ACE Personal Trainer Manual, 4th edition

Chapter 11: Cardiorespiratory Training: Programming and Progressions

Learning Objectives

- This session, which is based on Chapter 11 of the *ACE Personal Trainer Manual,* 4th edition, features a discussion of the physiological adaptations to acute and chronic cardiorespiratory exercise. It also includes coverage of the cardiorespiratory-training phases of the ACE IFT™ Model.
- After completing this session, you will have a better understanding of:
  - How cardiorespiratory exercise affects the following systems: muscular, cardiovascular, and respiratory
  - The components of a well-designed cardiorespiratory-training session
  - General guidelines for cardiorespiratory exercise
  - Various modes of cardiorespiratory exercise
  - The ACE IFT Model cardiorespiratory training phases and their appropriate application with clients
  - Special considerations for youth and older adults

Introduction

- Physical movement is essential for human survival.
- The obligatory need for physical activity is very low in modern society.
- The need for people to structure their lives to include higher levels of physical activity has risen dramatically.

Physiological Adaptations to Cardiorespiratory Exercise

- Muscular system
  - Type I muscle fibers (low- to moderate-intensity exercise)
  - Mitochondria
  - Capillaries
  - Type II muscle fibers (high-intensity exercise)

Physiological Adaptations to Cardiorespiratory Exercise (cont.)

- Cardiovascular system
  - With endurance training, the heart muscle will hypertrophy, enlarging its chambers and becoming a bigger and stronger muscle.
  - Increased cardiac output
    - Primarily due to a larger stroke volume
    - A redistribution of the cardiac output to the active muscles (via vasodilation) may also improve after training.

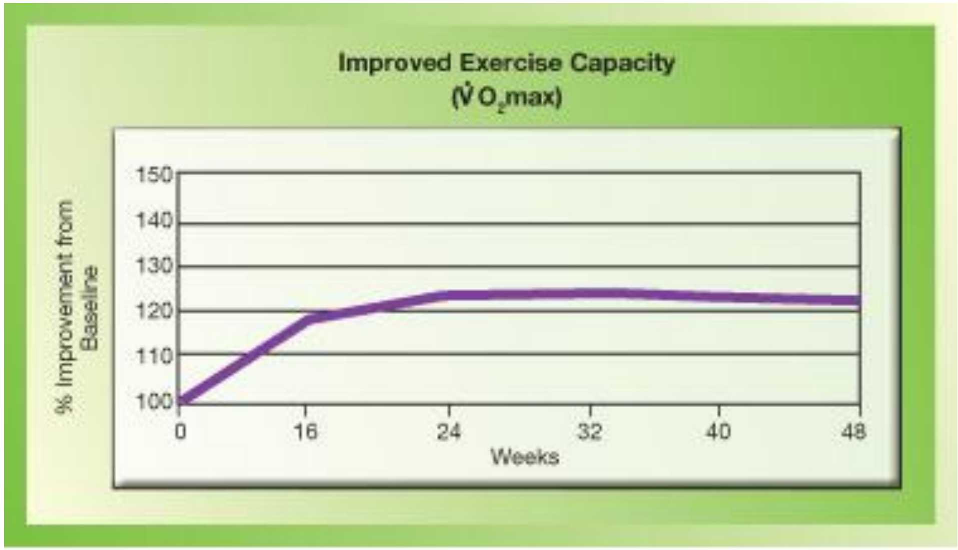
Physiological Adaptations to Cardiorespiratory Exercise (cont.)

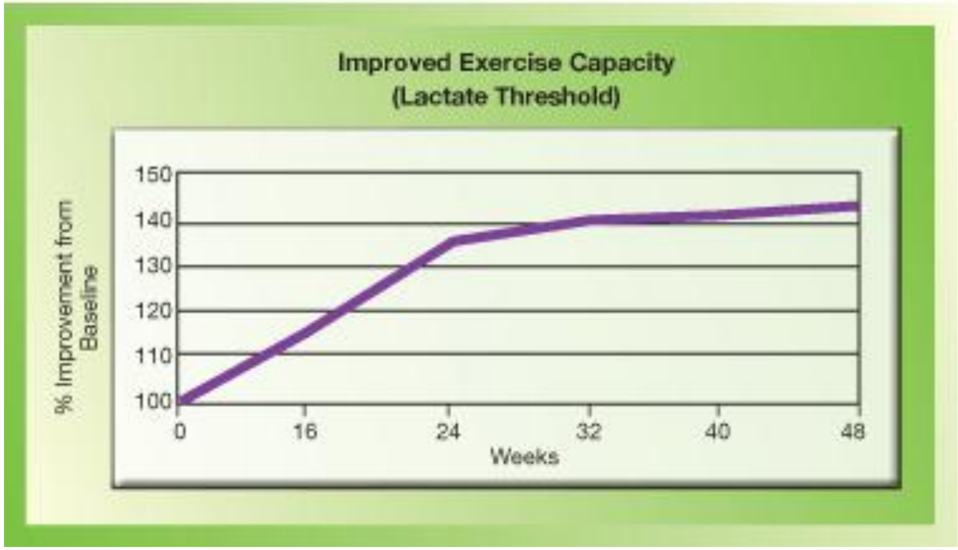
- Respiratory system
  - Alveoli
    - The structure in the respiratory system that interfaces with the cardiovascular system.
  - More efficient muscles of respiration
    - Diaphragm
    - Intercostals
    - Muscles that pull the ribcage upward during active inspiration
    - Muscles that pull the ribcage downward during active expiration
  - Increased tidal volume

Time Required for Increases in Aerobic Capacity

- Cardiovascular adaptations are usually measureable after a couple of weeks of training.
- VO_2max
  - Increases with training, but reaches a peak and plateaus within about six months
- Ventilatory threshold (VT)
  - A significant marker of metabolism that permits prediction of lactate threshold (LT) during progressive exercise
  - May continue to increase for years with continued training, as illustrated on the following slide

Schematic of Changes in VO_2max and Metabolic Markers





Steady-state and Interval-based Exercise

- Steady state
  - Consistent intensity of exercise where the energy and physiological demands are met by the delivery from the physiological systems
  - Limited by the willingness to continue or the availability of oxygen, muscle glycogen, and/or blood glucose
- Interval training
  - Higher-intensity exercise followed by recovery periods
  - Provides anaerobic adaptations that improve tolerance for the buildup of lactic acid (lactate threshold)
  - Provokes an increase in stroke volume that is not achievable with lower-intensity steady-state training

Components of a Cardiorespiratory Workout Session

- Warm-up
  - A period of lighter exercise preceding the conditioning phase of the exercise bout
  - Should last for five to 10 minutes for most healthy adults
  - Should not be so demanding that it creates fatigue that would reduce performance.
  - Stretching
    - The practice of stretching before performing any warm-up is not justified and may potentially be harmful.
  - May be subdivided into a general cardiovascular warm-up followed by a more exercise- or event-specific dynamic warm-up.

Components of a Cardiorespiratory Workout Session (cont.)

- Conditioning phase
  - The higher-intensity elements of a session should take place fairly early in the conditioning phase of the workout.
  - Cardiovascular drift during steady-state training
    - A gradual increase in heart-rate response during a steady-state bout of exercise
  - Aerobic-interval training exercise-to-recovery ratios between 1:2 and 1:1
  - “Lactate sinks”
    - Aerobically trained type II muscle fibers that are proficient at using lactate for energy during hard steady-state exercise

Components of a Cardiorespiratory Workout Session (cont.)

- Cool-down
  - Should be of approximately the same duration and intensity as the warm-up
  - Five to 10 minutes of low- to moderate-intensity activity
  - “Muscle pump”
  - An active cool-down can help remove metabolic waste from the muscles so that it can be metabolized by other tissues.
  - A stretching routine following the cool-down period is appropriate.

Cardiorespiratory Exercise for Health, Fitness, and Weight Loss

- Most health benefits occur with at least 150 minutes a week of moderate-intensity physical activity.
- ACSM and AHA F.I.T.T. guidelines are widely accepted.
- Additionally, clients should always enjoy the exercise experience.
- Changes in fitness are more sensitive to modifications in intensity than to modifications in the frequency or duration of training.

Cardiorespiratory Recommendations for Healthy Adults

Exercise Type	Weekly Frequency
Moderate-intensity aerobic exercise • 40% to <60% $\dot{V}O_2R$ or HRR	Minimum of 5 days per week
Vigorous-intensity aerobic exercise • ≥60% $\dot{V}O_2R$ or HRR	Minimum of 3 days per week
Combination of moderate- and vigorous-intensity aerobic exercise	3–5 days per week

Note: $\dot{V}O_2R$ = $\dot{V}O_2$ reserve; HRR = Heart-rate reserve

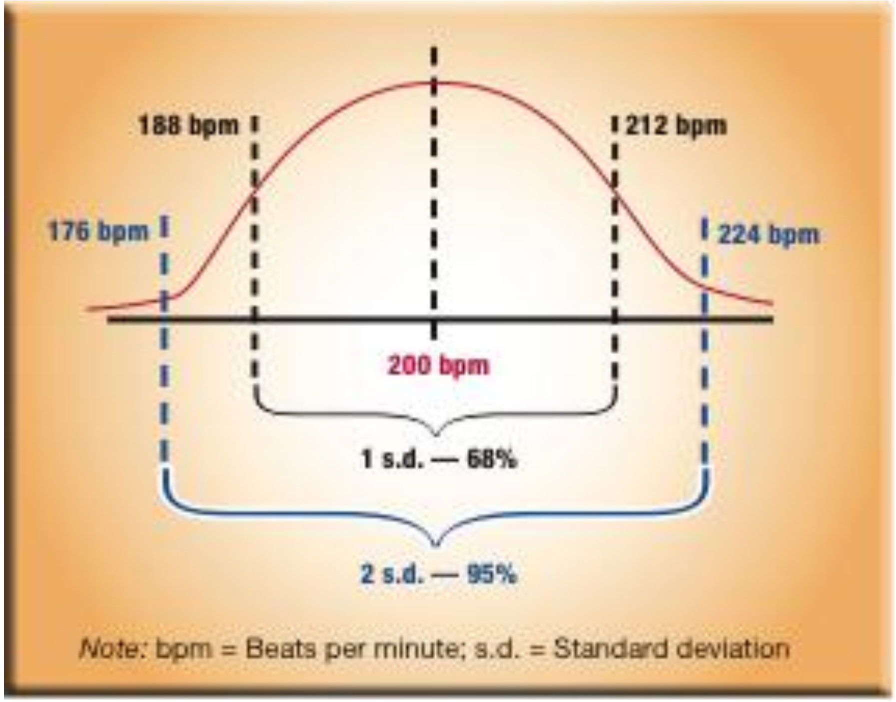
Source: American College of Sports Medicine (2010). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). Wolters Kluwer/Lippincott Williams & Wilkins.

Monitoring Intensity Using Heart Rate

- Numerous variables impact MHR:
  - Genetics
  - Exercise modality
  - Medications
  - Body size
    - MHR is generally higher in smaller individuals who have smaller hearts, and hence lower stroke volumes.
  - Altitude
    - Altitude can lower the MHR reached.
  - Age
    - MHR does not show a consistent 1-bpm drop with each year in all individuals.

Estimated Heart Rate Formulas

- Estimated MHR formulas (three formulas):
  - MHR = 220 – age
    - Standardized predicted MHR formula used in fitness for decades
    - Standard deviation (s.d.): +/- 12 bpm (+/- 36 bpm at 3 s.d.)
  - MHR = 208 – (0.7 x Age)
    - s.d. close to +/- 7 bpm (+/- 21 bpm at 3 s.d.)
  - MHR = 206.9 – (0.67 x Age)
    - s.d. close to +/- 7 bpm (+/- 21 bpm at 3 s.d.)
- Accurate programming with MHR requires actual MHR
  - Impractical for the vast majority of clients and trainers

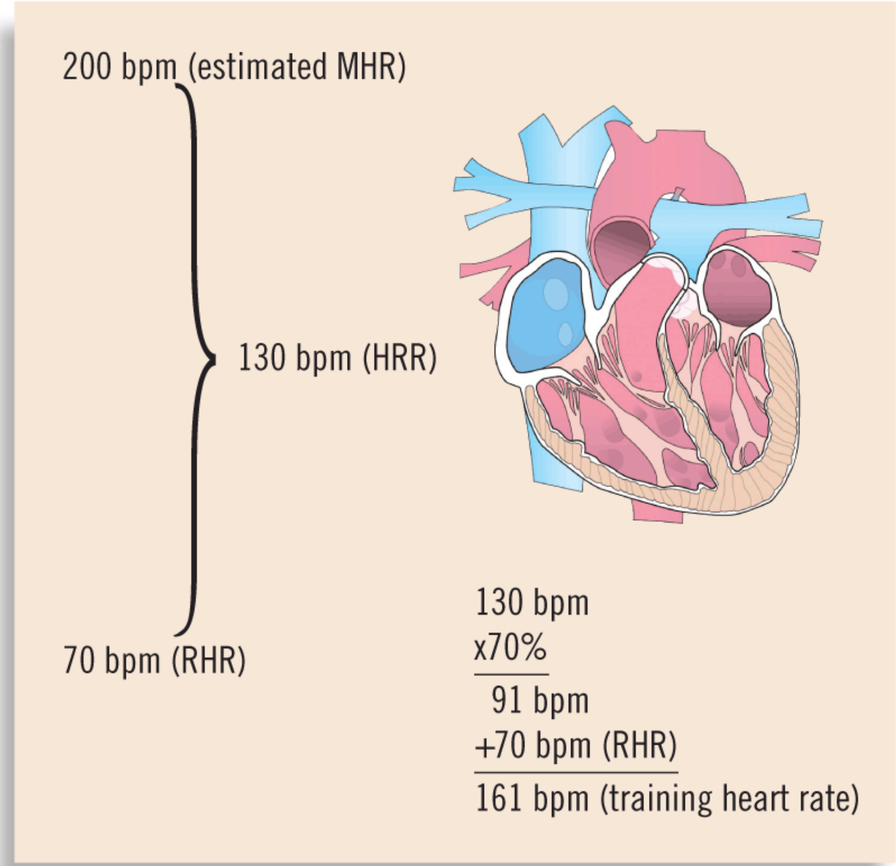


Monitoring Intensity Using Heart Rate Reserve (HRR)

- Heart-rate reserve (HRR) equals the difference between MHR and RHR
  - HRR = MHR – RHR
  - Target HR (THR) = the desired HR during exercise
  - The Karvonen formula can be used to calculate THR as a percentage of HRR:

THR = (HRR x % Intensity) + RHR

- Accurate programming with HRR requires actual MHR and RHR
  - Actual MHR is impractical for the majority of clients and trainers



ACSM Guidelines for Using %MHR

Recommended Framework for Exercise Intensity for Apparently Healthy Adults			
Activity/Exercise Level	**Fitness Classification**	**%MHR**	**%HRR/$\dot{V}O_2$max or $\dot{V}O_2R$**
Sedentary: No habitual activity or exercise, extremely deconditioned	Poor	57–67%	30–45%
Minimal activity: No exercise, moderately to highly deconditioned	Poor/fair	64–74%	40–55%
Sporadic physical activity: No or suboptimal exercise, moderately to mildly deconditioned	Fair/average	74–84%	55–70%
Habitual physical activity: Regular moderate-to-vigorous intensity	Average/good	80–91%	65–80%
High amounts of habitual activity: Regular vigorous-intensity exercise	Good/excellent	84–94%	70–85%

Note: MHR = Maximum heart rate; HRR = Heart-rate reserve; $\dot{V}O_2max = \dot{V}O_2$ maximum; $\dot{V}O_2R = \dot{V}O_2$ reserve

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

Monitoring Intensity Using Ratings of Perceived Exertion

- Two versions of the RPE scale:
  - Classical (6 to 20) scale
  - More contemporary category ratio (0 to 10) scale
- Both scales are capable of defining ranges of objective exercise intensity associated with effective exercise training programs.

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	

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

Monitoring Intensity Using VO_2

- Intensity can be monitored as a $\%VO_2max$ or $\%VO_2R$
  - Training based on metabolic or ventilatory responses is much more meaningful than using arbitrary ranges of $\%VO_2max$ or $\%VO_2R$, especially when these values are predicted.
  - Training intensities that are too far below the first ventilatory threshold (VT1) yield minimal cardiorespiratory fitness benefits.
- Submaximal assessments that predict VO_2max generally use predicted MHR
  - Errors in predicted MHR will affect predicted VO_2max

Monitoring Intensity Using METS

- METs
  - Multiples of an assumed average metabolic rate at rest of 3.5 mL/kg/min
    - Resting metabolic rate is not exactly 3.5 mL/kg/min in every individual.
  - The utility of using METs is so substantial that it more than makes up for any imprecision
    - Exercising at 5 METs equates to working 5x greater than when at rest
      - 5 MET x 3.5 mL/kg/min = 17.5 mL/kg/min

Monitoring Intensity Using Caloric Expenditure

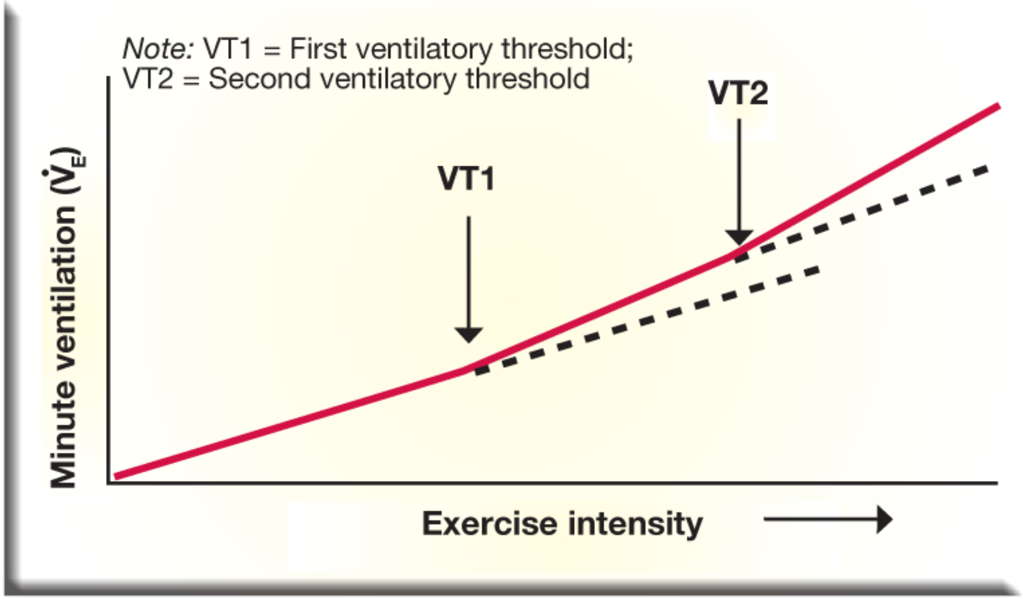
- When the body burns fuel, O_2 is consumed, which yields calories to perform work.
  - 5 kcal per liter of O_2
- Absolute VO_2 (L/min)
- Relative VO_2 (mL/kg/min)
- Commercial cardiovascular exercise equipment
  - Provide estimates of caloric expenditure using absolute VO_2 based on the amount of work being performed
  - Kcal per exercise session = L/min x 5 kcal/L x minutes
- Online caloric-expenditure calculators are available for a variety of physical activities on the ACE website.
  - www.acefitness.org/calculators

Monitoring Intensity Using the Talk Test

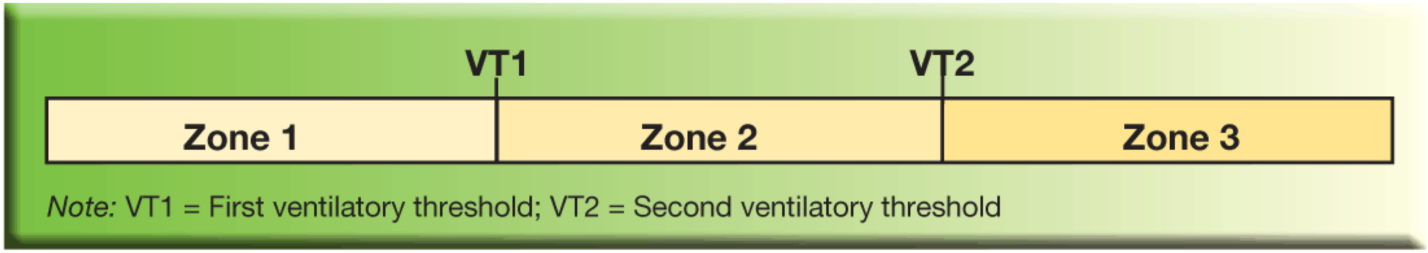
- Ventilation increases as exercise intensity increases
  - Linear increase, with the exception of two distinct deflection points: VT1 & VT2
- Initially, increased ventilation is accomplished through increased inspiration (tidal volume)
- At about the intensity of VT1, the increase in ventilation is accomplished by an increase in breathing frequency (respiration rate)
- Above VT1, but below the second ventilatory threshold (VT2), speaking is possible, but not comfortable.
- VT2 represents the point at which high-intensity exercise can no longer be sustained.
  - Onset of blood lactate accumulation (OBLA)
  - Above VT2, speech is not possible, other than single words.
- The talk test is an index of exercise intensity at VT1.

Monitoring Intensity Using Blood Lactate and VT2

- The metabolic response to exercise is generally non-linear.
  - It is more reasonable to program exercise in terms of metabolic response.
  - Easily marked by either blood lactate or VT1 and VT2
- Blood lactate threshold and VT1
  - Bicarbonate buffering system
- OBLA, HR turnpoint (HRTP), and VT2
  - HRTP is a flattening of the heart-rate response to increasing intensity.



Three-zone Training Model



- Zone 1
  - Relatively easy exercise
  - Reflects heart rates below VT1
  - Client can talk comfortably
- Zone 2
  - Reflects heart rates from VT1 to just below VT2
  - Client is not sure if he or she can talk comfortably
- Zone 3
  - Reflects heart rates at or above VT2
  - Client definitely cannot talk comfortably

Cardiorespiratory Exercise Duration

- Benefits gained from exercise and physical activity are dose-related.
  - Greater benefits are derived from greater quantities of activity.
  - Physical activity expending ≤1,000 kcal/week generally only produces improvements to health.
  - Expending ≥2,000 kcal/week promotes effective weight loss and significant improvements to overall fitness.
- Beginner exercisers
  - Typically cannot tolerate 30 minutes of moderate-intensity activity
  - Generally cannot start with the recommended frequency

Recommendations for Exercise Duration and Quantity

Physical Fitness Classification	Weekly Expenditure (kcal)	Duration/Day (minutes)	Weekly Duration (minutes)
Poor	500–1,000	20–30	60–150
Poor-fair	1,000–1,500	30–60	150–200
Fair-average	1,500–2,000	30–90	200–300
Average-good	>2,000	30–90	200–300
>Good-excellent	>2,000	30–90	200–300

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

Cardiorespiratory Exercise Progression

- Progression follows basic training principles, including:
  - Overload
  - Specificity
- Exercise duration is the most appropriate variable to manipulate initially.
- Thereafter, implement progressions by increasing exercise frequency and then exercise intensity.
- Fartlek training

Types of Cardiorespiratory Exercise

- Physical activities that promote improvement or maintenance of cardiorespiratory fitness:
  - Equipment-based cardiovascular exercise
  - Group exercise
  - Circuit training
  - Outdoor exercise
  - Seasonal exercise
  - Water-based exercise
  - Mind-body exercise
  - Lifestyle exercise

Physical Activities That Promote Improvement or Maintenance of Cardiorespiratory Fitness		
Exercise Description	**Recommended Groups**	**Activity Examples**
Endurance activities requiring minimal skill or fitness	All adults	Walking, slow-dancing, recreational cycling or swimming
Vigorous-intensity endurance activities requiring minimal skill	Adults participating in regular exercise or having better than average fitness	Jogging, rowing, elliptical training, stepping, indoor cycling, fast-dancing
Endurance activities requiring higher skill levels	Adults with acquired skill and higher fitness levels	Swimming, cross-country skiing
Recreational sports	Adults participating in regular training with acquired fitness and skill levels	Soccer, basketball, racquet sports

Equipment-based Cardiovascular Exercise

- The aerobic value of any equipment-based program is based on how the machine is used.
  - Sustained moderate-intensity exercise is the foundation of cardiorespiratory exercise training.
- Many pieces can estimate the MET or caloric cost of exercise.
  - Common sense is required when using the MET or caloric values generated by exercise equipment.
  - In less-fit individuals, and if handrail support is used, the values may overestimate the actual value attained.

Group Exercise

- During the past few decades, an enormous variety of group exercise formats has emerged.
- Common to most formats is the use of music.
- The choreography and intensity can vary greatly.
  - Group indoor cycling programs can elicit VO_2 or HR values greater than those achieved during exercise tests.
  - Group exercise designed for older individuals can be very low intensity.

Circuit Training

- Cardiorespiratory training effects can be observed during circuit training by:
  - Alternating muscular strength and endurance activities with classical aerobic training
  - Performing the activities in a rapid sequence
- Depending on equipment availability, circuit training can be performed by:
  - A single individual rotating through select exercises
  - Groups of participants rotating in an organized manner through several exercise stations

Outdoor and Seasonal Exercise

- Outdoor exercise activities
  - Have emerged out of recreational activities, many with the promise of providing cardiorespiratory fitness
  - Some activities are much more variable in their cardiorespiratory training effects.
- Seasonal exercise activities
  - Likely to have a large cardiorespiratory training effect if the activities require sustained physical activity
    - Cross-country skiing and snowshoeing in the winter months and walking and running in the warmer months

Water-based Exercise

- Water aerobics classes and games can be effective methods of exercise.
- Water-based exercise is particularly valuable for older or obese individuals or those with orthopedic issues.
- Energy cost of ambulatory activity in the water
- Immersion in water causes the blood to be redistributed to the central circulation.

Mind-body and Lifestyle Exercise

- Mind-body exercise
  - Generally not associated with high-intensity aerobic activity
  - May provide an intensity comparable to that of walking
  - Examples include Pilates, hatha yoga, Nia, and tai chi
- Lifestyle exercise
  - Consistently performed domestic activities can provide enough stimulus to make previously sedentary people fit and contribute to excellent health.
  - Activities like yard work should be viewed in the context of the total exercise load.

ACE IFT Model Cardiorespiratory Training Phases

- The ACE IFT Model has four cardiorespiratory training phases:

Phase 1
AEROBIC-BASE

Phase 2
AEROBIC-EFFICIENCY

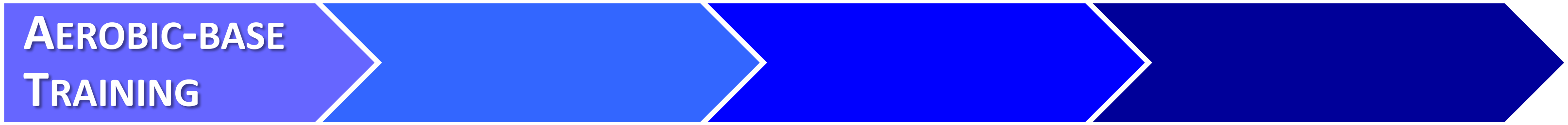
Phase 3
ANAEROBIC-ENDURANCE

Phase 4
ANAEROBIC-POWER

- Clients are categorized into a given phase based on their current health, fitness level, and goals.
  - Clients may be in different phases for cardiorespiratory training and functional movement and resistance training.

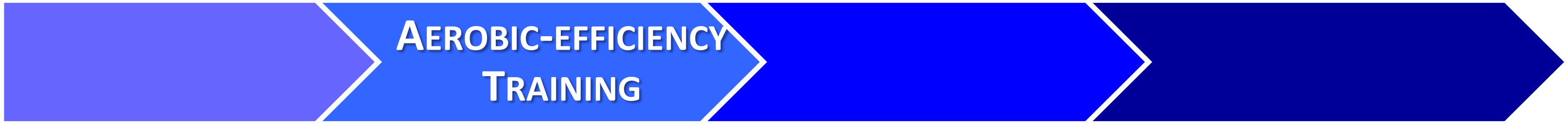
Phase 1: Aerobic-base training

- The focus is on creating positive exercise experiences that help sedentary clients become regular exercisers.
- No fitness assessments are required prior to exercise.
- Focus on steady-state exercise in zone 1 (below VT1).
- Gauge intensity by the client’s ability to talk comfortably and/or RPE of 3 to 4.
- Increase exercise duration ($\leq$10% increase per week)
- Progress to phase 2 once client can sustain steady-state cardiorespiratory exercise for 20 to 30 minutes in zone 1 (below talk test threshold; RPE of 3 to 4) and is comfortable with assessments.



Phase 2: Aerobic-efficiency Training

- The focus is on increasing the duration of exercise and introducing intervals to improve aerobic efficiency, fitness, and health.
- Administer the submaximal talk test to determine HR at VT1.
- Exercise programming in Zone 1 (< VT1) and Zone 2 (VT1 to < VT2)
- Progressions for Aerobic-efficiency Training:
  - Increase duration of exercise in zone 1
  - Then introduce low zone 2 intervals just above VT1 (RPE of 5)
  - Progress low zone 2 intervals by increasing the time of the work interval and later decreasing the recovery interval time.
  - As the client progresses, introduce intervals in the upper end of zone 2 (RPE of 6).
- Most clients will train in this phase for many years.
- If a client has event-specific goals or is a fitness enthusiast looking for increased challenges and fitness gains, progress to phase 3.



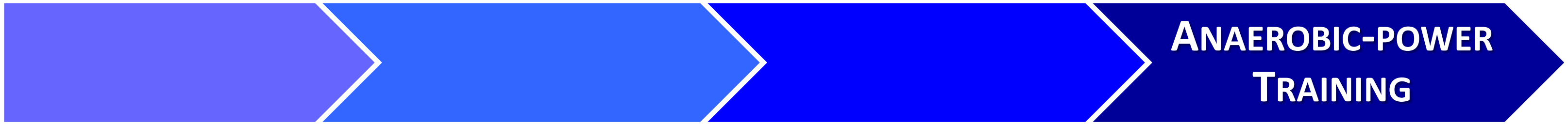
Phase 3: Anaerobic-endurance Training

- The focus is on designing programs to help clients who have endurance performance goals and/or are performing seven or more hours of cardiorespiratory exercise per week.
- Administer the VT2 threshold test to determine HR at VT2.
- The majority of cardiorespiratory training time is spent in zone 1, with intervals and higher-intensity sessions focused in zones 2 and 3.
- Cardiorespiratory training time is distributed as follows:
  - Zone 1 (< VT1): 70–80% of training time
  - Zone 2 (VT1 to < VT2): <10% of training time
  - Zone 3 (≥ VT2): 10–20% of training time
- Many clients will never train in phase 3.
- Only clients who have very specific goals for increasing speed for short bursts at near-maximal efforts will move on to phase 4.

ANAEROBIC-ENDURANCE TRAINING

Phase 4: Anaerobic-power Training

- The focus is on improving anaerobic power to improve phosphagen energy pathways and buffer blood lactate.
- Programs will have a similar distribution to phase 3 training times in terms of distribution among zones 1, 2, and 3.
- Zone 3 training will include very intense anaerobic-power intervals that are at or near maximal levels.
  - Zone 3 intervals in phase 4 will be of shorter duration than in phase 3, due to greater intensity (RPE = 9 or 10)
  - Increase length of recovery interval during zone 3 interval sessions
- Clients will generally only work in phase 4 during specific training cycles prior to competition.



Recovery and Regeneration

- As a general principle, training should be periodized.
- The biggest programming mistakes include:
  - Taking too few recovery days
  - Trying to do something other than recover on recovery days
  - Trying to progress the training load on recovery days (when it should only be progressed on hard days).
- The bottom line is that recovery days are for recovery.
- Two or three hard training days per week are probably adequate to allow progress toward most goals.

Cardiorespiratory Training for Youth

- In youth, there are two primary considerations:
  - Prevent early overspecialization
  - Protect against orthopedic trauma from training too much
- Youth typically perform intermittent activity rather than the more sustained activity that is typical of fitness exercise.

- For obese youth, structured exercise may be appropriate.
  - Intensity should be low enough that exercise is fairly comfortable (zone 1).
  - Since energy expenditure is of primary importance, the duration of exercise should probably progress to an hour or more.

Cardiorespiratory Training for Older Adults

- In older individuals, there are four overriding considerations that dictate modification of the exercise program:
  - Avoiding cardiovascular risk
  - Avoiding orthopedic risk
  - The need to preserve muscle tissue
  - The rate at which older individuals respond to training
- Older adults are less tolerant of:
  - Heavy training loads
  - Rapid increases in training load
  - Single-mode exercise
  - Stop-and-go game-type activities
- Sarcopenia and low bone mineral density are also concerns for those over 50.

Summary

- Physical activity or structured exercise performed with regularity causes adaptation in the heart, lungs, blood, and muscle tissue and promotes the ability to perform even more exercise.
- This session covered:
  - Physiological adaptations to cardiorespiratory exercise
  - Components of a cardiorespiratory workout session
  - Cardiorespiratory exercise for health, fitness, and weight loss
  - Types of cardiorespiratory exercise
  - ACE IFT Model cardiorespiratory-training phases
  - Recovery and regeneration
  - Considerations for youth and older adults