Programming for Cardiovascular Fitness

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Introduction

It has been well documented that cardiorespiratory fitness (CRF) is one of the single most important factors that influences lifespan and quality of life (42). These reasons alone support routine participation in aerobic activities to encourage adequate fitness throughout the duration of person’s life. In Chapter 6, “Cardiovascular Physiology,” the structures and organs responsible for maintaining adequate flow of blood and oxygen to the tissues were identified. The ability of the body to efficiently deliver oxygen-rich blood to all its tissues, and the tissues’ ability to use the oxygen to make energy is the foundation of aerobic fitness and will be the basis for the following text.

Based on statistical norms, previously sedentary and even physically active clients new to exercise are not likely to start off with a high level of CRF due to the lack of aerobic activity common amongst most Americans (22; 23). But as with any health component, there exists considerable variation among clients and numerous factors to determine a person’s fitness level. Evaluation of a client’s aerobic capacity is required to ascertain their relative ability to use oxygen and to establish exercise tolerance, interests, and starting points for the exercise program.

Assessing Cardiovascular Fitness

Following the screening process for exercise participation, a client should be tested in some capacity to identify his or her relative CRF. The test selection decisions will be based on the previously reviewed factors, including the client’s specific characteristics, a trainer’s knowledge and experience in testing, and other logistical concerns. Submaximal tests are far more common in personal training settings, compared to maximal tests and provide useful data for the exercise prescription when administered properly. For clients who are new to the exercise environment and have little experience with aerobic training, the test criteria should cater to these points. For instance, it would be unintelligent to ask a new exerciser to perform a 1-mile maximal run test. They would likely perform poorly, experience significant distress and might even become injured. It is very easy to turn a person off from exercise participation by being overly aggressive with the selected assessment activities. In addition, given their relative psychological states, new exercisers are likely to be somewhat anxious and may possess some level of intimidation related to the new experience, particularly if they have not performed well in similar activities in the past.

Selecting the appropriate test for a client does not need to be complicated. Each test has criteria distinctions that designate it as a viable option for the client or not. Submaximal test modalities offer different advantages and disadvantages, depending on the characteristics of the client. Matching the test with the client’s capabilities will provide quality data through improved validity.

If the test selection is appropriate for the client and the protocol is strictly adhered to, the tests should provide quality data. In some cases, the data will provide a prediction of oxygen consumption capabilities (VO2max). In others, the performance is charted and a category of fitness is determined. In either case, the exercise prescription will likely be based on heart rates for intensity determination rather than VO2 or MET intensities, as the latter two require specific knowledge of oxygen usage by premeditated calculations or the use of equipment that calculates intensity via those means. Although it serves as an accurate method to determine aerobic training intensities, using percentage of VO2max for the purposes of prescribing exercise is usually limited to cardiac rehabilitation programs.

Cardiorespiratory Test Comparisons

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step tests</strong></td>
<td>Easy to implement and perform; limited equipment needs; valid for general population but often overpredict fit individuals; metronome paced tests are superior to non-paced protocols; should not be used with moderate to high-level obese, or very deconditioned clients. Leg strength is a factor, as is rhythm during cadence tests.</td>
</tr>
<tr>
<td><strong>Walk/jog tests</strong></td>
<td>Easy to implement and perform; limited equipment; viable for deconditioned or new exercisers with no experience; validity affected by motivation and exercise tolerance, as well as measured distance accuracy; overpredicts fit populations.</td>
</tr>
<tr>
<td><strong>Run tests</strong></td>
<td>Easy to implement and perform; limited equipment; viable for fit or conditioned individuals; validity affected by test experience due to pace, client motivation, running economy, and measured distance accuracy; recommended for the fit populations only.</td>
</tr>
<tr>
<td><strong>Bike tests</strong></td>
<td>More difficult to implement; equipment dependent; technical expertise required; viable for multiple populations but some level of fitness required; validity is high with strict protocol adherence; leg strength a factor.</td>
</tr>
</tbody>
</table>
Measuring Intensity Through Heart Rate

Heart rate is the ideal measure to determine intensity because it has a linear relationship with aerobic work. During aerobic training, the harder a person exerts himself or herself, the more oxygen is required to satisfy the demand. Consequently, the heart must pump more frequently to correspond with the increased need for oxygenated blood. This relationship allows intensity to be measured indirectly by tracking heart rate response to exercise. The term heart rate training zone (HRTZ) is used to define the heart rate range that a person should work in to maximize their adaptation response to aerobic exercise.

The first step in determining the heart rate training zone is to measure or predict the maximum heart rate of an individual. A direct measurement is always the best for true validity, but it is not practical for most training situations. Direct measurement requires a person to perform a maximal aerobic test, which is most commonly a graded exercise test (GXT) performed on a treadmill. The problem with maximal GXTs is the equipment, expertise, and client effort required often create logistical issues for the average personal trainer. For this reason, predictive formulas are far more commonly employed to determine a heart rate maximum. The classic formula to predict maximum heart rate is to subtract a person’s age from 220 (220-age). The value is considered the highest attainable heart rate for an individual at a given age. The problem with this formula is that it suggests that everyone at a certain age has the exact same maximum heart rate, which is not correct (38). The standard deviation for the equation is 10-12 beats · min⁻¹. Using bell curve theory, this would make the formula accurate for 68% of the population at a given age. Using the same theory, the remaining 32% of the population’s maximum heart rate would either be under or over the predicted value by at least 10-24 beats · min⁻¹, depending on where they fall along the curve. This is hardly a precise prediction, and therefore may throw off the accuracy of the training zone, consequently leading to reduced effectiveness of the training (19).

Rate of Perceived Exertion (RPE)

One way to improve the Max HR formula is to compare the heart rate measures with the values of the Rate of Perceived Exertion Scale. Rate of perceived exertion (RPE) is based on Borg’s research to monitor exercise by perception of effort, rather than cardiovascular measures. Borg found that when local factors, such as perceived strain and discomfort, and the central factors, including respiration rate and heart rate were combined, they could be used to identify relative work level. In his original scale, the numbers 6-20 reflected heart rates of 60-200 beats · min⁻¹. A correlation exists between the scale defined for perceived effort and the intensity of the exercise (15; 36). A value of 12-14 on the RPE scale correlates with 60-80% of the heart rate reserve with 13-14 being closely related to lactate threshold (35). Using the combined method of age predicted max heart rate based training zones and RPE,

~Key Terms~

**Metronome** – An instrument used to indicate the exact tempo at which work should be performed during certain tests (i.e. Step test).

**MET** – A unit of measure used to describe the amount of oxygen one consumes at a given intensity.

**Heart Rate Training Zone (HRTZ)** – The heart rate range that a person should work between in order to maximize their adaptation response to aerobic exercise.

**Graded Exercise Test (GXT)** – A maximal aerobic test used to determine an individual’s heart rate training zone.

**Rate of Perceived Exertion (RPE)** – A scale, usually numbered 6-20, that is used to monitor a client’s own perception of their exertion during exercise.

![Borg RPE Scale](image)
a person expected to be within a specific target zone should match the zone defined by perceived exertion when training above an intensity of 50% HRmax (13). When the zones align, the measured heart rates can be documented for improved accuracy to generate the exercise prescription.

Researchers have come up with other formulas that may increase the accuracy for heart rate prediction for specific populations. Research findings have indicated that age, obesity, fitness, and smoking status all contribute to prediction error when using the traditional heart rate max formula (54). Therefore, modified formulas to predict max heart rates have surfaced, each of which holds statistical merit for the respective population it is designed for. The following formulas can be used in place of the heart rate max formula for the select populations.

Even with the improved accuracy associated with the formulas below, standard deviations still exist that can reduce the accuracy of the predicted training zone. Personal trainers should utilize the rate of perceived exertion scale and other indicators to contend with the inherent variability associated with the prediction of heart rate max.

**Talk Test**
Another informal, subjective method of qualifying predicted heart rate max values is to employ the talk test. The method requires subjects to exercise at an intensity at which conversation is comfortable. The intensity is gradually increased until the exerciser has difficulty maintaining regular conversation. At this point, the individual is at, or near, ventilatory threshold. Ventilatory threshold describes a non-linear increase in respiration that corresponds with higher levels of

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**Multifactor General Population Formula for Max Heart Rate**

**Men**

\[
\text{Max HR} = 203.9 - (0.812 \times \text{age}) + (0.276 \times \text{RHR}) - (0.084 \times \text{kg}) - (4.5 \times \text{smoking code})
\]

**Women**

\[
\text{Max HR} = 204.8 - (0.718 \times \text{age}) + (0.162 \times \text{RHR}) - (0.105 \times \text{kg}) - (6.2 \times \text{smoking code})
\]

Age = years
RHR = resting heart rate
Kg = body weight in kilograms
Smoking code = (1) for smoker, (0) nonsmoker

**Obese Individuals**

\[
\text{Max HR} = 200 - (0.5 \times \text{age})
\]

**Older Adults**

\[
\text{Max HR} = 208 - (0.7 \times \text{age})
\]

### Example

68 Year old male
161 lbs
RHR 75 bpm
Current Smoker

\[
\text{Max HR} = 203.9 - (.812 \times 68) + (.276 \times 75) - (.084 \times 73) - (4.5 \times 1) \\
\text{Max HR} = 203.9 - 55.2 + 20.7 - 6.1 - 4.5 \\
\text{Max HR} = 159 \text{ bpm}
\]
exercise intensity due to increased blood temperature and reduction of pH. Respiration increases fairly linearly with intensity until the ventilatory threshold is reached, at which time the increase in respiration breaks the linear progression. Research has demonstrated a close correlation between the Talk Test, VO$_2$, ventilatory threshold, and heart rate (30; 56). The Talk Test can be used with the RPE scale to increase accuracy of training heart rates. An RPE value of 14 generally equates to the value found in the Talk Test performance when conversation becomes difficult (55).

Heart Rate Training Zones
The predicted maximum heart rate can be used to prescribe exercise intensity by creating heart rate training zones. Different formulas can be used to calculate the training zones. The two most widely used formulas are the Heart Rate Max Formula and the Heart Rate Reserve method. The heart rate max formula is very easy to implement, and it is the method used to create most exercise intensity charts found on popular brands of cardiovascular equipment. This formula, though, has major drawbacks. Because it is simply a percentage of the max heart rate, any error in the determination of the max heart rate value will skew the range. Other problems include an underestimation of the required training heart rate, unless an upward adjustment is made, and it estimates the same value for all individuals in the same age range (51). It is inappropriate to assume all people of the same age will have similar heart rates at the same respective training intensities.

Heart Rate Max Method
Training HR = Max HR x Training Intensity Percentage

Heart Rate Reserve Method
The Heart Rate Reserve method is considered a superior technique to the Heart Rate Max method for defining heart rate training zones because it factors in an additional cardiovascular variable: resting heart rate. In Chapter 6, the relationship between resting heart rate and cardiorespiratory efficiency was established, and it was further identified that lower resting heart rates indicate higher stroke volume. The formula uses this relationship to make individual adjustments in the training heart rate estimates. Heart rate reserve (HRR) is calculated by subtracting a person’s resting heart rate from their predicted maximum heart rate, using the above mentioned maximum heart rate formula. The value is then entered into the formula to estimate training heart rates, based on a selected intensity.

Heart Rate Max Method
Max Heart Rate Formula
20 Year Old Male

220 – 20 Years = 200 beats · min$^{-1}$

Predicted Max HR= 200 beats · min$^{-1}$

HR Max Method
200 beats · min$^{-1}$ x 0.75 = 150 beats · min$^{-1}$

200 beats · min$^{-1}$ x 0.90 = 180 beats · min$^{-1}$

Training Zone = 150-180 beats · min$^{-1}$

The Heart Rate Reserve method requires that the HRR be multiplied by the desired training intensity. The resting heart rate is then added back into the equation to estimate the training intensity heart rate value. Heart rate reserve works on the logical premise that training heart rates must lie somewhere between the resting heart rate value and the maximal heart rate value. Due to individual variations, that range will be different for most people; therefore, it needs to be determined to accurately estimate the training intensities for exercise.

Adequate stimulus for cardiovascular improvements varies by the individual. General guidelines suggest that the intensity must be at least 40% of VO$_2$max for any cardiovascular adaptations to occur (61). This value though, is insufficient for performance improvements for most of the population. The following ranges will be appropriate for improvements in health and fitness in the majority of the population.

The specific intensity used will be based on a variety of factors, including current fitness level, exercise tolerance, and risk factors for disease. VO$_2$ and HRR do not correlate as well at lower intensity as they do at the

Recommended Training Intensities
Training Intensity Ranges for Deconditioned Individuals
40-60% VO$_2$max

50-60% Heart Rate Reserve
60-70% Heart Rate Max

Training Intensity Ranges for Healthy Individuals
60-80% Heart Rate Reserve or VO$_2$max
75-90% Heart Rate Max
higher intensities, so mild adjustments for deconditioned individuals are made in the intensity selection for this population (59). Deciding on the exact intensity to employ for a client is similar to other health related components. A period of acclimation is recommended to familiarize clients with exercise and to help in the adoption of routine engagement in the activity. When creating the exercise prescription, the exercise principles should be properly applied so that the progressive overload is appropriate for the client. Starting or progressing too aggressively can lead to attrition and possible injury.

**Types of Aerobic Training**
Different types of aerobic training can be used to elicit the desired adaptation response. In general, aerobic training is performed using steady-state heart rates or varying interval heart rates. Steady-state is probably the most common method for aerobic training. It requires exercisers to perform at a set pace without varying the resistance or movement factors. The term steady-state refers to the consistency of the heart rate during the performance of work. Adjustments less than 5 beats per minute suggest the aerobic pathways are maintained at a constant level due to the fact that oxygenated blood supply is meeting the demand.

**Interval Training**
Interval training, on the other hand, uses variation in heart rate and resistance or speed. The heart rates fluctuate based on the intensity of the work at a given time. Interval training is an effective method for attaining higher exercise intensities. It is based on the premise that the body will adapt to the highest perceived stress, even though the time spent in the higher intensity range is fairly limited compared to the total duration of the activity. It is much easier to push the body at high intensities for short periods of time, compared to attempting to maintain higher steady-state levels for the duration of the exercise session. Using intervals, a client can reach exercise intensities they otherwise would not be able to experience or maintain. It is suggested that interval training yields a greater adaptation response compared to steady-state training performed for the same period of time when applied properly (53).
~Quick Insight~

**Fat Burning Zone**

When aerobic activity is used for weight loss, all attempts should focus on the caloric expenditure, even though training in the “fat-burning zone” is often recommended by some professionals to encourage weight loss. Low and low-moderate intensity training do yield a higher percentage of calories metabolized from fat compared to moderate and high intensity training, but again these training intensities do not measure up when total caloric expenditure is compared (26; 43).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
<th>Caloric Expended</th>
<th>Fat Kcal Expended</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 mph walking</td>
<td>30 min</td>
<td>117 kcal</td>
<td>64 fat kcal</td>
</tr>
<tr>
<td>6 mph running</td>
<td>30 min</td>
<td>357 kcal</td>
<td>117 fat kcal</td>
</tr>
</tbody>
</table>

Example based on a 150 lb person

As you can see, the elevated intensity not only burned more than two times the total calories, but also utilized more fat during the exercise bout, even though the percentage of calories burned from fat was higher with the lower intensity exercise (70). In fact, the amount of calories expended from fat while running equated to the total calories burned while walking. In addition, higher intensities increase post-exercise metabolism (10-13% of total calories expended), further contributing to weight loss potential (44; 71).

Consistent with exercise intensity, the desired outcomes of the program will dictate the training frequency and duration. Unlike other types of exercise, aerobic training requires frequent and consistent participation to optimize results (16). It is recommended that for optimal health improvements, aerobic activities should be performed most days of the week and equal 14-20 calories per kilogram of body weight per week (9; 32). The same can be said when training for performance. The minimal frequency that aerobic activity should be performed is three or four days per week (8). For improvements in CRF, it is recommended that deconditioned individuals accumulate 30 minutes of aerobic activity most days of the week, while healthy individuals should engage in aerobic exercise for 30 or more minutes, 3-5 days per week (11; 66). In addition, vigorous intensity activities should be performed for 10-15 minutes at least twice per week by healthy individuals. Interestingly, deconditioned participants show almost equal benefit when the 30 minute time period is divided up into multiple sessions throughout the day (3 x 10 minutes), as long as the heart rates remain above the minimum threshold for CRF improvements (10). Additionally, deconditioned individuals have shown improvements with a participation of 2-3 sessions per week (65).

From an overall health standpoint, training at higher intensities most days of the week may initiate a cost-benefit imbalance due to the elevation in risk for musculoskeletal injury seen with more frequent and longer bouts of aerobic exercise. Likewise, training beyond 80% VO2max has been correlated with greater risk for injury (37; 64). Longer duration bouts and high intensities are, in fact, necessary for higher end performance and competition level training. But, if the

prevention, and reduced risk for injury, compared to high intensity training (40). Additionally, many exercisers prefer moderate intensity activity because it is more tolerable for sustained periods of time compared to training at higher intensities (29). Low intensity aerobic training helps acclimate clients to exercise, and is indicated for those with health issues that prevent the use of more elevated intensity levels.

In some circles, low intensity exercise has been recommended for weight loss due to the emphasis on lipid metabolism. Although it is true that sleep, rest, and low intensity activity utilize fat preferentially for aerobic metabolism, the total calories expended during activities of low metabolic demand are considerably less than the expenditures associated with higher intensity activities (41). Therefore, although the percentage of calories burned from fat is higher with low intensity exercise, the total number of fat calories burned is actually lower (68). Individuals who attempt to lose weight by training in the “fat-burning zone” are actually limiting their ability to burn calories, which is the primary factor affecting weight loss (45). If the “fat-burning zone” was the optimal weight loss zone simply based on the percentage of fat used for fuel, then sleeping would be the best choice for weight loss activity, as it uses the highest percentage of fat for energy. Clearly this logic is skewed because a low number of calories are expended per minute while sleeping. In other words, a large percentage of a small number equates to an even smaller number in the end. Compared to moderate and high intensities, low intensity exercise reduces caloric expenditure, reduces cardiovascular adaptations, and in some cases (duration being the variable) reduces the total amount of fat utilized during the exercise bout (69).
goal is optimal health, then training at roughly 80% of VO₂max, 4-5 days per week, for approximately thirty minutes is well justified.

### General Aerobic Training Guidelines

<table>
<thead>
<tr>
<th>Goal</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Health</td>
<td>Most days</td>
<td>Accumulate 30 min/day</td>
</tr>
<tr>
<td>Fitness</td>
<td>3-5 days</td>
<td>30-60 min</td>
</tr>
<tr>
<td>Performance</td>
<td>5-7 days</td>
<td>45-90 min</td>
</tr>
</tbody>
</table>

### Energy Expenditure

An energy expenditure of 200-400 kcal per day is a marker for CRF improvement consistent with the other aerobic prescription guidelines for health (46; 62). It has been observed that when aerobic exercise is performed for a duration and intensity that meets or exceeds 14 kcal per kilogram of body weight per week, the body experiences improved health. Calories per training bout or those expended when performing aerobic activity seem to be part of the multifactorial threshold for health (31). The relationship between calories and aerobic training stems from the oxidation value of energy. Approximately 5 kcal of energy is released per liter of oxygen used. Therefore, measuring calories expended in an exercise bout or the oxygen used by the body during the exercise period will each identify the work performed. In fact, energy expenditure can be represented in numerous ways that all reflect the amount of oxygen or calories used while performing activity.

### Understanding METs

The different ways to express energy expenditure allow for multiple variables to predict how much work is being done and how much oxygen and calories are needed to perform the activity. One of the more common ways to convey the demands of an activity is through a unit referred to as a MET, or metabolic equivalent. The MET intensity of an activity reflects the magnitude of work performed by the body relative to rest. Therefore, one MET is the value of oxygen used when the body is resting and equals the derived unit 3.5 ml of oxygen per kg of body weight per minute ($3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$). This value is the same for every person. The way it becomes relative to a particular person is by factoring in the individual’s weight and the time they spend at that relative oxygen demand. If an activity is performed above a resting level, then the MET value changes to reflect the oxygen demand. For instance, casual walking is generally performed at 2.8 METs, working at a desk is 1.5 METs, while washing and waxing a car is 4.5 METs. Each of these values can be multiplied by the 3.5 ml · kg⁻¹ · min⁻¹ unit to convert it to the specific oxygen demand. Once the total amount of oxygen utilized has been determined, the amount of calories expended can be calculated given that each liter (L) of oxygen used equates to 5 kcal burned.

#### MET Example One

**Example: 220 lb. (100 kg) man sitting in a chair for 60 minutes (1 MET)**

\[
\begin{align*}
3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \times 100 \text{ kg} &= 350 \text{ ml} \cdot \text{min}^{-1} \\
350 \text{ ml} \cdot \text{min}^{-1} \times 60 \text{ min} &= 21,000 \text{ ml} \\
21000 \text{ ml} \times \frac{0.001 \text{ L}}{\text{ml}} &= 21 \text{ L} \\
21 \text{ L} \times 5 \text{ kcal} \cdot \text{L}^{-1} &= 105 \text{ kcal}
\end{align*}
\]

The example above shows that when the relative variables of an individual are factored in, the MET value can be expressed as a measure of oxygen use and calories expended. In the case of the 220 lb. man sitting in the chair for an hour, he would require 21 liters of oxygen, or 105 calories for his tissues to function. This ability to express the values based on known variables allows for the identification of how much oxygen or energy is needed to perform a particular task. The equation used above can also be used to identify oxygen demand and calories for any level of work when the necessary variables are known. In fact, this is the same formula that aerobic exercise equipment uses to provide exercisers with the calories they expend during a workout.

One of the first values requested of an exerciser when they start on an aerobic machine is his or her weight. The machine quickly converts the pounds entered into kilograms and adds this value into the equation. The next value the machine often requests is the amount of time the exercise will be performed. This number is also entered into the equation. The last bit of
information used is the speed setting or intensity level selected. The machine has MET intensities built into its default program data, based on the level or speed selected. The following example demonstrates the machine’s conversion of information to provide the user with a caloric value.

**MET Example Two**

**Example:** 220 lb (100 kg) male exercising at level 8 on a Stairclimber for 30 minutes.

| Weight | 
|---|---|
| 220 lbs ÷ 1 kg = 100 kg | 2.2 lbs |

| Intensity: Level 8 = 10 METs (Default value based on resistance and speed) |

| Time: | 30 minutes |

1 MET = 3.5 ml · kg⁻¹ · min⁻¹

10 MET × 3.5 ml · kg⁻¹ · min⁻¹ = 35 ml · kg⁻¹ · min⁻¹

1 MET

35 ml · kg⁻¹ · min⁻¹ × 100 kg = 3500 ml · min⁻¹

3500 ml · min⁻¹ × 30 min = 105,000 ml

105,000 ml ÷ 1 kg = 105 L

105 L × 5 kcal · L⁻¹ = 525 kcal

This equation works for any activity that has been scientifically measured for work. Clinicians have analyzed hundreds of activities to provide MET intensities for use in determining oxygen demand and energy expenditure. In some cases, the activities are weight-bearing, like the Stairclimbing example, where the exerciser must lift his or her body weight as part of the work. In others, such as biking, the weight of an individual is not a relevant factor to determining the oxygen demand. Activities where bodyweight is a factor when determining work express the value as ml · kg⁻¹ · min⁻¹, whereas in non-weight-bearing activities the oxygen is expressed as L · min⁻¹.

The exercise bike uses revolutions per minute and the selected resistance to determine the MET intensity. The subsequent energy expenditure is based on how long that MET intensity is performed. This explains why a person who weighs 150 lbs. exercising at level 5 on the stationary bike will burn the same calories as a person weighing 200 lbs. exercising at the same intensity for the same period of time. Based on size, the smaller exerciser is performing more relative work when the liters of oxygen are converted to milliliters per kilogram of body weight per minute.

During weight-bearing exercise the amount of bodyweight determines the work being performed. The person’s weight most often represents the vertical and horizontal resistive force that must be overcome to perform the movement. This variable becomes a factor when exercisers working out on this type of equipment lean on the guide rails or support bars to make the exercise easier. Any weight alleviated from the resistance to the movement and applied to the machine guide rails is not actually contributing to the vertical or horizontal component of work necessitated by running or climbing. If 30% of the body weight is removed from the leg’s resistance force, the resultant calories displayed by the machine are 30% higher than the actual number burned. Commonly, exercisers set the machine on high training levels and compensate by resting on the machine to manage the work rate. This causes people to perceive a caloric expenditure during the exercise that may be as much as 50% above what they actually burned.

Similar pitfalls exist for non-weight-bearing machines. The MET value determined by the selected training level is based on a default RPM speed (rotations per minute), normally about 70 RPM’s (numbers may vary). When exercisers select training levels that are too difficult they compensate by peddling slower, which negates the workload. Most machines are not technologically advanced enough to identify the change and recalculate the value, even though a light often flashes to signify a low RPM rate. Logically, most people should realize that if the exercise becomes easier by cheating, then it must not burn the same calories. However, most exercisers will acknowledge their work rate as consistent with the machine’s data display, which is often an over-prediction of actual calories burned.

When METs are applied to a person’s predicted or measured VO₂max, the amount of work they can tolerate becomes increasingly evident. The math required to convert VO₂max into METs is simple. One MET equals 3.5 ml · kg⁻¹ · min⁻¹, and relative VO₂max is expressed using the same units. Therefore, to identify a person’s maximum MET intensity capabilities, all one has to do is divide the VO₂max by 3.5 ml · kg⁻¹ · min⁻¹. Once this maximal MET value is identified, it can be used to determine the individual’s realistic energy expenditure capacity.

For example, if a 37-year-old male weighing 200 lbs. was identified through aerobic testing to have a VO₂max of 43 ml · kg⁻¹ · min⁻¹ his maximal MET intensity would be 12.25 METs.
If the individual wanted to lose weight, the length of time it would take can easily be figured out based on their respective capacity. A healthy person is expected to train at an intensity between 60% and 80% HRR or VO₂max. The individual’s VO₂max was 43 ml · kg⁻¹ · min⁻¹, or 12.25 METs.

\[
\frac{43 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}} = 12.25 \text{ METs}
\]

1 MET

I f t h e  i n d i v i d u a l  w a n t e d  t o  l o s e  w e i g h t, t h e  l e n g t h  o f
time it w ou l d  t a k e  c a n  e a s i l y  b e  f i g u r e d  o u t  b a s e d  o n
their respective capacity. A healthy person is expected
to train at an intensity between 60% and 80% HRR or
VO₂max. The individual’s VO₂max was 43 ml · kg⁻¹ ·
min⁻¹, or 12.25 METs.

60% x 12.25 METs = 7.35 METs
80% x 12.25 METs = 9.8 METs

The training intensity value suggests this individual
should perform aerobic exercise at a work rate between
7.35 and 9.8 METs. Assuming this person could sustain
the lower level for 30 minutes, the predicted aerobic
training contribution to weight loss can be calculated.

\[
7.35 \text{ MET} \times \frac{3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{1 \text{ MET}} = 25.7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}
\]

\[
25.7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \times 91 \text{ kg} = 2,338 \text{ ml} \cdot \text{min}^{-1}
\]

\[
2,338 \text{ ml} \cdot \text{min}^{-1} \times 30 \text{ min} = 70,140 \text{ ml}
\]

\[
70,140 \text{ ml} \times 0.001 \text{ L} = 70.1 \text{ L}
\]

\[
70.1 \text{ L} \times 5 \text{ kcal} \cdot \text{L}^{-1} = 350 \text{ kcal}
\]

Based on these findings, it would be realistic to expect
this healthy male individual to be able to burn 350 kcal
in an aerobic exercise bout in the early stages of the
training program. This prediction is very helpful
because the expected caloric expenditure helps to
identify the rate at which weight loss can occur via exercise
capacity and the amount of dietary adjustments that must
be made to compensate for the value. When clients
have a 12 MET capacity or higher, it is
easier to elicit the desired training response and reach
weight loss goals because they have a high capacity to
expend energy. When clients are deconditioned and present
MET capacities lower than 10 METs, it becomes increasingly
difficult to reach the same weight loss goals (12).

**METs & Daily Caloric Expenditure**

METs can also be used in the energy balance equation
to identify daily caloric expenditure. As stated above,
the average daily caloric expenditure is more relevant
than any single segment of high energy expenditure
with regard to weight management. Therefore,
identifying the mean energy expenditure value helps to
identify the need for additional physical activity if
weight loss and health are to be attained. In the same
way one can use food logs to identify the caloric intake
for a day, activity logs can be used to calculate the
caloric expenditure. Recording the activity and the
participation duration provides the data necessary to
calculate the daily energy expenditure. The chart below
is an example of a 24-hour activity recall for a 39-year-
old female weighing 152 lbs.

The example represents a total daily oxygen use of 475
liters of oxygen or 1.65 kcal · min⁻¹. Adding additional
activity to this individual’s lifestyle would increase the
calories expended per day. Simply increasing daily
oxygen use by an average of only one liter per hour
would increase the caloric expenditure by 120 kcal.
Encouraging more movement throughout the day can
dramatically enhance the likelihood for a successful
weight loss program (27). Additionally, those
individuals who attain a minimum expenditure of 1,000-
2,000 kcal per week from physical activity notably
increase their health and reduce their risk for disease
(47; 60).

**Using METs to Determine Daily Caloric Expenditure**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>MET</th>
<th>Kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 – 8:30 am</td>
<td>Showered and dressed</td>
<td>2.5</td>
<td>91</td>
</tr>
<tr>
<td>8:30 – 8:50 am</td>
<td>Ate breakfast</td>
<td>1.5</td>
<td>36</td>
</tr>
<tr>
<td>8:50 – 9:30 am</td>
<td>Worked w/traffic</td>
<td>2.0</td>
<td>97</td>
</tr>
<tr>
<td>9:30 – 9:40 am</td>
<td>Walk to office</td>
<td>3.0</td>
<td>36</td>
</tr>
<tr>
<td>9:30 – 10:45 am</td>
<td>Eat lunch</td>
<td>1.5</td>
<td>136</td>
</tr>
<tr>
<td>10:45 – 12:00 am</td>
<td>Work to desk</td>
<td>1.5</td>
<td>136</td>
</tr>
<tr>
<td>12:00 – 1:00 pm</td>
<td>Meeting</td>
<td>1.5</td>
<td>136</td>
</tr>
<tr>
<td>1:00 – 2:30 pm</td>
<td>Sat at desk</td>
<td>1.5</td>
<td>163</td>
</tr>
<tr>
<td>2:30 – 3:00 pm</td>
<td>Walk to other office</td>
<td>3.0</td>
<td>72</td>
</tr>
<tr>
<td>3:00 – 5:00 pm</td>
<td>Presentation (standing)</td>
<td>3.0</td>
<td>361</td>
</tr>
<tr>
<td>5:00 – 5:15 pm</td>
<td>Walk to car</td>
<td>3.0</td>
<td>54</td>
</tr>
<tr>
<td>5:15 – 5:35 pm</td>
<td>Drove home</td>
<td>2.0</td>
<td>48</td>
</tr>
<tr>
<td>5:35 – 6:00 pm</td>
<td>Washed-up and changed</td>
<td>2.5</td>
<td>76</td>
</tr>
<tr>
<td>6:00 – 6:45 pm</td>
<td>Ate dinner</td>
<td>1.5</td>
<td>82</td>
</tr>
<tr>
<td>6:45 – 11:00 pm</td>
<td>Watch TV</td>
<td>1.0</td>
<td>308</td>
</tr>
<tr>
<td>11:00 – 11:10 pm</td>
<td>Self-care</td>
<td>1.0</td>
<td>12</td>
</tr>
<tr>
<td>11:10 pm – 8:00 am</td>
<td>Sleep</td>
<td>0.9</td>
<td>576</td>
</tr>
</tbody>
</table>

Total Energy Expenditure 2,393
Mode

Physical activity can come from a variety of different modalities. Aerobic exercise activities aimed at improving CRF include numerous modes that are equally effective. The key factors are the duration, intensity, frequency, and the energy expended per session. This suggests that any continuous, rhythmic activity that utilizes large muscle groups can be included in the CRF program. The exercise or mode selected should be based on the client’s capabilities, interests, and experience. Each mode has advantages and disadvantages that should be evaluated and matched to the client. Identifying the activities that the client finds to be fun or most tolerable will help ensure compliance and adherence to the training prescription. If several modes are of interest to the client, the exercise prescription should include a mixture of activities. Commonly referred to as cross training, varying aerobic activities reduces boredom, risk of overuse injury, and emphasizes different muscle groups. These modes can even be combined in a single training session. Running, rowing, and biking, for instance, can each be utilized in 10 minute segments for a 30 minute workout. The variation in mode and musculature used allows for higher training intensity due to improved mental focus. Boredom becomes a factor in any long duration activity performed on a frequent basis. Therefore, varying the modes reduces the consequences of mental staleness commonly experienced with single-mode, steady-state training.

Systems of Training

Within any of the selected modes of aerobic training, different systems exist to elicit improved adaptation responses. Each system varies by specific factors that modify the intensity, such as speed, terrain, or resistance. These systems can be used independently or in a coordinated fashion depending on the goals of the program and the interests of the client. Some common systems include lactate threshold, or tempo training, cross-training, cardio-circuits, and Fartlek training.

Lactate Threshold Training

Lactate threshold training employs tactics that vary the amount of anaerobic contribution during the aerobic exercise bout. This technique is used by conditioned individuals to push training levels for improvements in stamina and lactate tolerance. Anaerobic, or lactate threshold, is the point where lactic acid production is equal to the rate of lactate clearance. This state uses contributions from both energy systems (aerobic and anaerobic), but the effects of the anaerobic system are accommodated via buffering mechanisms, which allow the steady-state heart rate to be maintained and the work to be performed without consequence. When the pace is increased beyond the lactate threshold, the contribution from anaerobic metabolism can no longer be compensated for via the buffering mechanisms used for lactate turnover. This causes lactic acid to accumulate, which increases discomfort, ventilation rate, and perceived exertion, eventually forcing the exerciser to slow down to a recovery pace, or to stop. It is suggested that exercisers should attempt to train using a pace at, or just below, lactate threshold for optimal cardiorespiratory adaptations (20; 24). This type of training is called “tempo training.” Many endurance athletes will use steady-state tempo pace on certain training days and then cross the lactate threshold, using intervals to push the energy system to tolerate greater demands and to improve VO2max on other days. Lactate intervals generally last between 2-5 minutes, depending on the intensity reached and the condition of the exerciser. This method of training should only be used by individuals acclimated to the training intensity (25).

Cross Training

Cross training, as mentioned earlier, utilizes different modes of exercise for aerobic improvements. In some cases, the mode of exercise varies by exercise session. In other cases, different modes of exercise are used within the same workout. The benefits include reduced risk of overuse of a particular muscle or group, reduced risk of boredom, utilization of different muscle groups for improved condition, and better mental focus during the exercise session. Cross training can also be employed in cycles to help maximize the efficiency of a particular mode of exercise. Over a 12-week training cycle, three different modes may be used for each four-week period. Biking can be used for the first segment, attempting to improve aerobic conditioning in the legs without impact, before switching to stair climbing in the second four-week period, and then jogging for the last segment of the cycle. This method allows adaptations specific to the mode to take place and encourages improvement in neural efficiency.

Cardio-Circuit Training

Cardio-circuit training is a type of aerobic conditioning that utilizes different exercise modalities and often total body contributions during the exercise session. Cardiocircuits require exercisers to perform steady-state aerobic activity with intermittent resistance training activities. A common example would be a parcour, which employs jogging at a set pace and stopping at designated locations along the route to perform calisthenics, pull-ups, push-ups, or other anaerobic activities, before continuing on the jog at the steady-state pace to the next activity stop. Parcours often
exist at local community parks. These courses can be mimicked in the fitness facilities by switching from aerobic activity to resistance training movements with only transitional rest. In most cases, an exercise will be selected for each body part and performed every three minutes during the exercise routine. Cardio-circuits work very well in the personal training environment because they can be used to address several facets of the exercise program in an on-going, aerobic-based exercise session.

Fartlek Training
Fartlek is Swedish for “speed play.” Fartlek training is essentially a type of interval training that uses steady-state pace with periodic variations in speed and grade. The biggest difference compared to standard interval training is the variation in speeds and distances used within the interval segment, along with the changes in the surface angle. Fartlek training uses flat surfaces, uphill running and sprints, and downhill over-speed segments at different intervals in between steady-state pace. The distances used and segment speeds will be determined by the goals of the training and the capabilities of the client.

Aerobic Training Considerations

Genetics
Participants in routine aerobic exercise are generally able to increase their VO2 max by 10-30% with an average improvement of approximately 15% (5; 6). The amount of improvement is dependent upon pre-training status, exercise tolerance, level of participation, and genetics. Of these factors, the largest variation is attributed to genetics, which accounts for as much as 35% of the differences (2; 28). This is largely attributed to adaptational responses in maximal cardiac output and oxygen extraction capabilities. Individuals with larger stroke volumes, greater concentrations of type I fibers, mitochondria, and capillaries, higher myoglobin concentrations, and more efficient neural and metabolic pathways show the greatest improvements (52; 73). Certain individuals are physiologically more efficient in aerobic pathways and therefore, present the most dramatic improvements in training (52; 74).

Age
Healthy, sedentary adults experience a decline of approximately 1% per year in maximal aerobic capacity. The combination of inactivity, weight gain, and age-related decline in muscle mass and maximal heart rate are all implicated in the loss of aerobic efficiency (4). In trained individuals, the rate of loss decreases in males to approximately 0.5% per year, but female aerobic decline remains consistent with their sedentary counterparts (1; 7; 63). Individuals who attain higher levels of aerobic fitness early in life and consistently work to maintain those levels will obviously experience higher values throughout their lifespan, thereby preventing the early onset of functional decline. When previously sedentary, older adults engage in aerobic activity, they experience similar improvements compared to younger individuals (10-20%) (72). However, due to their lower starting

~Key Terms~

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate reserve (HRR)</td>
<td>The difference between heart rate maximum and resting heart rate (Max HR-Resting HR).</td>
</tr>
<tr>
<td>Fartlek training</td>
<td>A type of interval training that uses steady-state pace with periodic variations in speed and grade.</td>
</tr>
<tr>
<td>Radiation</td>
<td>One of the body’s cooling methods in which heat from the body passes through the air into colder solids within close proximity.</td>
</tr>
<tr>
<td>Convection</td>
<td>The body’s process of cooling, in which heat from the body is transferred into the air.</td>
</tr>
<tr>
<td>Conduction</td>
<td>The process in which heat is transferred from the body to a colder object upon contact.</td>
</tr>
<tr>
<td>Evaporation</td>
<td>The process by which water is passed through the skin and is converted to water vapor, causing a cooling effect.</td>
</tr>
</tbody>
</table>
values, older adults have difficulty reaching high levels of aerobic fitness. The adaptations in older men and women are different, as older men show improvement in both maximal cardiac output and oxygen extraction from increased capillary and mitochondria density. Improvements in aerobic efficiency in older women are solely limited to improvements in oxygen extraction (33).

Environmental Factors
The body is subjected to stress from external factors, including the environmental conditions it is exposed to. Heat, humidity, and altitude all exert potential adverse effects on the body during physical activity. Heat provides considerable stress to the body’s internal environment because it increases the body’s thermoregulatory response. When the tissues contract, they produce heat, which must be released from the body to prevent dangerous elevation of core temperatures. The human body cools itself via four methods: radiation, convection, conduction, and evaporation. Radiation causes heat from the body to pass through air into colder solids within close proximity. It works in the same fashion that light from the sun warms the earth. Convection works in a similar way, but the heat is transferred into the air. When it is windy, heat is mobilized from the skin into the air that passes over the body. Conduction represents heat loss to a colder object that comes in contact with the body or heat transferred from deep tissues to the skin. Jumping into cold water illustrates this concept very well. In fact, heat loss to water is 25 times that of heat loss to air at the same temperature. The last method of heat loss is the primary defense used by the body to prevent overheating. Evaporation is the process by which water is passed through the skin and evaporated into the air, causing a cooling effect. Heat is also lost through respiratory water vapor. All four mechanisms cooperate to keep body temperature regulated.

If environmental conditions are hot, heat loss via radiation, convection, and conduction becomes less effective, or even halts. This leaves evaporation as the only functioning mechanism to remove heat from the body. The body begins to mobilize extracellular fluid to the skin for evaporation. This leads to dehydration, causing the water content of the blood to decrease. Exercise in the heat becomes more difficult as blood volume is reduced. The reduction in blood plasma makes the heart work harder, thereby making exercise more difficult, even though the pace remains the same.

This problem is exacerbated when heat combines with high humidity. When the humidity is high, the process of evaporation decreases significantly because the ambient air/water vapor pressure is consistent with that of the skin. Sweat is produced, but it cannot evaporate into the air. This forces the body to increase sweat rate and further contributes to water loss. Exercise in high heat and humidity can be dangerous, as it increases risk of heat illness and thermoregulatory shut-down.

Altitude
Altitudes will also affect aerobic performance. At higher altitudes, the oxygen concentration of air is lower, leading to a reduction in available oxygen that can be extracted during respiration. When physical activity is performed at higher altitudes, the stress becomes apparent as an individual’s respiratory and heart rates must increase to deliver the same amount of oxygen to peripheral tissues. Due to the progressive decline in the partial pressure of oxygen as elevations rise, the higher a person climbs, the more difficult it becomes to perform all activities, including breathing.
At extreme heights, such as Mt. Everest in Nepal, climbers have died from hypoxia as their blood oxygen concentrations drop into lethal ranges.

The disadvantage of altitude becomes an advantage when the body is acclimated to the environment. Slow progressions in activity at higher altitudes over several weeks cause physiological adjustments in hemoglobin and red blood cell concentrations that become advantageous upon return to sea level (14; 58). Many athletes train in Colorado to acclimate to the high altitudes. When they return to lower terrestrial levels, these athletes are better able to remove carbon dioxide, experience higher red blood cell concentrations, allowing for higher arterial oxygen levels and also increase muscle capillary and mitochondrial density (48). All of these factors improve aerobic performance.

**Acclimation to Heat**

Acclimation also occurs when the body is exposed to heat over an extended period of time. With ongoing exposure, the body makes physiological adjustments that provide greater heat tolerance. Sweat rate threshold decreases, while sweat production increases and expands the sweat distribution across a broader surface, allowing for greater evaporation (3). Correspondingly, plasma volumes increase to account for the improvements in sweat efficiency and the sodium concentration in sweat is reduced. The cardiovascular system also improves circulation and cutaneous blood flow to distribute more heat to the skin. These adaptations allow the body to more efficiently remove heat and enhance performance in hot environments.

**Gender**

Gender differences account for about a 15% disparity between VO2max measures in adult men and women. The physiological differences found between genders accounts for the discrepancy between maximal attainable values (34). Females have smaller hearts, lower stroke volume, lower hemoglobin concentrations, and less muscle mass relative to size. In addition, females maintain higher body fat values compared to men (49). During submaximal work at the same absolute VO2, females experience higher heart rates and higher cardiac output to compensate for the gender-related differences (67). Notably however, females do experience the same relative improvements to aerobic training as do men (21).

**Recovery**

Recovery needs to be a consideration any time the body performs work at elevated intensities due to damage of the tissue and changes in the cellular environment associated with increased metabolic activity. When exercise is performed at steady-state between 50-60% HRR, the metabolic conditions are not significantly disrupted. Hydrogen ion accumulation is attenuated via a slower rate of ATP hydrolysis, and a greater reliance is placed on lipid metabolism. Therefore, the resynthesis of high-energy phosphate (ATP), oxygen replenishment, and other mechanisms of recovery occur rather quickly with rest. When greater concentrations of lactate accumulate due to high volumes of glycogen and high energy phosphate utilization during high intensity work, the recovery process benefits from a longer, active cool down. Active recovery increases blood flow to the working myocytes to increase the rate of lactate transfer to neighboring aerobic muscle cells and increases mobilization of blood lactate to the liver, thereby increasing the rate of glycogen re-synthesis.

Muscle fatigue is another factor in recovery. Repeated bouts of exercise utilizing the same muscle groups can cause repetitive microtrauma in tissue not acclimated to the training, which increases requirements of rest for recovery. New exercisers can benefit from the one day on, one day off method, as progressions are steadily applied over an early training cycle. Individuals who train for aerobic performance often use six or seven consecutive days of training, which creates significant stress on the tissue. To compensate for the stress, variations in distance and speed are used to aid in recovery from one bout to the next. A full day of rest every 7-9 days is a generally accepted practice for individuals focusing on endurance performance enhancement. Using cross training techniques can also aid in recovery if multiple days are used without rest. Non-weight-bearing activities, such as swimming and biking, can be used to replace running, as the eccentric component of these activities, a major contributor to recovery requirements, is less intense than that experienced with running.

**Detraining**

The absolute cessation of aerobic activity has deleterious effects on aerobic endurance in a relatively short period of time. Trained individuals show a decline in aerobic performance within the first few weeks of detraining, due primarily to a reduction in blood plasma and consequent stroke volume diminution (17; 50; 57). If training is stopped for three or more weeks, oxygen extraction is reduced due to mitochondria loss in the muscle cell (18). When training volumes decrease, similar reductions are experienced, but at a slower rate. To prevent periods of reduced volume from affecting VO2max, intensities must be elevated to provide an overload stimulus on the system. Reductions in volume from 6 days to 3 days can be relatively negated by
increasing the intensity to maximal tolerable levels. For example, if a training volume of 4 days per week at 70% HRR for 30 minutes is reduced to two days per week, the intensity should increase to 80-85% HRR. This can be accomplished using interval training and lactate threshold steady-states. Even if the intensities cannot be maintained for long periods of time, the body must experience this level of stress to maintain its current condition.

**Preventing Common Overuse Injuries**

Inherent to any increase in physical activity is the risk of injury. Due to the repetitive nature of aerobic training, overuse injuries are not uncommon. These injuries often stem from a variety of factors. Some of the more common variables that contribute to problems include starting off too aggressively, abruptly increasing progressions, muscle imbalances and lack of range of motion, incorrect footwear, and uneven running surfaces. Common injuries associated with aerobic training include chondromalacia, plantar fasciitis, IT Band syndrome, acute low back pain, and shin splints.

**Chondromalacia**

Chondromalacia is a common injury associated with impact aerobic activities. The condition occurs from damage to the articular cartilage of the knee. It can be caused by trauma, overuse, poor joint alignment, or muscle imbalances. It often occurs from the knee cap rubbing against the lower end of the thigh, damaging the cartilage underneath the knee cap. The level of damage varies from slight surface abnormalities in the cartilage surface to complete wear of the tissue, exposing the bone. Chondromalacia can also occur from blunt trauma, which tears off either a small piece of articular cartilage or a large fragment containing a piece of bone. This often requires invasive surgery to fix.

Chondromalacia can be treated using closed-chain exercises that strengthen the medial quadricep, and other connecting structures at, and around, the joint. Non-impact aerobic exercises can be used for aerobic conditioning if the knee is not bent more than 90 degrees. Therapeutic modalities include rest, anti-inflammatory medication, and ice therapy. If these treatments fail to improve the condition, arthroscopic surgery may be used to smooth the surface of the articular cartilage and remove cartilage fragments that cause irritation.

**Plantar Fasciitis**

Plantar fasciitis is the most common cause of heel pain from aerobic activity. A flat ligament band connects the calcaneous to the toes, called the plantar fascia, which supports the arch of the foot. When the tissue becomes strained, it becomes swollen and irritated, causing pain in the heel or bottom of the foot when weight is placed upon it. The exact cause of the tissue damage is not known, but it is likely attributed to repeated small tears in the plantar fascia during normal stride when the plantar fascia stretches upon foot strike. Plantar fasciitis can be caused by a tight Achilles tendon, abrupt increase in repetitions from exercise, or improper arch support. Remedies for plantar fasciitis include stretching the fascia, myofascial release using a tennis ball or similar object, anti-inflammatory medication, massage, foot splints, arch supports, and rest.

**Iliotibial Band Syndrome**

Iliotibial band syndrome (ITBS) is common among runners and is responsible for more than 10% of all running-related overuse injuries. The injury occurs in the ligament that runs along the lateral aspect of the thigh, connecting the top of the hip to the lateral side of the knee. The tissue can become inflamed by uneven
Chondromalacia – Abnormal degeneration of the cartilage of the joints, especially in the knee, commonly associated with impact aerobic activities.

IT Band syndrome – An overuse injury, commonly associated with running, in which the iliotibial band running along the lateral aspect of the thigh becomes irritated due to the inflammation in the area.

Shin splints – Also known as medial tibial stress syndrome, which is a condition that is commonly associated with overuse and is characterized by pain and tenderness over the middle or lower part of the shin bone.


