Aerobic Training Program Design

Synonyms for “Aerobic Training”
- Aerobic training/exercise
- Endurance training/exercise
- Cardiovascular training/exercise
- Cardiorespiratory training/exercise
- Aerobic capacity = \( \dot{V}O_2 \) (dot over V omitted)
  \[ [\text{ml O}_2/\text{kg/min}] \]

Readings:
- NSCA text: Chapter 16 pp 389 – 406
- Course web site:
  - Physical Activity Guidelines For Americans 2008 - Fact Sheet

General Training Principles
- Specificity of Exercise
  - You must stress the cardiorespiratory system to produce adaptations in aerobic capacity
  - Resistance training is not a effective stimulus to produce significant increases in aerobic capacity
  - There is some transfer of capacity from one aerobic exercise mode to another, but it is not 100%
    - Swimming peak aerobic capacity in a trained swimmer will not be produced if swimmer runs, due to different muscle use pattern
Program Design Variables

1. **Mode**
2. **Intensity**
3. **Duration**
4. **Frequency**
5. **Progression**
6. **Variation**

More commonly known as: F.I.T.T.
- **Frequency**
- **Intensity**
- **Type**
- **Time**

Mode of exercise

- Variety of modes discussed in “Cardiovascular Activity Techniques” unit
- Select mode based on:
  - Training goal (“I want to run a 5KM race” vs. “I want to lose weight”)
  - Enjoyment preference (“I hate to swim”, “I find machines boring”, “I like the social aspect of group exercising”)
  - Equipment available, weather
  - Client physical characteristics (e.g., obese, knee injuries, etc.)

Terms, Abbreviations, Basic Formulae

- **Resting Heart Rate** = RHR
- **Maximum Heart Rate** = MHR
- **Age-predicted maximal heart rate** = APMHR = 220-age (most common formula)
- **Heart Rate Reserve** = HRR = APMHR-RHR
MHR

Use Age-predicted maximal heart rate (APMHR) equation:

\[ \text{APMHR} = 220 - \text{age} \]

- Error ±10-15 beats/min
- Client must not be using medication that affects HR
- Obese clients use: \[ \text{APMRH} = 200 - (0.5 \times \text{age}) \]

“Training Zone” “Target Heart Rate Range” (THRR) determined using:

1) Percent of APMHR
2) Karvonen Formula takes into account client’s resting HR

We use Heart Rate as an easy to measure indicator of aerobic work the body is doing.

We don’t have to measure VO\(_2\) while a person exercises.

True maximum method:
Graded exercise test (increasing intensity) to point where HR no longer increases

- Have physician clearance &/or presence
- Not typically done outside of training athletes
### Intensity of Exercise

**“Training Zone” by % APMHR**

**APMHR**

- **85% APMHR**
- **70% APMHR**

**Training zone = 70%-85% APMHR**

- For very low capacity clients: 55%-65% APMHR

**Target HR upper limit = APMHR(.85)**

**Target HR lower limit = APMHR(.70)**

**Resting HR**

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**EXAMPLE:**

- **30 yr-old client**
  - APMHR = 220-age = 220-30 = 190 beats/min
  - Target HR upper limit = APMHR(.85) = 162
  - Target HR lower limit = APMHR(.70) = 133

**THRR** (Target Heart Rate Range) = 133 to 162 beats / min

- = 22 to 27 beats / 10 sec

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**Intensity of Exercise**

**“Training Zone” by % APMHR**

**APMHR**

- **85% APMHR**
  - 75% VO$_2$ max

**70% APMHR**

- 55% VO$_2$ max

- 45% VO$_2$ max

**Resting HR**

So, a person training at 70% APMHR, is training at approximately 55% of VO$_2$ max

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**Intensity of Exercise**

**“Training Zone” by % APMHR**

**APMHR**

- **85% APMHR**
  - Age-Predicted Maximal Heart Rate (APMHR)

<table>
<thead>
<tr>
<th>%VO$_2$ max</th>
<th>%APMHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

**Relationship Between Percentages of VO$_2$ max and Age-Predicted Maximal Heart Rate (APMHR)**

**Low Capacity Client**

- 55% APMHR

**Optimum Heart Rate Zone**

**Maximum Heart Rate**

**Heart Rate Chart for Men**

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**Aerobic Training Program Design**
Intensity of Exercise
“Training Zone” by % APMHR

Intensity of Exercise
“Training Zone” by Karvonen (HRR) formula

EXAMPLE:
30 yr-old client, RHR = 70 beats/min
APMHR = 220-age = 220-30 = 190 beats/min
HRR = APMHR-RHR = 190-70 = 120 beats/min
Target HR upper limit = HRR(.85)+RHR
= 120(.85)+70 = 172 beats/min
Target HR lower limit = HRR(.50)+RHR
= 120(.50)+70 = 130 beats/min
THRR (Target Heart Rate Range) = 130 to 172 bpm
= 22 to 29 beats / 10 sec

Intensity of Exercise
“Training Zone” by Karvonen (HRR) formula

Intensity of Exercise
“Training Zone” by Karvonen (HRR) formula

Takes into account client’s resting HR

HRR (Heart Rate Reserve) = APMHR-RHR
Training zone = 50%-85% HRR

Target HR upper limit = HRR(.85)+RHR
Target HR lower limit = HRR(.50)+RHR

Measure RHR in bed after waking up in the morning, or after laying quietly for 15 minutes

APMHR

85% HRR

50% HRR

Resting HR

Heart Rate Reserve

Increasing aerobic work

Resting HR

THRR

Target Heart Rate Range = 130 to 172
bpm

= 22 to 29 beats / 10 sec

Trained client

Beginner client
Intensity of Exercise

Comparison of “Training Zone” by %APMHR & Karvonen formula

Intensity of Exercise

“Training Target Intensity” by Talk Test

Breathing rate will increase with intensity of aerobic exercise. You should exercise at an intensity that is just below the level at which you can no longer speak comfortably (i.e. When comfortable speech is just barely possible you are at the correct exercise intensity) (1,2).

Increasing aerobic work

Resting HR

APMHR

Can not speak comfortably
Comfortable speech is just barely possible

Aerobic Training Program Design

Intensity of Exercise

by Perceived Exertion

A 10 step OMNI Rating of Perceived Exertion (RPE*) scale has been used to gauge exercise intensity, and relate that perceived intensity to aerobic work intensity (1). The interpretation of the 0-10 scale is aided by illustrations.

Example: For a male, a 68% of VO2 max training level corresponds to a RPE of 5 (see also next slide)

At start of exercise program, check the training intensity HR target calculated using formula with client’s subjective assessment of intensity (talk test or perceived exertion) WHY?

EXAMPLE: 72 yr-old client exercises at APMHR?

70% APMHR

Resting HR

85% APMHR

For women
For men
aerobic training intensity
aerobic training intensity
RPE 3.5 – 5
RPE 4 – 5.5

RPE
% of VO2 max
RPE
% of VO2 max

3.5
58
4
58

4
92
5
88

5
92
7
89

Dr. Chalmers has found that some trainers prefer a 0-10 scale, such as the OMNI scale, to the Borg scale of 6-20.


A widely used Borg RPE scale also exists, and the Utter 2004 article table 2 also relates that scale to % VO2 max. The Utter benchmas has found that some trainers prefer a 0-10 scale, such as the OMNI scale, to the Borg scale of 6-20.
Intensity of Exercise

HR targets can be wrong.
70-85% APMHR may be:
• Way too hard for one person
• Too easy for another person
BUT…..
“Exertion does not lie”

RPE technique to set aerobic exercise intensity in:
Faster, Better, Stronger, Heiden, Testa, Musolf, pg 215-7

Intensity of Exercise

Faster, Better, Stronger, Heiden, Testa, Musolf, pg 215-7

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nothing at all</td>
</tr>
<tr>
<td>0.5</td>
<td>Very, very weak</td>
</tr>
<tr>
<td>1</td>
<td>Very weak</td>
</tr>
<tr>
<td>2</td>
<td>Weak</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat strong</td>
</tr>
<tr>
<td>5</td>
<td>Strong</td>
</tr>
<tr>
<td>6</td>
<td>Between strong and very strong</td>
</tr>
<tr>
<td>7</td>
<td>Very strong</td>
</tr>
<tr>
<td>8</td>
<td>Between very strong and very, very strong</td>
</tr>
<tr>
<td>9</td>
<td>Very, very strong</td>
</tr>
<tr>
<td>10</td>
<td>Maximal</td>
</tr>
</tbody>
</table>

RPE 2-3, ZONE 2 = Aerobic base, mild stress, good for beginners
RPE 3-5, ZONE 3 = Aerobic capacity zone, intensive aerobic/cardio-fitness zone
RPE 5-7, ZONE 4 = Aerobic-anaerobic transition (required zone for athletes only)
RPE 8-10, ZONE 5 = only for elite athletes

Intensity of Exercise

HR targets can be wrong.  

“An APMHR of 85% or more and peak RPP of 25,000 or more were both ineffective in identifying patients who put forth a maximal exercise effort (ie, peak RER, ≥1.10). Perceived exertion was a significant indicator (P=.04) of patient exertion, with a threshold of 15 (6-20 scale) being an optimal cut point.”

Exertion does not lie

Intensity of Exercise

RPE and HR targets can result in same outcomes.  
• 40 untrained males
• HR- and RPE-prescribed run training resulted in similar exercise intensity and performance outcomes over six weeks.
Intensity of Exercise

“Heart rate by itself is not a very meaningful measure. It must be in context with other measures. Impossible to base training on heart rate, too many variables affect it. 99% of the time RPE is a great window into stress and adaptation.”

Vern Gambetta Blog, June 11, 2012
http://www.functionalpathtrainingblog.com/archives.html

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Duration of exercise


- **Minimum** 2 hr 30 min/wk (150 min/wk) moderate intensity or 1 hr 15 min/wk (75 min/wk) vigorous intensity (or combination), at least 10 min episodes, spread throughout week (intensity defn next slide)
  - E.g. 5x/wk @ 30 min moderate exercise
- **Aim for** additional benefits with 5 hr/wk (300 min/wk) moderate intensity or 2 hr 30 min/wk vigorous intensity exercise (or combination)

**Durations over 10 min, spread through week, adding up to target time**

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Program Design Variables

1. Mode
2. Intensity
3. **Duration**
4. Frequency
5. Progression
6. Variation

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Duration of exercise


**Note the use of a “talk test” to judge intensity of exercise**

<table>
<thead>
<tr>
<th>Moderate Activities</th>
<th>Vigorous Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>(You can talk while doing this, but can’t sing)</td>
<td>(You can only say a few words without stopping to catch your breath)</td>
</tr>
<tr>
<td>✓ Aerobic dance</td>
<td></td>
</tr>
<tr>
<td>✓ Biking on level ground or with few hills</td>
<td></td>
</tr>
<tr>
<td>✓ Canoeing</td>
<td></td>
</tr>
<tr>
<td>✓ General gardening (raking, trimming shrubs)</td>
<td></td>
</tr>
<tr>
<td>✓ Sports where you catch and throw (baseball, softball, volleyball)</td>
<td></td>
</tr>
<tr>
<td>✓ Tennis (doubles)</td>
<td></td>
</tr>
<tr>
<td>✓ Using your manual wheelchair</td>
<td></td>
</tr>
<tr>
<td>✓ Using hand-cycles—also called ergometers</td>
<td></td>
</tr>
<tr>
<td>✓ Walking briskly</td>
<td></td>
</tr>
<tr>
<td>✓ Water aerobics</td>
<td></td>
</tr>
<tr>
<td>✓ Aerobic dance</td>
<td></td>
</tr>
<tr>
<td>✓ Biking faster than 10 miles per hour</td>
<td></td>
</tr>
<tr>
<td>✓ Fast dancing</td>
<td></td>
</tr>
<tr>
<td>✓ Heavy gardening (digging, hoeing)</td>
<td></td>
</tr>
<tr>
<td>✓ Hiking uphill</td>
<td></td>
</tr>
<tr>
<td>✓ Jumping rope</td>
<td></td>
</tr>
<tr>
<td>✓ Martial arts (such as karate)</td>
<td></td>
</tr>
<tr>
<td>✓ Race walking, jogging, or running</td>
<td></td>
</tr>
<tr>
<td>✓ Sports with a lot of running (basketball, hockey, soccer)</td>
<td></td>
</tr>
<tr>
<td>✓ Swimming fast or swimming laps</td>
<td></td>
</tr>
<tr>
<td>✓ Tennis (singles)</td>
<td></td>
</tr>
</tbody>
</table>
**Duration of exercise**


**Minimum of:**
- 30 min moderate intensity, at least 10 min episodes, 5 days/week (= 150 min/wk)
  - i.e. 5x/wk @ 30 min moderate exercise
- 20 min vigorous intensity, 3 days/week (= 60 min/wk)

**Aerobic Training Program Design**

**Frequency of exercise**

# training sessions / week


- Exercise “spread through week”, adding up to target time


- Moderate intensity, 5 days/week
- Vigorous intensity, 3 days/week

**Program Design Variables**

1. Mode
2. Intensity
3. Duration
4. **Frequency**
5. Progression
6. Variation
Frequency of exercise

Note that with aerobic training (unlike resistance) it is common that once a client is beyond the beginner stage, there is often no rest day between 2 training days of the same tissues, to allow 4+ workouts/wk.

Rest days most likely placed after higher volume (intensity &/or duration) day.

Program Design Variables

1. Mode
2. Intensity
3. Duration
4. Frequency
5. Progression
6. Variation

Progression

- By increase in exercise intensity, frequency, &/or duration
  - Typically, frequency, &/or duration are increased first
  - Later, intensity must also be increased to continue to stimulate aerobic capacity
- General Rule: Limit increases to 10% per week
  - E.g. 20 min run increased to 22 min next week

Maintenance of aerobic fitness

- Maintain exercise intensity & duration
- Frequency can be decreased (no less than 2x/wk)
## Program Design Variables

1. Mode
2. Intensity
3. Duration
4. Frequency
5. Progression
6. Variation

## Variation

- **Cross training**: Variety in exercise mode (across or within sessions)
- Modifications in exercise intensity & duration once base aerobic capacity is developed
  - LSD (Long Slow Distance) – see next slide…
    - Lower intensity and greater duration
  - Pace/Tempo Training - see next slide…
  - Interval Training - more after next slide…
    - Brief (3-5 min) high intensity (≥ lactate threshold) and longer lower intensity exercise (1:1 – 1:3 work:rest)

## LSD (Long Slow Distance)

**Vern Gambetta Blog: Feb 7, 2012**

“Long slow distance was a term coined to describe running at a steady pace to develop the aerobic base. Unfortunately as it evolved the emphasis was on SLOW. This is a huge mistake. The result was proficiency at running slow for a prolonged period. This has little carryover to racing, remember the goal of training is to prepare to race. The emphasis in this method should be on long steady distance. Select a degree of effort that allows the runner to run a steady effort for the duration of the distance with good running mechanics. This type of training needs to be a means to an end. Unfortunately for many runners it has become an end to itself.”

## Tempo Training

Intensity is generally between:
- High Intensity Interval Training
- Steady state aerobic work

For more information see the article:
**Optimal Tempo Training Concepts for Performance and Recovery**
August 27, 2014 by Derek M. Hansen
Overview: Energy System Development (ESD) is the cardiovascular component of Core Performance training programs. The intensity of the workouts is broken up into three different heart rate zones.

How It Works: Forget everything you currently believe about cardio work. Forget keeping your heart rate in some “fat-burning” zone. Forget plodding along with the vague goal of increasing the distance you can plod. Instead of training like a plow horse, start training like a thoroughbred. You’ll only work at the same effort level for an extended period of time, as you would with traditional cardio exercise on regeneration or recovery days. But you’re going to take the time you typically spend on cardio and develop the ability to perform at a more intense level. You’ll improve your energy levels, gaining physical strength and stamina without investing additional time.

Interval Training – The usefulness of interval training for recreational athletes is now being explored...

Effects of high intensity training and continuous endurance training on aerobic capacity and body composition in recreationally active runners

The aim of the study was to examine the effects of two different training programs (high-intensity training vs. continuous endurance training) on aerobic power and body composition in recreationally active men and women and to test whether or not participants were able to complete a half marathon after the intervention period. Thirty-four recreational endurance runners were randomly assigned either to a Weekend-Group (WE, n = 17) or an After-Work-Group (AW, n = 17) for a 12 week-intervention period. WE weekly completed 2 h 30 min of continuous endurance running composed of 2 sessions on the weekend. In contrast, AW performed 4 30 min sessions of high intensity training and an additional 30 min endurance run weekly, always after work.

……...

Only the improvements of VO2 peak were significantly greater in AW compared with WE. Both groups completed a half marathon with no significant differences in performance (p = 0.63). Short, intensive endurance training sessions of about 30 min are effective in improving aerobic fitness in recreationally active runners.

Interval Training –The science of designing interval training workouts

Buchheit & Laursen, High-Intensity Interval Training, Solutions to the Programming Puzzle.

Part I. Sports Medicine, 2013, 43:5, 313-338
Part II. Sports Medicine, 2013, 43:10, 927-954

High-Intensity Interval Training (HIIT) can stress (i.e., train):

- Aerobic system (“…one of the most effects means of improving cardiorespiratory and metabolic function…”)
- Anaerobic system
- Neuromuscular and musculoskeletal systems
Interval Training – The science of designing interval training workouts. Buchheit & Laursen 2013

**1: WORK INTERVAL INTENSITY**
**2: WORK INTERVAL DURATION**
**3: RELIEF INTERVAL INTENSITY**
**4: RELIEF INTERVAL DURATION**
**5: NUMBER OF REPS IN A SERIES**
**6: NUMBER OF SERIES**
**7: BETWEEN SERIES RECOVERY DURATION**
**8: BETWEEN SERIES RECOVERY INTENSITY**
**9: EXERCISE MODALITY**

RESTING LEVEL OF WORK

**Interval Training – Tabata Training**

Tabata intervals:
- Eight, 20 second all out exercise bouts (170% VO\text{max}) + 10 sec rest
- **Total workout duration=4 min!**
- Work time = 2 min 40 sec (does not meet requirement in Buchheit & Laursen 2013 of several min at high work level)
- 5 days/week, 6 weeks

Tabata results:
- VO\text{2max} increased by 7 ml*kg\(^{-1}\)*min\(^{-1}\)
- Anaerobic capacity increased significantly

Steady state aerobic training:
- 60 min at 70% VO\text{2max}
- 5 days/week, 6 weeks

Steady state aerobic training results:
- VO\text{2max} increased by 5 ml*kg\(^{-1}\)*min\(^{-1}\)
- No change in anaerobic capacity

Interval Training – and fat loss

An appropriate pattern of work and relief cycles

WILL

produce a progressive increase in fatigue and RPE

over the duration of the session

Interval Training – and fat loss

![Image](image-url)
Interval Training – and fat loss
CHALMERS’ 5-MINUTE DISCUSSION OF FAT REDUCTION

“The effect of regular aerobic exercise on body fat is negligible; however, other forms of exercise may have a greater impact on body composition. For example, emerging research examining high-intensity intermittent exercise (HIIE) indicates that it may be more effective at reducing subcutaneous and abdominal body fat than other types of exercise.”

Interval Training – and fat loss


Interval Training – and fat loss


DO INTERVAL TRAINING TO LOSE FAT
(or develop your photo editing skills to make it look like you lost fat)
Exercise Dose (intensity, duration & freq)

Is it proven to be effective?

Aerobic Training Program Design 57

Duration of exercise

Current US guidelines recommend that most adults seek to engage in at least moderate-level exercise for ≥150 minutes a week (eg, 30 minutes a day for 5 days a week). Barlow and colleagues argue that their data support widespread prescription of higher doses of exercise even among low-risk adults. To date, though, there are no large-scale randomized trials supporting exercise recommendations. One small trial of sedentary obese women found that as little as 72 minutes of exercise per week could lead to potentially meaningful improvements in physical fitness. A large-scale observational study of >400,000 adults suggested that even as little as 15 minutes of exercise per day predicted a 14% reduction in risk of death. Some of us worry that that people might misinterpret public health recommendations to mean that anything less than 150 minutes of exercise per week is of no value and therefore not worth pursuing at all. To add to the confusion, we now are aware of data suggesting that some adults might be harmed by exercise. It is critically important to avoid oversimplifications that overlook nuanced quantitative and qualitative issues:

Increase Your Chances of Living Longer

1. You don't have to do high amounts of activity or vigorous-intensity activity to reduce your risk of premature death. You can put yourself at lower risk of dying early by doing at least 150 minutes a week of moderate-intensity aerobic activity. (Chalmers emphasis added)

Source: http://www.cdc.gov/physicalactivity/everyone/health/

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Exercise Dose (intensity, duration & freq)

VERSUS.....

Can you do less than 150 min/week and still get benefits??

Aerobic Training Program Design 60
**Exercise Dose (intensity, duration & freq)**

**Aerobic Training Program Design**

- Mortality Risk reduced by <51 min/wk, < 6 miles/wk, 1-2x/wk (not by <6mph)
- Risk has similar level up to 120-175 min/wk, 13-19 miles/wk, 5x/wk.
- Risk INCREASES (still less than sedentary) for ≥176 min/wk, ≥ 20 miles/wk, ≥ 6x/wk.

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**Exercise Dose (intensity, duration & freq)**

**Chalmers' CONCLUSIONS**:

- Less than current PA recommendations reduces risk of all-cause mortality (and so IS useful).
  - Current PA recommendations **may** reduce risk of all-cause mortality further.
    - Very high levels of PA may, or may not, increase risk compared to moderate exerciser.

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Exercise Dose (intensity, duration & freq) and Health Outcomes

Do the standard exercise recommendations really work for our sedentary population?

- FINDINGS...
- Time spent sitting was independently associated with total mortality, regardless of physical activity level. This means: Even when adults meet physical activity guidelines, sitting for prolonged periods can compromise metabolic health and increase mortality.
- Reduction of too much sitting, or too few breaks from sitting, should be included in physical activity and health guidelines.
- Excess sitting should be considered a health hazard
- Reduction in overall sedentary time is desirable.
- Breaking up sedentary time, even without a reduction, is beneficial.

- Spending more than four hours a day sitting more than doubles your risk of dying from or being hospitalized for heart disease, even for those who exercise more than two hours (!) per day.
- Perhaps due to other unhealthy lifestyle factors associated with the sitting, or due to elevated inflammation resulting from the sitting (blood levels of C-reactive protein were elevated in the prolonged sitters).

Hamilton et al., Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior Current Cardiovascular Risk Reports, Volume 2, Number 4, 292-298, doi: 10.1007/s12170-008-0054-8

Do the standard exercise recommendations really work for our sedentary population?
Exercise Dose (intensity, duration & freq) and Health Outcomes