chapter 20

Program Design and Technique for Aerobic Endurance Training
Chapter Objectives

- Discuss factors related to aerobic endurance performance.
- Select modes of aerobic endurance training.
- Set aerobic endurance training frequency based on training status, sport season, and recovery requirements.
- Assign aerobic endurance training duration and understand its interaction with training intensity.

(continued)
Chapter Objectives (continued)

• Assign aerobic endurance exercise intensity and understand the various methods used to monitor intensity.

• Describe various types of aerobic endurance programs.

• Apply program design variables based on the sport season.

• Address cross-training, detraining, tapering, and supplemental resistance training when designing an aerobic endurance training program.
Factors Related to Aerobic Endurance Performance

• Maximal Aerobic Power
  – As the duration of an aerobic endurance event increases, so does the proportion of the total energy that must be supplied by aerobic metabolism.
  – There is a high correlation between $\dot{V}O_2$max and performance in aerobic endurance events.
  – $V_2O_2$max is the best predictor of an athletes cardiorespiratory fitness level
  – Since $\dot{V}O_2 = CO \times a-v O_2 \text{ diff} = HR \times SV \times a-v O_2 \text{ diff}$, an ↑ in CO or a-v O_2 Diff Results in an ↑ in $V_2O_2$ Max
<table>
<thead>
<tr>
<th></th>
<th>VO₂ MAX NORMS (ml·kg⁻¹·min⁻¹)*</th>
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<td>High</td>
<td>Athletic</td>
<td>Olympic</td>
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<td>22-28</td>
<td>29-36</td>
<td>37-41</td>
<td>42-45</td>
<td>46-49</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>
Factors Related to Aerobic Endurance Performance

• Lactate Threshold
  – The speed of movement or the percentage of VO₂max at which a specific blood lactate concentration is observed or the point at which blood lactate concentration begins to increase above resting levels.
  – In aerobic endurance events, the best competitor among athletes with similar VO₂max values is typically the person who can sustain aerobic energy production at the highest percentage of his or her VO₂max without accumulating large amounts of lactic acid (lactate) in the muscle & blood.
  – Several studies have shown that an athlete’s lactate threshold is as good as or even a better indicator of his or her aerobic endurance performance than VO₂max.
Factors Related to Aerobic Endurance Performance

• **Exercise Economy**
  
  – A measure of the energy cost of activity at a given exercise velocity is referred to as the *exercise economy*.
  
  – An improvement in exercise economy can enhance maximal aerobic power ($\dot{VO}_2$max) and lactate threshold.
Designing an Aerobic Endurance Program

• **Step 1: Exercise Mode**
  – Exercise mode is the specific activity performed by the athlete: cycling, running, swimming, and so on.
  – Remember that the more specific the training mode is to the sport, the greater the improvement in performance.
Designing an Aerobic Endurance Program

• **Step 2: Training Intensity**
  – It is measured by the volume of O₂ consumed per min (VO₂), by HR, by using a rate of perceived exertion (RPE) scale, or by multiple of METS. As VO₂, HR, RPE, or METS increases, intensity increases.
  – Adaptations in the body are specific to the intensity of the training session.
  – High-intensity aerobic exercise increases cardiovascular and respiratory function and allows for improved oxygen delivery to the working muscles.
  – Increasing exercise intensity may also benefit skeletal muscle adaptations by affecting muscle fiber recruitment.
Table 18.1

Relationship Between $\dot{V}O_2$ max, HRR, and MHR

<table>
<thead>
<tr>
<th>% $\dot{V}O_2$ max</th>
<th>% HRR</th>
<th>% MHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>50</td>
<td>66</td>
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<td>95</td>
<td>98</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

HRR = heart rate reserve; MHR = percentage of maximal heart rate.

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TARGET HEART RATE (HR) CALCULATION USING HR RESERVE: KARVONEN FORMULA

• Age-predicted maximum heart rate ($HR_{\text{max}}$) = 220 – age
• Heart rate reserve (HRR) = $HR_{\text{max}}$ – $HR_{\text{rest}}$, where $HR_{\text{rest}}$ = resting Heart Rate
• Target heart rate (THR) = (HRR x exercise intensity) + $HR_{\text{rest}}$
• For optimal cardiorespiratory fitness, exercise intensity should be between approx 60-85% of HRR
  – Example: 20 y.o. athlete with $HR_{\text{rest}}$ = 50 bpm assigned an exercise intensity of 60% (lower THR limit) to 85% (upper THR limit) of HRR:
    • Lower THR Limit = [(220 - 20) – 50] x 0.60 + 50 = 140
    • Upper THR Limit = [(220 - 20) – 50] x 0.85 + 50 = 178
    • THR aerobic training zone is between 140-178 bpm
TARGET HEART RATE (HR) CALCULATION USING %HR MAX

• Age-predicted maximum heart rate \( (HR_{\text{max}}) = 220 - \text{age} \)
• Target heart rate \( (THR) = (HR_{\text{max}} \times \text{exercise intensity}) \)
• For optimal cardiorespiratory fitness, exercise intensity should be between approx 70-90% of \( HR_{\text{max}} \)
  – 20 y.o. athlete assigned an exercise intensity of 70% (lower THR limit) to 90% (upper THR limit) of \( HR_{\text{max}} \):
    • Lower THR Limit = \((220 - 20) \times 0.70 = 140\)
    • Upper THR Limit = \((220 - 20) \times 0.90 = 180\)
    • THR aerobic training zone is between 140-180 bpm
• Although THR using \( HR_{\text{max}} \) was similar to THR using %HRR, if \( HR_{\text{rest}} \) was 80 instead of 50 bpm, THR using %HRR would have been between 152-182 bpm instead of between 140-178 bpm. Hence, for any given age THR varies with \( HR_{\text{rest}} \) using %HRR, will not with \( HR_{\text{max}} \).
• Ratings of Perceived Exertion
  – Can be used to regulate intensity of aerobic endurance training across changes in fitness level
  – Typically uses the 15-point Borg scale
  – May be influenced by external environmental factors, such as heat
Multiples of METS (metabolic equivalents)

• 1 METS represents the energy expenditure at rest (i.e., resting O\textsubscript{2} uptake)
  – 1 MET = 3.5 ml·kg\textsuperscript{-1}·min\textsuperscript{-1},
  – Expressed another way, 1 MET = 1 kcal·kg\textsuperscript{-1}·hr\textsuperscript{-1}
  • For example, using 1 kcal·kg\textsuperscript{-1}·hr\textsuperscript{-1}, 1 MET for a 100 kg athlete (220 lbs) is estimated to be 100 kcal/hr. If this 100 kg athlete performing an aerobic activity with an energy cost of 10 METS, his energy expenditure would be 1000 kcal/hr, which can also be expressed as 17.5 kcal/min since (METS x 3.5 x BW in kg)/200 = kcal/min.
  – Convert VO\textsubscript{2} Max to METS by dividing by 3.5:
    • eg, (35 ml·kg\textsuperscript{-1}·min\textsuperscript{-1})/(3.5 ml·kg\textsuperscript{-1}·min\textsuperscript{-1}) = 10 METS
**APPROX. METS OF COMMON PHYSICAL ACTIVITY**

- **Level Ground Walking**
  - Slower (2.5 - 3 mph): 3 METS
  - Brisk (3.5 - 4 mph): 4 METS

- **Level Ground Running** (1 - 2 METS ↑ Every 1 mph ↑)
  - 5 mph (12 min/mi): 8.5 METS
  - 6 mph (10 min/mi): 10 METS
  - 8 mph (7.5 min/mi): 13.5 METS
  - 10 mph (6 min/mi): 16 METS

- **Level Ground Cycling or Stationary Cycling**
  - Slow & Leisurely (10-12 mph or 100-125 Watts): 6 - 7 METS
  - Moderate & Leisurely (12-14 mph or 125-150 watts): 7 - 8 METS
  - Fast & Leisurely (racing) (15-16 mph or 175-200 watts): 9-10 METS
  - World class cyclists can generate ~6 watts of power per kg BW for > 30 min at 25-30 mph, equating to an intensity of > 15-20 METS

- **Walking Upstairs**: 8 METS; **Walking Downstairs**: 3 METS

- **Running Upstairs**: 15 METS
<table>
<thead>
<tr>
<th>INTENSITY</th>
<th>Relative Intensity</th>
<th>Absolute Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%HRR</td>
<td>%HR_{Max}</td>
</tr>
<tr>
<td>Light</td>
<td>20-39</td>
<td>35-54</td>
</tr>
<tr>
<td>Moderate</td>
<td>40-59</td>
<td>55-69</td>
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<tr>
<td>Hard</td>
<td>60-84</td>
<td>70-89</td>
</tr>
<tr>
<td>Very Hard</td>
<td>&gt;85</td>
<td>&gt;90</td>
</tr>
</tbody>
</table>
Designing an Aerobic Endurance Program

• Step 3: Exercise Duration
  – The length of time of the training session.
    • 20-60 Minutes is typical, continuous or intermittent, with at least 10 min intervals is intermittent
  – The duration of a training session is inversely related to exercise intensity: Therefore, the longer the exercise duration, the lower the exercise intensity; and the shorter the exercise duration, the higher the exercise intensity.
Inverse Relationship Between Intensity & Duration

– Lower Intensity ↔ Higher Duration
  • Slow Walking for 60 Min at 3.0 mph (~ 3 MET)
    Requires $\approx 0.9$ L O$_2$/min, Expending $\approx 250$ kcal

– Moderate Intensity ↔ Moderate Duration
  • Brisk Walking for 45 Min at 4.0 mph (~ 4 MET)
    Requires $\approx 1.1$ L O$_2$/min, Expending $\approx 250$ kcal

– High Intensity ↔ Low Duration
  • Moderate Jogging at 6 mph (~ 10 MET) for 20 min
    Requires $\approx 2.7$ L O$_2$/min, Expending $\approx 250$ kcal
Designing an Aerobic Endurance Program

• **Step 4: Training Frequency**
  – The number of training sessions conducted per day or per week (3-6 sessions/week is typical).
  – The frequency of training sessions will depend on the interaction of exercise intensity and duration, the training status of the athlete, and the specific sport season.
  – Frequency Should Increase If Weight Loss is Desired
Designing an Aerobic Endurance Program

• **Step 5: Exercise Progression**
  – Progression of an aerobic endurance program involves increasing the frequency, intensity, and duration.
  – Frequency, intensity, or duration should not increase by more than 10% each week.
  – When it is not feasible to increase frequency or duration, progression can occur with intensity manipulation.
  – Progression of intensity should be monitored to prevent overtraining.
# SAMPLE TRAINING PROGRESSION

<table>
<thead>
<tr>
<th>Program Stage</th>
<th>Week</th>
<th>Exercise Frequency (Sessions/wk)</th>
<th>Exercise Intensity (%HR Max)</th>
<th>Exercise Duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>1</td>
<td>2-3</td>
<td>40-50</td>
<td>15-20</td>
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<tr>
<td>Preparatory Stage</td>
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<td>50-60</td>
<td>20-25</td>
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<td></td>
<td>4</td>
<td>3-4</td>
<td>50-60</td>
<td>25-30</td>
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<tr>
<td>Improvement</td>
<td>5-7</td>
<td>3-4</td>
<td>60-70</td>
<td>25-30</td>
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<tr>
<td>Stage</td>
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<td></td>
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<td>65-75</td>
<td>30-35</td>
</tr>
<tr>
<td></td>
<td>17-20</td>
<td>4-5</td>
<td>70-85</td>
<td>35-40</td>
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<td></td>
<td>21-24</td>
<td>4-5</td>
<td>70-85</td>
<td>40-45</td>
</tr>
<tr>
<td>Maintenance</td>
<td>24+</td>
<td>3-5</td>
<td>70-85</td>
<td>30-45</td>
</tr>
</tbody>
</table>
MAINTENANCE OF THE TRAINING EFFECT

• Cardiorespiratory Fitness Decreases Within 2 Weeks of Stopping Intense Endurance Training, With a Return to Pre-Training Fitness Levels 10 – 32 Weeks of Detraining

• With Complete Inactivity Aerobic Fitness is Lost at a Greater Rate Than it Was Gained

• Reduced Training Frequency or Duration Will Not Significantly Decrease VO₂ Max Acquired From a Training Program as Long as the Training Intensity is Maintained, Which Implies Training Intensity is More Influential in Maintaining VO₂ Max Than is Duration & Frequency.
### Table 18.4

<table>
<thead>
<tr>
<th>Training type</th>
<th>Frequency per week*</th>
<th>Duration (work bout portion)</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long, slow distance (LSD)</td>
<td>1-2</td>
<td>Race distance or longer (~30-120 minutes)</td>
<td>~70% of (\hat{\text{VO}_2}\text{max})</td>
</tr>
<tr>
<td>Pace/tempo</td>
<td>1-2</td>
<td>~20-30 minutes</td>
<td>At the lactate threshold; at or slightly above race pace</td>
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<tr>
<td>Interval</td>
<td>1-2</td>
<td>3-5 minutes (with a work:rest ratio of 1:1)</td>
<td>Close to (\hat{\text{VO}_2}\text{max})</td>
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<td>Repetition</td>
<td>1</td>
<td>30-90 seconds (with a work:rest ratio of 1:5)</td>
<td>Greater than (\hat{\text{VO}_2}\text{max})</td>
</tr>
<tr>
<td>Fartlek</td>
<td>1</td>
<td>~20-60 minutes</td>
<td>Varies between LSD and pace/tempo training intensities</td>
</tr>
</tbody>
</table>

*The other days of the week are composed of other training types and rest/recovery days.

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Types of Aerobic Endurance Training Programs

• **Long, Slow Distance Training**
  – Training is longer than race distance (or 30 minutes to 2 hours) at 70% of VO$_2$max.
  – Adaptations from this exercise include the following:
    • Enhances the body’s ability to clear lactate
    • Chronic use of this type of training causes an eventual shift of fibers from Type IIx to Type IIa to Type I
  – Intensity is lower than that of competition, which may be a disadvantage if too much LSD training is used.
## Sample LSD Training Program for a Marathon Runner

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest day</td>
<td>45-minute Fartlek run</td>
<td>60-minute LSD run</td>
<td>45-minute interval run</td>
<td>60-minute run at race pace over hills and flats</td>
<td>45-minute repetition run</td>
<td>120-minute LSD run</td>
</tr>
</tbody>
</table>

### COMMENTS
- **Frequency:** To help combat overtraining or overuse, the two LSD training days should be spread out evenly during the week to allow recovery between sessions.
- **Duration:** Since the athlete's race distance is a marathon (26.2 miles, 42 km), the duration or running distance of the LSD training sessions should approach those of the marathon (for a trained athlete), at least for one of the two LSD sessions.
- **Intensity:** To complete the extended LSD sessions, the athlete should run at a lower intensity or training pace (minutes per mile or per km); high respiratory stress is not required.

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Types of Aerobic Endurance Training Programs

• Pace/Tempo Training
  – Intensity at or slightly above competition intensity, corresponding to the lactate threshold
    • Steady pace/tempo training: 20 to 30 minutes of continuous training at the lactate threshold
    • Intermittent pace/tempo training: series of shorter intervals with brief recovery periods
  – Objectives
    • Develop a sense of race pace and enhance the body’s ability to sustain exercise at that pace
    • Improve running economy and increase lactate threshold
# Sample Pace/Tempo Training Program for a 50 km Cyclist

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest day</td>
<td>60-minute LSD ride</td>
<td>30-minute <strong>pace/tempo ride</strong></td>
<td>45-minute Fartlek ride</td>
<td>45-minute easy ride</td>
<td>30-minute <strong>pace/tempo ride</strong></td>
<td>90-minute LSD ride</td>
</tr>
</tbody>
</table>

**COMMENTS**

- **Frequency:** Because the pace/tempo rides are stressful, the two training days should be spread out during the week to allow recovery between sessions.
- **Duration:** For *steady* pace/tempo training, exercise duration is shorter than race distance or duration to allow for a higher training intensity.
- **Intensity:** The athlete should cycle at a high intensity or training pace (minutes per mile or per km); high respiratory stress is required to simulate race pace.

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Types of Aerobic Endurance Training Programs

• High-intensity interval training (HIIT)
  – Brief repeated bouts of high-intensity exercise with intermittent recovery periods to elicit cardiopulmonary, metabolic, and neuromuscular adaptations
  – Cumulative duration and intensity of active portions should equate to several minutes above 90% of VO₂max

• For example, at the K-Lab at Duke University I tested the VO₂ max in world class marathon runner Elly Rono’s VO₂ max (2 hour, 10 min marathon, which equates to 4:58 average running pace for 26.2 miles). His VO₂ max was 79.1 ml/kg/min, or 22.6 METS, so >90% VO₂ max (0.9*22.6 = 20.3 METS) would equate to running at approx. a 4:45 or faster pace for intervals (could be mile intervals, or he could run at an even faster pace for shorter intervals, like 400 m. Some athletes also use lactate analyzes and HR monitors during training to assess lactate levels and HR, respectively.
Types of Aerobic Endurance Training Programs

• High-intensity interval training (HIIT)
  – For aerobic athletes, suggested work-to-rest ratios should be 1:1 to 1:2 for intervals >3 min in duration, or 1:3 to 1:4 for intervals between 1-3 min in duration.
  – This allows athletes to train at intensities close to VO$_2$max for a greater amount of time.
  – It increases VO$_2$max and enhances anaerobic metabolism.
  – When used in conjunction with other training sessions, may result in greater stress and risk of injury, so should carefully be cycled on and cycled off within a periodization schedule and only when training athletes with a firm aerobic endurance training base.
### Sample Interval Training Program for a 10 km Runner

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest day</td>
<td>10 reps of 0.5 km intervals at race pace</td>
<td>10 km</td>
<td>45-minute LSD</td>
<td>5 reps of 1 km intervals at race pace</td>
<td>45-minute LSD</td>
<td>45-minute Fartlek run on flat course</td>
</tr>
<tr>
<td></td>
<td>with a 1:1 W:R ratio</td>
<td>easy run</td>
<td>run</td>
<td>with a 1:1 W:R ratio</td>
<td>run</td>
<td>course</td>
</tr>
</tbody>
</table>

**COMMENTS**

- **Frequency:** Because the interval runs are stressful, the two training days should be spread out during the week to allow recovery between sessions.
- **Duration:** The total distance or duration of the training portion of the session (i.e., the sum of the interval work bouts) should approach the competition distances as the athlete becomes more highly trained.
- **Intensity:** The athlete should run at an intensity (pace) close to $\dot{V}O_2\text{max}$ when completing the work bout portions of the interval training sessions.

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Types of Aerobic Endurance Training Programs

• Repetition Training
  – Conducted at intensities greater than $\text{VO}_2\text{max}$, with work intervals lasting 30-90 seconds
  – Work:rest ratio is about 1:5
  – Long recovery periods needed between sessions to prevent rapid lactate accumulation
  – Benefits include
    • Improved running speed and economy
    • Increased capacity and tolerance for anaerobic metabolism
### Sample Repetition Training Program for a Triathlete

(Swim training portion; the race distance is 2.4 miles)

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest day</td>
<td>60-minute LSD swim</td>
<td><strong>50-minute repetition training using 60-second work bouts with 5-minute recovery periods of easy swimming</strong></td>
<td>45-minute LSD swim</td>
<td>“Rest” day (no swim workout)</td>
<td>1-mile swim at race pace</td>
<td>60-minute LSD swim</td>
</tr>
</tbody>
</table>

**COMMENTS**

- Frequency: Because the REPS workouts are stressful, only one training day should occur during the week.
- Duration: The total distance or duration of the training portion of the session (i.e., the sum of the interval work bouts) should approach the competition distance as the athlete becomes more highly trained.
- Intensity: The athlete should swim at an intensity (pace) higher than VO\textsubscript{2}max when completing the work bout portions of the REPS training sessions.

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Types of Aerobic Endurance Training Programs

• Fartlek Training
  – Combines other methods of training
  – Easy running (~70% VO$_2$max) combined with hills or short, fast bursts (~85-90% VO$_2$max)
  – Can be adapted for cycling and swimming
  – Benefits are likely to include
    • Enhanced VO$_2$max
    • Increased lactate threshold
    • Improved running economy and fuel utilization
### Sample Fartlek Training Program for a Collegiate Cross-Country Runner

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest or easy run</td>
<td>60-minute LSD run</td>
<td><strong>45-minute Fartlek run of hard/easy work on hills and flats</strong></td>
<td>25-minute pace/tempo run</td>
<td>45-minute LSD run</td>
<td>25-minute LSD run</td>
<td>Competition</td>
</tr>
</tbody>
</table>

**COMMENTS**
- Frequency: Because the Fartlek runs are stressful, only one training day should occur during the week.
- Duration: The total distance or duration of the training portion of the session (i.e., the sum of the interval work bouts) should approach the competition distance as the athlete becomes more highly trained.
- Intensity: The athlete should run at an intensity (pace) close to VO\(_2\)\text{max} when completing the work bout portions of the Fartlek training sessions.

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The various types of training induce different physiological responses. A sound program should incorporate all types of training into the athlete’s weekly, monthly, and yearly training schedule. This concept is referred to as periodization.
Application of Program Design to Training Seasons

• Off-Season (Develop Sound Conditioning Base)
  – Begin with long duration and low intensity. Gradually increase intensity and, to a lesser extent, duration. 5-6 sessions/week.

• Preseason
  – Focus on increasing intensity (moderate to high), maintaining or reducing duration (moderate to long), and incorporating all types of training. Improve factors important to aerobic performance. 6-7 sessions/week.

• In-Season (Competition)
  – Program should be designed around competition, with low-intensity and short-duration training just before race days. 5-6 sessions/week.

• Postseason (Active Rest)
  – Focus on recovering from the competitive season while maintaining sufficient fitness. Short duration and low intensity. 3-5 sessions/week.
• A sound year-round aerobic endurance training program should be divided into sport seasons with specific goals and objectives designed to improve performance gradually and progressively.
Special Issues Related to Aerobic Endurance Training

• Cross-Training
  – Cross-training is a mode of training that can be used to maintain general conditioning in athletes during periods of reduced training due to injury or during recovery from a training cycle.

• Tapering
  – Tapering is the systematic reduction of training duration and intensity combined with an increased emphasis on technique work and nutritional intervention.
  – The objective of tapering the training regimen is to attain peak performance at the time of competition.
Special Issues Related to Aerobic Endurance Training

• Detraining
  – Detraining occurs when the athlete reduces the training duration or intensity or stops training altogether due to a break in the training program, injury, or illness.
  – In the absence of an appropriate training stimulus, the athlete experiences a loss of the physiological adaptations brought about by training.
Special Issues Related to Aerobic Endurance Training

• Resistance Training
  – Research is limited, but some data suggest that benefits can be derived from performing resistance training during aerobic endurance training.
  – Benefits may include
    • Improvement in short-term exercise performance
    • Faster recovery from injuries
    • Prevention of overuse injuries and reduction of muscle imbalances
  – It can improve hill climbing, bridging gaps between competitors during breakaways, and the final sprint.
Special Issues Related to Aerobic Endurance Training

• Altitude
  – The height above sea level ranging from >500 m to >5,500 m
  – Acclimatization may occur between 12 and 14 days at moderate altitudes up to 2,300 m, but can take up to several months.
  – In order to see an ergogenic effect, athletes need a hypoxic dose ≥12 hours/day for a minimum of three weeks at moderate altitude.
Aerobic Exercises
Exercise 20.1
Treadmill

• Movement phase
  – While holding the handrails, allow one leg to swing freely, and using a pawing action, strike the treadmill with the midfoot.
  – Once comfortable with the speed of the belt, begin walking/running on the treadmill.
  – Run/walk, keeping toward the front portion of the machine while remaining in the center of the treadmill deck.

(continued)
Exercise 20.1
Treadmill (continued)

• Movement phase
  – Release the hands from the handrails, and adjust the speed and incline accordingly until the desired training level is attained.
  – Avoid holding on to the console or front handrails and leaning backward while walking or running.
Exercise 20.2
Stationary Bike

- Proper seat height adjustment (next slide)
  
  (a) Leg straight with knee locked and heel on pedal
  
  (b) Knee slightly bent with ball of foot on pedal
  
  (c) With the pedal at 12 o’clock, the knee will be about even with the hips and approximately parallel with the floor.
Proper Seat Height Adjustment
Exercise 20.2
Stationary Bike

• Movement phase
  – Begin pedaling while keeping the balls of the feet in contact with the pedals throughout the duration of the exercise.
  – Maintain a neutral posture and do not round the shoulders.
Exercise 20.2
Stationary Bike (continued)

• Movement phase
  – When using “bullhorn” handlebars, a variety of hand positions are acceptable:
    • Pronated palms-facing downward grip, allowing a more upright posture
    • Neutral palms-facing grip on the sides of the handlebars, encouraging a greater forward lean
    • Racing position, with the forearms resting on the handlebars, creating maximum forward lean
Exercise 20.3
Rowing Machine

• **Starting position**
  – Keep the back upright, not rounded, with a slight lean forward from the hips.

• **Movement phase (the drive)**
  – Extend the hips and knees while using the arms to pull the handle toward the abdomen just below the rib cage.
  – Adjust the air vent to increase (more air admitted) or decrease (less air admitted) the resistance provided.
Starting Position
The Drive
Exercise 20.3
Rowing Machine

• Ending position
  – The legs should be fully extended with the torso leaning slightly backward.
  – Arms are bent at the elbows, and the handle is at the abdomen just below the rib cage.
The Finish
The Recovery
Exercise 20.4
Stair Stepper

• Movement phase
  – Begin stepping, using the handrails for support.
  – While maintaining an upright posture, take deep (4-8 inch) steps.
  – Do not allow the steps to contact the floor or the upper-limit stop of the machine.
  – Continue to hold the handrails lightly while looking straight ahead, keeping an upright posture with the shoulders squared and relaxed, the torso over the hips, the knees aligned with the feet, and toes pointed forward.
Proper Position on a Stair Stepper
Exercise 20.5
Elliptical Trainer

• **Movement phase**
  – Begin pedaling forward, moving the arms and legs in a reciprocating fashion.
  – The feet should remain in full contact with the pedals throughout the duration of the exercise unless the design of the machine causes the rear heel to lift.
  – The knees should not be allowed to come forward past the toes when in the flexed position.

(continued)
Exercise 20.5
Elliptical Trainer (continued)

• Movement phase
  – Hold on to the handrails in order to maintain balance. If handrail holding is unnecessary, the individual should be encouraged to release the hold on the handrails & pump the arms similarly to what occurs with walking or running.
  – The incline of the elliptical may be increased to more closely simulate a running motion or reduced to replicate a walking motion.
  – Performing this exercise in a forward motion may place greater emphasis on the quadriceps, whereas performing it in a backward manner may increase the stress on the hamstrings and gluteals.
Proper Position on an Elliptical Trainer
Exercise 20.6  
Walking (Gait)  

• Foot strike  
  – The heel should strike the ground first, followed by a gentle “rolling” heel-to-ball action allowing the weight to be spread over the foot.  
  – The weight should transfer from the outer side of the heel and continue to shift forward and slightly inward toward the middle of the ball of the foot at push-off.  

(continued)
Exercise 20.6
Walking (Gait) (continued)

• Stride
  – Without rolling the pelvis (unless racewalking), allow the hips to move freely to increase stride length.
  – Lift the knees and engage the hips and gluteals in the movement.
Exercise 20.6
Walking (Gait) (continued)

• Arm action
  – The arms should swing forward and backward in a reciprocating motion in relation to the lower body (e.g., when the left arm is forward the right leg is extended forward of the body, and vice versa).
  – The shoulders should be relaxed, allowing the arms to swing freely.
Exercise 20.7
Running (Gait)

• Foot strike
  – The heel should strike the ground first, followed by a gentle “rolling” heel-to-ball action allowing the weight to be spread over the foot.
  – The weight should transfer from the outer side of the heel and continue shift.
Exercise 20.7
Running (Gait) (continued)

• Stride
  – Without rolling the pelvis (unless racewalking), allow the hips to move freely to increase stride length.
  – Lift the knees and engage the hips and gluteals in the movement.
  – With each running step, the foot should land approximately under the hips to avoid “braking” and spending too much time in the air.
• Arm action
  – The arms should swing forward and backward in a reciprocating motion to the lower body (e.g., when the left arm is forward the right leg is extended forward of the body, and vice versa).
  – The shoulders should be relaxed, allowing the arms to swing freely.
  – In contrast to walking, the majority of arm movement comes from the lower arm, as too much shoulder movement wastes energy.
Exercise 20.7
Running (Gait) (continued)

• Arm action
  – The forearms should be carried between the waist and the chest.
  – The arms and hands should swing backward and forward, not crossing the midline of the body, in order to create forward propulsion.