measures upper-body endurance.
- Due to common variations in upper-body strength between men and women, women should perform a modified push-up.
- The push-up is also a prime activity for developing and maintaining upper-body muscular fitness.

Standard push-up position

Modified bent-knee position

Push-up Test Contraindications/Considerations

- This test may not be appropriate for clients with shoulder or wrist problems.
  - Alternate muscular-endurance tests or the Cooper 90-degree push-up test may be more appropriate.
  - A major problem associated with tests that require performance to fatigue is that the point of “exhaustion” or fatigue is a motivational factor.

Curl-up Test

- The curl-up test is used to measure abdominal strength and endurance.
- The curl-up is preferred over the full sit-up because it is a more reliable indicator of abdominal strength and endurance and is much safer.
- Most clients will be able to perform the curl-up test unless they suffer from low-back problems.

Curl-up test: Down position. Head support is optional.

Curl-up test: Up position

Curl-up Test Contraindications

- The following issues should be considered prior to the performance of abdominal strength assessments:
  - Clients with low-back concerns should check with their physicians prior to attempting this test.
  - Clients with cervical neck issues may find that this exercise exacerbates their pain.

McGill's Torso Muscular Endurance Test Battery

- Core stability involves complex movement patterns that continually change.
- To evaluate balanced core strength and stability, it is important to assess all sides of the torso.
- Poor endurance capacity of the torso muscles or an imbalance between these three muscle groups can contribute to low-back dysfunction and core instability.
- Dr. Stuart McGill's torso muscular endurance test battery:
  - Trunk flexor endurance
  - Trunk lateral endurance
  - Trunk extensor endurance

Trunk Flexor Endurance Test

- The flexor endurance test is the first in the battery of three tests that assesses muscular endurance of the deep core muscles.
- It is a timed test involving a static, isometric contraction of the anterior muscles, stabilizing the spine until the individual exhibits fatigue and can no longer hold the assumed position.
- This test may not be suitable for individuals who:
  - Suffer from low-back pain
  - Have had recent back surgery
  - Are in the midst of an acute low-back flare-up

Trunk Lateral Endurance Test

- The trunk lateral endurance test assesses muscular endurance of the lateral core muscles.
- This test may not be suitable for individuals:
  - With shoulder pain or weakness
  - Who suffer from low-back pain, have had recent back surgery, and/or are in the midst of an acute low-back flare-up

Trunk Extensor Endurance Test

- The trunk extensor endurance test is generally used to assess muscular endurance of the torso extensor muscles.
- This is a timed test involving a static, isometric contraction of the trunk that stabilize the spine.
- This test may not be suitable for:
  - A client with major strength deficiencies
  - A client with a high body mass
  - Individuals who suffer from low-back pain, have had recent back surgery, and/or are in the midst of an acute low-back flare-up

Evaluation of McGill's Torso Test Battery

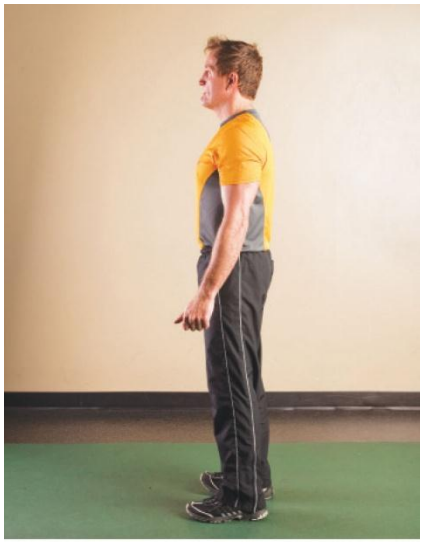
- Each individual test in this battery is not a primary indicator of current or future back problems.
- The relationships among the tests are the important indicators of muscle imbalances that can lead to back pain.
- McGill suggests the following ratios indicate balanced endurance among the muscle groups:
  - Flexion:extension ratio should be less than 1.0
  - Right-side bridge (RSB):left-side bridge (LSB) scores should be no greater than 0.05 from a balanced score of 1.0
  - Side bridge (either side):extension ratio should be less than 0.75

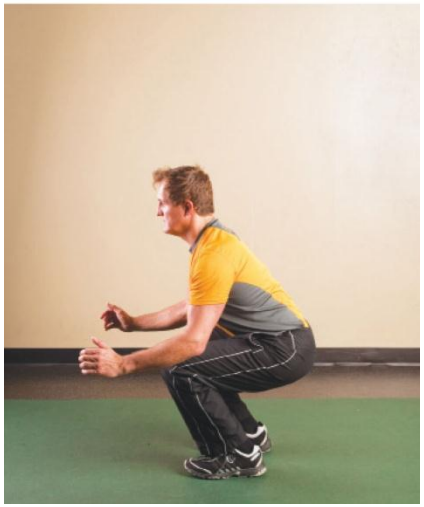
Application of McGill's Torso Test Battery

- Demonstrated deficiencies should be addressed during exercise programming as part of the foundational exercises for a client.
- Muscular endurance, more so than muscular strength or ROM, has been shown to be an accurate predictor of back health.
- Low-back stabilization exercises have the most benefit when performed daily.

Bodyweight Squat Test

- This test assesses muscular endurance of the lower extremity when performing repetitions of a squat and stand movement.
  - This test is only suitable for individuals who demonstrate proper form when performing a squat movement.
- While this test lacks strong scientific validity, it can be used to effectively gauge relative improvements in a client's lower-extremity muscular endurance.
- This test may not be suitable for:
  - A deconditioned or frail client with lower-extremity weakness
  - A client with balance concerns
  - A client with orthopedic issues, especially in the knees
  - A client who fails to demonstrate proper squatting technique





Muscular Strength

- Strength is dependent on variables such as muscle size, limb length, and neurological adaptations.
- Strength can be expressed as either absolute strength or relative strength.
  - Absolute strength is the greatest amount of weight that can be lifted one time
  - Relative strength takes the person's body weight into consideration and is used primarily when comparing individuals.

Muscular-strength Testing

- 1-RM tests should only be performed during phase 3 or 4 of the ACE IFT Model.
  - Submaximal strength testing can be used with a high amount of accuracy to determine a client's likely 1 RM.
  - There is no single assessment that evaluates total-body muscular strength.
- The following strength tests are described in this section:
  - Bench press
  - Leg press
  - Squat

Considerations/Contraindications for 1-RM Testing

- Many strength tests are performed using free weights, so proper form and control are necessary elements.
  - Beginning exercisers are often unsure of their abilities and tend to quit before their true maximum.
  - Proper breathing patterns are necessary.
  - Individuals with hypertension and/or a history of vascular disease should avoid a 1-RM testing protocol.

1-RM Bench-press Test

- This test assesses upper-extremity strength using a fundamental upper-extremity movement.
  - It is only suitable for individuals who demonstrate proper form in performing a bench press.

1-RM Leg-press Test

- This test assesses lower-extremity strength using a stable, supported movement.
  - It is only suitable for individuals who demonstrate proper form in performing a leg press and are free of low-back or knee pain.

1-RM Squat Test

- This test assesses lower-extremity strength using an unsupported, functional movement.
  - It is only suitable for individuals who demonstrate proper form when performing a squat and are free of low-back or knee pain.

Submaximal Strength Testing

- Strength can also be assessed using submaximal efforts.
  - Suitable for inexperienced exercisers and individuals with health concerns
  - The client completes between one and 10 repetitions at a maximal effort.
- 1 RM can also be estimated by simply observing a workout and making the appropriate calculation using a prediction coefficient.

One-repetition Maximum (1 RM) Prediction Coefficients		
Number of repetitions completed	**Squat or leg press coefficient**	**Bench or chest press coefficient**
1	1.000	1.000
2	1.0475	1.035
3	1.13	1.08
4	1.1575	1.115
5	1.2	1.15
6	1.242	1.18
7	1.284	1.22
8	1.326	1.255
9	1.368	1.29
10	1.41	1.325

Brzycki, M. (1993). Strength testing: Predicting a one-rep max from reps-to-fatigue. *Journal of Physical Education, Recreation, and Dance*, 68, 88–90.

Muscle Balance

- Assessments can also be performed to determine left-to-right muscle balance or appropriate ratios of agonist to antagonist muscle strength.
- The table at right presents the recommended strength ratios between opposing muscle groups.

Appropriate Strength Ratios

Joint	Movements	Muscles	Ratio
Shoulder	Flexion:Extension	Anterior deltoids:Trapezius, posterior deltoids	2:3
Shoulder	Internal rotation: External rotation	Subscapularis:Supraspinatus, infraspinatus, teres minor	3:2
Elbow	Flexion:Extension	Biceps:Triceps	1:1
Lumbar spine	Flexion:Extension	Iliopsoas, abdominals:Erector spinae	1:1
Hip	Flexion:Extension	Iliopsoas, rectus abdominus, tensor fascia latae:Erector spinae, gluteus maximus, hamstrings	1:1
Knee	Flexion:Extension	Hamstrings:Quadriceps	2:3
Ankle	Plantarflexion:Dorsiflexion	Gastrocnemius:Tibialis anterior	3:1
Ankle	Inversion:Eversion	Tibialis anterior:Peroneals	1:1

Heyward, V.H. (2006). *Advanced Fitness Assessment and Exercise Prescription* (5th ed.). Champaign, Ill.: Human Kinetics.

Sport-skill Assessments

- Some clients may desire or need assessments of the skill- or performance-related parameters of fitness, which include:
  - Balance
  - Power (anaerobic power and anaerobic capacity)
  - Speed
  - Agility
  - Reactivity
  - Coordination
- Many of these assessments consist of rapid phases of acceleration and deceleration.
- Trainers should therefore determine whether these assessments are skill- and conditioning-level appropriate for clients beforehand.

Power

- Human power is defined as “the rate at which mechanical work is performed under a defined set of conditions.”
  - Power correlates to the immediate energy available through the anaerobic energy system, specifically the phosphagen energy system.
  - Anaerobic capacity represents the sustainability of power output for brief periods of time.
  - Power is also sport- or activity-specific.
- Power equations
  - Power = Force x Velocity or Power = Work/Time
  - Force = Mass x Acceleration
  - Velocity = Distance/Time
  - Work = Force x Distance

Anaerobic Power and Capacity Testing: Field Tests

- Field tests that assess power measure how fast the body can move in a short time period.
- Field tests that assess anaerobic capacity measure the highest rate of sustainable power.
- The following tests are commonly used to assess anaerobic power and capacity:
  - Anaerobic power: Standing long jump test
  - Anaerobic power: Vertical jump test
  - Anaerobic power: Kneeling overhead toss
  - Anaerobic capacity: Margaria-Kalamen test
  - Anaerobic capacity: 300-yard shuttle run

Contraindications for Field Tests of Power

- These tests are intended for athletes and those interested in advanced forms of training.
  - Individuals in “special populations” are not likely candidates.
  - When working with a client who is still recovering from an injury, omit these tests.

Anaerobic Power: Standing Long Jump Test

- The standing long jump test is simple to administer and does not require much time or equipment.
- It is a valuable tool for assessing explosive leg power.

Anaerobic Power: Vertical Jump Test

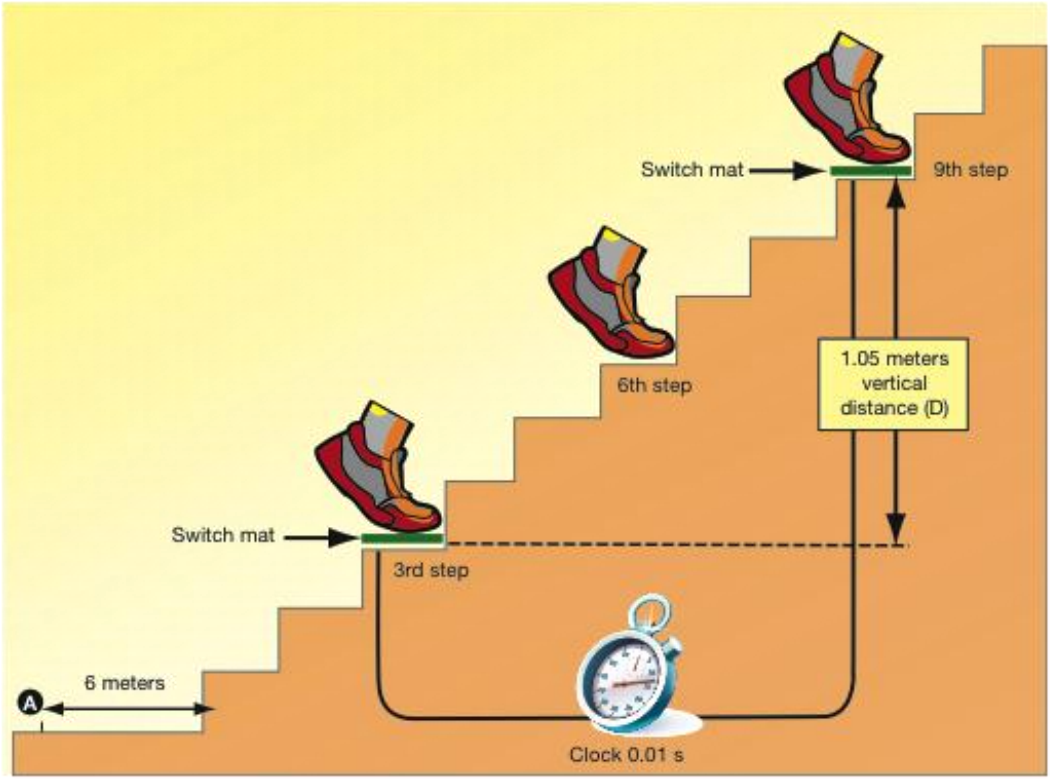
- The vertical jump test is very simple and quick to administer.
- It is especially valuable when assessing the vertical jump height in athletes who participate in sports that require skill and power in jumping.

Anaerobic Power: Kneeling Overhead Toss

- This test measures power in the upper extremities.
  - Especially appropriate for clients who take part in sports where upper-body power is important
- This is also an appropriate power test for wheelchair athletes, if modified.
- The kneeling overhead toss test is simple to administer and does not require much time.

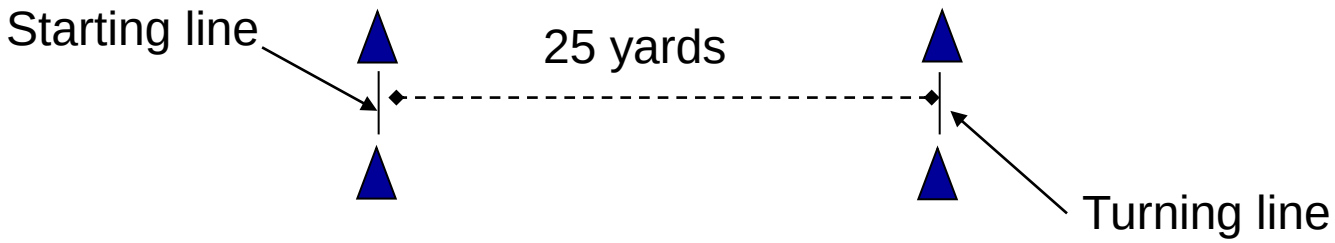
Anaerobic Capacity: Margaria-Kalamen Stair Test

- The Margaria-Kalamen stair climb test is a classic test used to assess leg power and activation of the phosphagen energy system.



Anaerobic Capacity: 300-yard Shuttle Run

- This test assesses anaerobic capacity, or the highest rate of sustainable power over a predetermined distance.

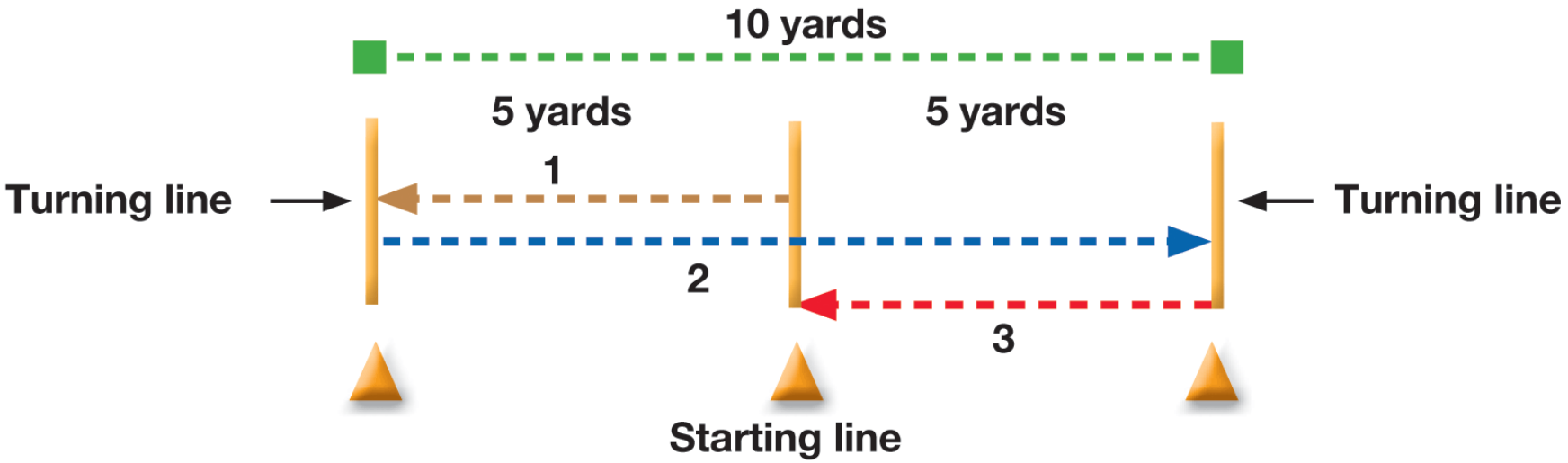


Speed, Agility, and Quickness Testing

- Speed and agility tests are useful in predicting athletic potential.
- Peak running speed is a strong predictor of running performance, even more so than VO_2max.
- For a trainer working with an individual interested in improving his or her performance in a timed sprint, it is important to:
  - Focus on drills that will increase overall muscular speed
  - Work on sprinting techniques
- Speed and agility tests require maximal effort and swift limb movement.
- To perform well and avoid injury, it is imperative that clients warm up adequately.
- The following tests are described in this section:
  - Pro agility test
  - T-test
  - 40-yard dash

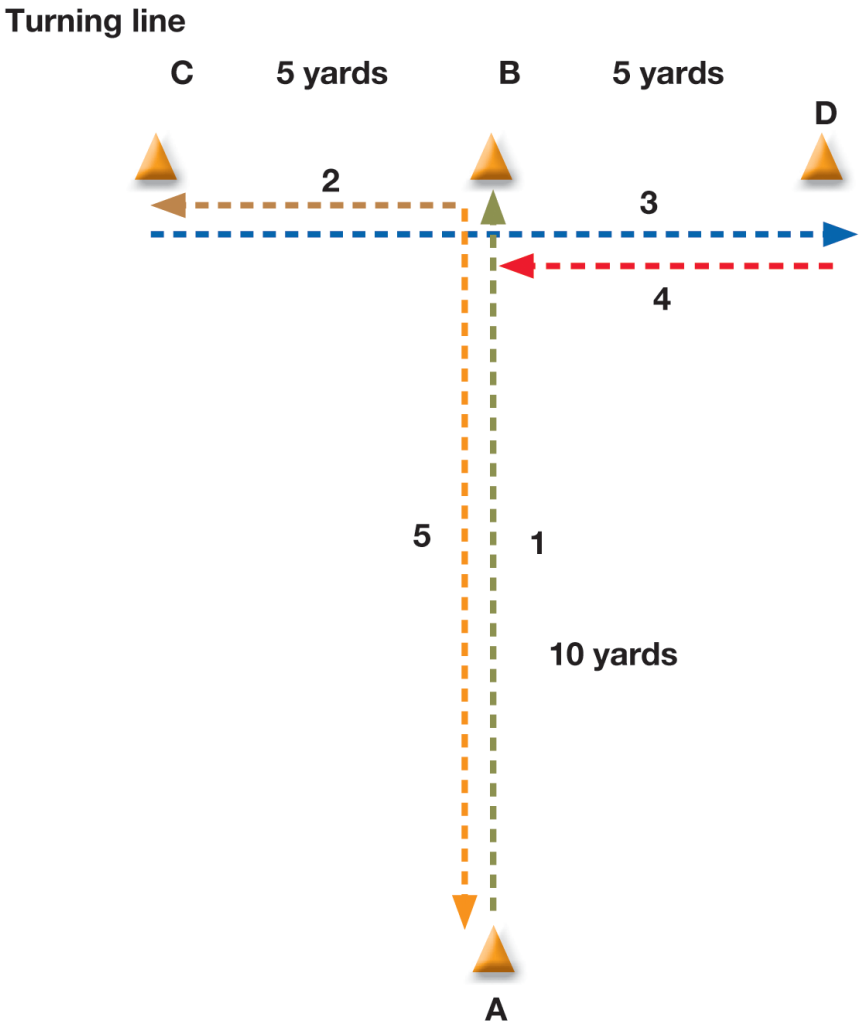
Pro Agility Test

- The pro agility test is sometimes called the 20-yard agility test or the 5-10-5 shuttle run.
  - Measures an individual's ability to accelerate, decelerate, change direction, and then accelerate again



T-test

- The T-test is a useful agility test for assessment of multidirectional movement.
- It is simple to administer and does not require much time or investment in supplies.



40-yard Dash

- The 40-yard dash is performed extensively in sports that require quick bouts of speed.
- Weather conditions and running surface can greatly affect the speed of the client.
- On follow-up assessments, it is important to test on the same running surface and in the same conditions as in the initial test.

Four-point stance (track start)

Three-point stance

Fitness Testing Accuracy

- There are many causes of inaccuracy in fitness testing, ranging from equipment failure to human error.
  - Repeating the same test, in the same environment, and at the same time of day, will ensure that test results can be compared to earlier test outcomes.

Causes of Fitness Test Inaccuracy	
Client Fatigue, lack of sleep Motivation, lack of conviction Excess activity prior to test Food intake prior to test Hydration level Chronic health condition(s) Medications or supplements	**Trainer or Test Technician** Inexperience with testing protocol Poor application of testing protocol Partiality; trying to affect results Level of encouragement
Equipment Improper calibration Mismatched to subject Failure, out of order	**Environment** Distractions Privacy Temperature Weather conditions

Summary

- Assessments are an integral part of any personal-training program.
- A thorough assessment can provide valuable information to use in exercise program planning and implementation.
- Periodic reassessments are also important to gauge progress and continue to foster the client–trainer relationship.
- This session covered:
  - Testing and measurement
  - Anthropometric measurements and body composition
  - Cardiorespiratory-fitness testing
  - Muscular-fitness testing
  - Sport-skill assessments
  - Fitness testing accuracy