Anaerobic and Aerobic Conditioning: Training Methods & Determining Intensity

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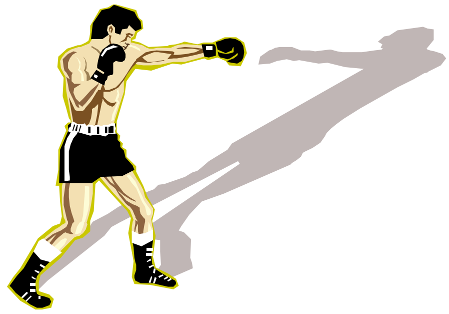
Anaerobic & Aerobic Conditioning

Training Methods & Determining Intensity

By Robin Marc Orr

Introduction



There are numerous training methods used for aerobic and anaerobic conditioning and, although only several will be discussed, you should find that many other methods are derived from, or similar to, those discussed.

Most references divide the methods of training into two broad categories, these being distance and speed. Distance training revolves around developing an aerobic base of fitness and conditioning, with speed work obviously improving running speed.

Intensity provides another means of dividing training into categories. Ranging from a simplistic low through to high intensity, to a more physiological view involving lactate thresholds and MVO_2 training.

Continuous Running

Continuous running (or training) involves training at a steady - pace, maintained for a long continuous period. Wilt (68) divides continuous running into two categories, these being;

- ***continuous slow - running***[*9*16] also known as the ***uniform method,***[*20] ***long slow distance (LSD)***,[*2*7*8*9*11*12] ***low intensity running***[*27] or ***long easy distance,***[*8] and
- ***continuous fast - running***[*9*16] also known as ***high intensity continuous,***[*2*11*27] ***long solid distance***[*8] or ***up - tempo training.***[*12]

Continuous Slow - Running.

As the name implies this form of training requires the maintenance of a continuous slow pace with the objective being distance rather than speed.[*2] The exact duration of the session varies depending on the references used. Some references show a minimum of a 30 minute duration, whilst others state that the session should last at least 45 minutes to an hour.[*7*8*11*13*28]

The greatest debate comes over training intensities. In regards to maximal heart rates (MHR) most references agree on an intensity of around 60 % to 80 %,[*2 *11*12] however some go as high as 80% to 85 %.[*9*16] When determining intensities via VO_{2max} the variations are even greater ranging from 57 % VO_{2max}[*11] to 80% VO_{2max}.[*6] From a Karvonen or heart rate reserve (HRR) perspective, a training intensity of 70% to 75% HRR[*9 *16] is deemed appropriate.

This form of low intensity training develops both aerobic 'base', through aerobic adaptations (like improved fat metabolism), as well as improving basic musculoskeletal conditioning. This development of the musculoskeletal system is an important step in the preparation for the more demanding speed work.[*8*9*12] It also develops the mental discipline required for longer distance events.

Continuous Fast - Running.

The difference between continuous fast - running and continuous slow running is fairly clear, the pace is faster therefore the duration is shorter.[*9*16] The aim of this faster pace is to train at, or near lactate threshold in order to develop maximal aerobic power,[*11] leg speed (stride frequency or stride rate), leg strength and muscular endurance.[*2]

The training intensity should be set at around 85 % to 95 % MHR[*2*9*11*16] or 80 % to 95 % HRR.[*9*11*16]

Both forms of continuous running do have one area for concern and this comes from the continuous skeletal impact that can lead to muscle and joint injury.[*2]

Fartlek Training

Fartlek comes from the Swedish word meaning 'speed play'.[*1*2*6*7*9*16*26*27*28] It is thought to have been developed by Scandinavian and German runners around the 1930s[*2 *20] and involves alternating fast and slow speeds during a session.[*2*6*7*9*16*26*28] It is said to have been the forerunner of Interval training.[*9*16] By varying speeds, not only is variety given to continuous training, but both the aerobic and anaerobic systems can be developed.[*9*16]

Most references mention the use of undulating terrain and variety as the key aspects to a fartlek session, with the actual proportions of fast and slow speeds left up to the runners and how they feel.[*6*7*8*9*16]

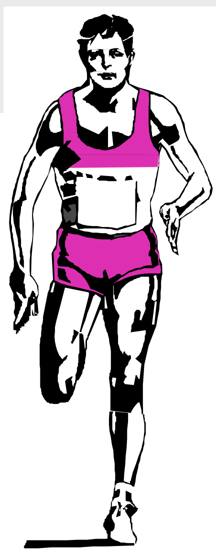
The following example shows a 'planned' fartlek session.

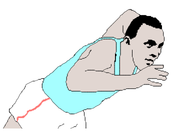
300 M	Slow to moderate pace	60 % to 70 % pace
100 M	Surge	80 % to 90 % pace
300 M	Slow to moderate pace	60 % to 70 % pace
100 M	Surge	80 % to 90 % pace
600M	Slow	50% to 60 % pace
150M	Moderate pace	70 % to 80 % pace
50M	Sprint	90 % to 100 % pace
Repeat		

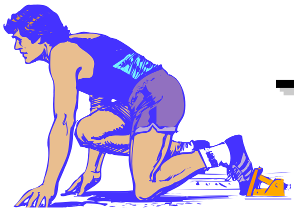
Although the example is 'planned' with pace indicators, the athlete still performs what 'they - feel' as their 80 % effort.

An example of an 'free - style' session may look like this.

Jog	3 Light Posts
Surge	1 Light Post
Jog	6 Light Posts
Surge	2 Light Posts
Repeat.	







Interval Training

The concept of interval training, introduced by Gerschler and Reindell,[*17] has a strong physiological backround.[*2] It involves interspersed work sessions of high intensity and recovery periods.[*1*2*6*7*8*9*11*16*20]

The session is divided into work or exercise intervals[*6*9*11*16] and relief intervals.[*6*9*11*16] The aim of the session is to achieve a near maximal to maximal effort (heart rate should be from 85 % to 100 %[*9*11*16]) during the work intervals.

By breaking the session into short intense bouts of exercise, more total work can be achieved when compared to a single maximal effort.[*2*6*7] Astrand et al.(1960) found that a high workload, trained via intervals for an hour, resulted in exhaustion after only nine minutes of continuous training at the same intensity.[*6]

Fox and Mathews have identified the predominant variables that determine training parameters for interval work, these being :[*2 *8*9*11*16]

- ***Rate and distance of work interval.***
  The rate and distance of interval work depends on the energy systems to be trained. They can be either long duration at low intensity, moderate duration at moderate intensity or short duration at high intensity.[*9*16]

  There are various methods for determining work rate. One involves reaching a THR (near maximal to maximal) whilst another, devised by Wilt, involves time over distance.

Event	***&***	***Distance***	***Work Rate***	
Run 50m	or	Swim 15m }	1 1/2	seconds slower than fastest
Run 100m	or	Swim 25m }	3	from a moving start
Run 200m	or	Swim 50m }	*5*	
Run 400m	or	Swim 100m }	1 to 4 secs faster than	
			a. time for 400m of best 1.6 km time (400m swim) or	
			b. time for average 400m run or 100m swim	
Run 600m - 1200m		}	3 to 4 secs slower than	
or		}	a. time for 400m of best 1.6 km time (400m swim) or	
Swim 150m - 300m		}	b. time for average 400m run or 100m swim	

From Fox and Mathews.[*9*11*16]

- ***Number of reps***

  The number of repetitions performed depends on the distance of the work intervals. A guide is to complete between 1.5 to 2 miles (2.4 to 3.2km) through the session.[*9*16] Therefore shorter intervals require more repetitions whereas longer intervals require less.

	Short Interval	***Long Interval***
Duration of Work	5 - 30 Secs	2 - 5 Mins
Repetitions	5 - 20	3 - 12

The example comes from Rushall and Pyke (1993).

- ***Duration of relief interval***

  There are two methods of determining the duration of the relief interval.

  1. *Heart rates.*

     The average guide has the heart rate returning to between 120 and 140 bpms[*9*11*17] or dropping 40 to 50 b.p.m.'s from the training heart range[*12] before the next interval begins.

  2. *Rest Ratios.*

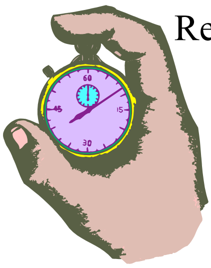
     Rest ratios supply a more mathematical approach to recovery with the duration of the relief period associated with the duration of the work interval.

# Long intervals,	800m+	1 / 1 or 1 / $^{1}/_{2}$ ratio.
# Moderate intervals,	400m - 600m	1 / 2 ratio
# Short intervals,	up to 400m	1 / 3 ratio[*9 *16]

- ***Type of activity during relief interval***

  Several factors determine whether the relief interval is active or passive in nature.[*9]

  1. *Rest - Relief*



Rest - relief is predominantly used for those training the ATP - PC_R system as rest allows a greater phosphagen recovery. Like wise those training their aerobic system who desire minimal lactic acid accumulation have a greater lactic recovery with a rest relief protocol.[*9*16]

  2. *Work - Relief*

     Lactic acid partially blocks ATP - PC_R recovery. This means that by actively moving and maintaining a higher lactate level, there will be less ATP - PC_R recovery thereby placing a greater reliance on the lactic system.[*9*16]

There are several 'race pace' training methods and, although slightly different in both definition and training regimes, have the same purpose.............to prepare for a race.

Race Pace

Race pace or ***tempo***[*26] training has the athlete training at the pace required for an event. For example the athlete wants to run five kilometres in 20 minutes. The pace they need to run at is 15 km/hour or 4min a kilometre. This pace would then be the athletes training pace.

As this pace is usually faster than their current pace, great strain would be placed on the athlete if they where to complete the event distance. Intensity (and possible injury) can be down - graded through the use of repetitions.

Due to the common use of repetitions, race pace training is associated with ***repetition training***[*27] which Rushall & Pyke (1990) define as ***" Units of work completed at competition quality."***[*27] Some authorities however have slightly different interpretations of repetition training.

The interpretation of repetition running given by Fox et al. (1993) is divided into two methods. The first involves running repetitions of 1/2 race distance at race pace or slightly faster.[*9*16] The second involves running 3/4 race distance at a slightly slower than race pace.[*9*16] The amount of repetitions completed should allow one and a half to two times the distance of the event to be completed.[*9*16]

These guidelines plus the recommended length of intervals given by Fox et al. (1993), being repetitions of 1.4km to 3.2 km would indicate that this form of training be for the shorter aerobic events up to 6.5 or so kilometres.[*9*16] Another variation, given by deVreis & Housh (1994), has the repetition bouts lasting only 30 to 90 seconds. The intensity is up to 5 seconds faster than a 400m race pace with the total distance of the repetitions equal to, or less than, eight kilometers.[*7]

Although interpretations may differ, most authorities agree that recovery is to be more complete in repetition training than interval training.[*9*16*27] Fox et al. recommend a guideline of ***" ..a recovery heart rate well below 120 beats per minute."***[*16*27] A ratio comparison provided by deVreis & Housh (1994) shows a 1:5 work / rest ratio.[*7]

Time Trials

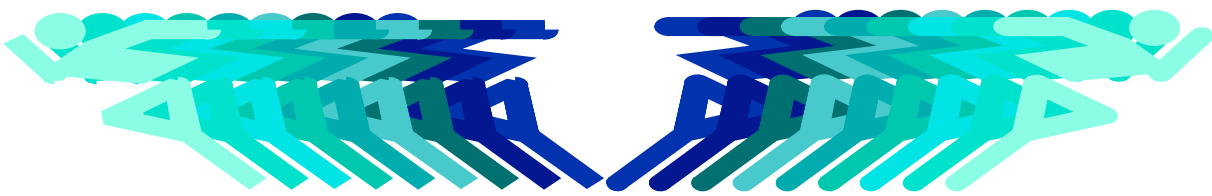
Some of the forms of training previously mentioned rely on established guideline times, for example ; *3 to 4 secs slower than time for average 400m run* used by an athlete performing *600m - 1200m* Intervals. As the athletes improve the timing guidelines need to re - evaluated in order to avoid the guideline times from becoming under valued. The best means of re - evaluating these times is through competition itself or ***time trials***.[*8*31]

Time trials also provide progressive evaluation. As times improve the effect of the training regime can be evaluated and adjusted. Improved times can also provide motivation and target goals.

A note by Tulloh (1994) suggests that time trials be performed when "*...you are physically rested and mentally prepared.*".[*31] If the time trial comparisons are to be accurate diurnal variations should also be considered.

Conclusion

There are numerous other training regimes performed by coaches or found in reference material. Most will most likely be variations of the methods discussed, again with the emphasis on either endurance, speed or a combination of both.



Determining

Intensity

Heart Rates

The most widely used method of determining exercise intensities involves the use of ***target heart rates (THR)***. However before we discuss methods of calculating target heart rates the 'base' or 'starting - points' for these calculations needs to be determined The first and most accurate utilises the ***maximal heart rate***, yet establishing a true maximal heart rates is stressful and potentially dangerous, hence ***predicted maximal heart rates (PMHR)*** are used.

Predicted Maximal Heart Rate.

Unless true maximal heart rates are known, predicted maximal heart rates are utilised in calculating THR. The calculation for determining PMHR is shown below.

Calculation of PMHR.

$$PMHR = 220 - Age, \quad OR$$
$$PMHR = 210 - (0.65 \times Age)$$ [*10]

Initially the PMHR used only age as a determining factor. Now however, more and more programmers are including gender differences into the equation.

Calculation of PMHR.

$$PMHR = 220 - Age \text{ (Males)}$$
$$PMHR = 225 - Age \text{ (Females)}$$ [*4]

The premise of a slightly higher 'base' point of 225 for females can be attributed to their gender orientated higher heart rates.

Percentage of Maximal Heart Rate.

With PMHR now established THR can be determined. If the athlete is required to work at 60 % of their predicted maximal heart rate, their PMHR value would be multiplied by 60 % or 0.6.

Calculation of a THR.

$$THR = 220\text{-}Age(PMHR) \times 60\%$$
$$THR = 220 - 25 \times 0.6$$
$$THR = 195 \times 0.6$$
$$THR = 117 \text{ b.p.m.}$$

This method of determining heart rates, although quick and easy does not cater for an individuals fitness levels and hence, a 25 year old male who has never before trained, has the same 60 % PMHR THR value as a highly trained athlete of the same age.

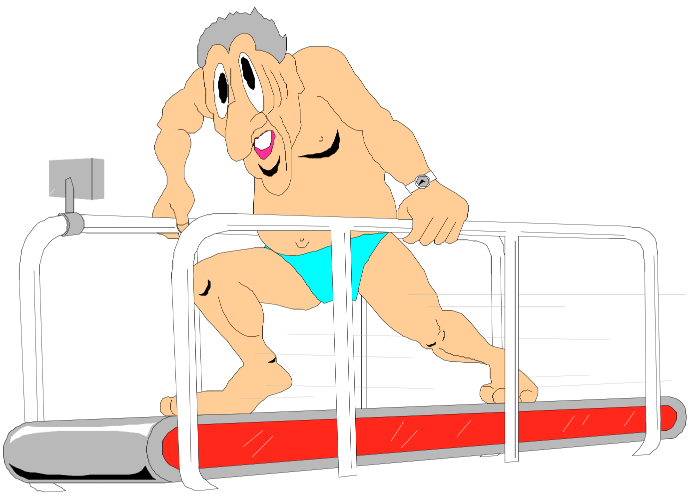
Karvonen Formula.
In order to including a subjects fitness level into the calculations, the ***heart rate reserve (HRR)*** becomes useful. The HRR can be defined as the difference between MHR (or PMHR) and ***resting heart rate (RHR or HR_{rest}).***[*1*2*3*6*7*11*15*20] Through determining HRR the 'percentage - of - intensity' is more accurate as it does not include the body's sustaining heart rate. This method, made popular by Karvonen et al. (1957), is also known as the 'Karvonen' formula.[*20]

The calculation involves subtracting RHR from their MHR (PMHR), thus giving HRR, then multiplying the figure by the training intensity required. Once this figure is obtained HRR is then added back on.

Calculation of a THR utilising the Karvonen formula.

$$THR = (MHR - HR_{rest}) \times 60\% + HR_{rest}$$
$$THR = (195 - 70) \times 0.6 + 70$$
$$THR = (125\ (HRR)) \times 0.6 + 70$$
$$THR = 75 + 70$$
$$THR = 145\ b.p.m.$$

As can be seen, when comparing the two methods of determining heart rate the results are greatly varied. The method of dividing training intensity directly with PMHR resulted in 117 b.p.m. training range whilst the method utilising the HRR resulted in a 145 b.p.m. training range. As the first method is more simple, quick and, as can be seen above, conservative, it is the most popular of the two methods for beginners and / or large groups of people.



R.P.E. Scale

As heart rates require a means of pulse taking and monitoring, a simpler, more user friendly means of determining exercise intensity was needed, hence ***the rate of perceived exertion (RPE) scale*** was devised.

RPE Scale.

The rate of perceived exertion (RPE)[*2*6*7*11*15] or ***perceived rate of exertion (PRE)***[*3] ***scale*** was developed by Dr Gunner Borg[*1*2*6*7*11*15] and as such is also known as the ***'Borg' scale***. It revolves around a scaled interpretation of how the athlete feels. The original scale rated from 6 to 20. The revised scale rates from 1 to 10.

Original Scale	
6 - 8	**Very, very light**
9 - 10	**Very light**
11-12	**Fairly light**
13 - 14	**Somewhat hard**
15 - 16	**Hard**
17 - 18	**Very hard**
19 - 20	**Very, very hard**

Modified Scale	
0	**Nothing**
0.5	**Very very weak**
1	**Very weak**
2	**Weak**
3	**Moderate**
4	**Somewhat strong**
5 - 6	**Strong**
7 - 9	**Very strong**
10	**Very, very strong (Maximal)**

RPE Scales. Adapted from Borg (1952), Pollack & Wilmore (1990) and Wimore & Costill (1995).

Talk Test

The talk test in itself is very similar to the RPE and rates subjects by their audio speech or responses to questions. This provides instructors with an effective means of determining a client's intensity for themselves, immediately, with no equipment.

Light Intensity:	**Can talk comfortably**
Moderate to Hard:	**Can answer questions but does not wish to hold a prolonged conversation.**
Very Hard (Anaerobic):	**Cannot answer questions / 'out - of - breath'.**

Metabolic Equivalent

The metabolic equivalent or MET is based on how much oxygen we consume, which in turn is related to how much energy our bodies require. The MET measuring method uses 'rest' as a base or 1.0 level. 1.0 MET is the amount of oxygen we consume at rest and equates to 3.5ml of oxygen per kilogram of body weight per minute.[*1*2*3*7*11*15*16*19] An activity, such as walking at a 7km/hour pace, utilises approximately 6.5 METS[*2] or 6.5 times more oxygen than at rest.

METS are also used in conjunction with calories. In terms of caloric value, 1MET is equivalent to between 1.0 cal / min[*3] and 1.2 cal/min[*1] depending on various references. As many 'Cardio Theatre' machines portray either METS or calories per hour, one can be worked out from the other and visa versa.

1. A 72 kg male running at 15 km / hour burns 1143 calories per hour (Lifestride HR9500).
2. The subject completes 5 km in 20 minutes burning 381 calories.
3. To determine the metabolic equivalent 381calories are divided by the 20 minutes work or the 1143 calories per hour are divided by 60 minutes.
4. The result is calories burnt per minute. This figure is then divided by 1.2 (The caloric value for 1MET)
5. The MET value is given at 15.8 METS.

The entire working is shown below.

Calories burnt in total	**/**	**time**
381	**/**	**20**
	= 19 cal per min	
Cal per min	**/**	**Caloric value for MET**
19	**/**	**1.2**
	= 15.8 METS	

by reversing the equation and inserting METS, calories burnt can be determined.

METS	**x**	**Caloric value MET**
15.8	**x**	**1.2**
=	**19 cal per min.**	
Time worked	**x**	**Cal per min**
20mins	**x**	**19**
	= 380 calories *	

* Slight variation due to rounding off.

Intensity Comparisons

As was discussed earlier, different methods of determining intensity produced different results. Where does the MET stand in this comparison ?

As different trainers and athletes use different methods of determining their intensities an integration is often called for. The table below provides a basic comparison between the various methods.

Grading	%PHRM	%Karvonen	METS	RPE (1-10)
Very light	< 35 %	< 30 %	< 3.9	<1
Light	35 -59%	30 -49%	4.0 - 8	1 - 2
Moderate	60 - 79 %	50 - 74 %	8.1 - 9.9	3 - 5
Heavy	80 - 89%	75 - 84 %	10. - 11.9	6 - 7
Very heavy	90+ %	85 + %	12 +	8 - 10

Table 1. Intensity comparisons. [*1*2*6*7*11*15*16]

The table above has been modified utilising a variety of sources, it is interesting to note that almost all sources were slightly different.

The Fat Burning Zone.

The fat burning zone is claimed to be a training intensity zone between 60 - 70 % of the predicted maximum heart rate[*45] or similar depending on the references you use.
The theoretical reasons behind this argument are found in the fact that the lower the exercise intensity, the greater the percentage of energy requirements met by fat. Most references state that at these lower intensities more fat is 'burned' in comparison to carbohydrates. The primary reason is that fat requires more oxygen to burn and more oxygen is available at lower intensities. This would agree with the RER which has a higher ratio of fat being burnt at lower intensities. With an RER value between 0.76 and 0.8 sitting at complete rest is the closest we can get to burning 100 % pure fat. This is the portion of information most people see and straight away decide to train at low intensity. Why then train at all if we burn more fat doing nothing ?

- **Problem**

The zone disregards the total amount of calories burnt. - What would you prefer 60 % of $5 or 40 % of $10 ?

Example 1:
A 72 kg male walks at 7km / hour and burns 234 calories over a 30 minute walk at 6.5 MET.
Because the subject is training at low intensity, approximately 60 % of the calories burnt comes from fat and 40 % from carbohydrates. This means that ***140 calories comes from fat.***

Example 2:
The same male runs at 15 km / hour burns 569 calories over a 30 minute run at 15.8 MET.
Now working at a higher intensity only approximately 40 % of the calories 'burnt' comes from fat, which equals ***227 calories of fat***.

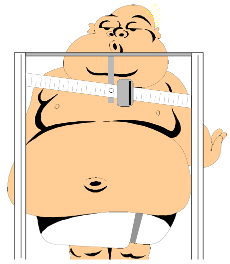
This shows that not only are more 'fat calories burnt' but more importantly more total calories. If you remember fat loss also comes from creating a calorie deficit or using more than you eat.[*46] With this in mind which of the above examples complies more readily ?

- **Positives of the FBZ.**

There are benefits of low intensity training however. If you were to train longer in your 'fat burning zone' than in your 'cardio zone', a greater percentage of fat would be burnt from a higher total value.[*47]

Example 3:
In relation to Example 2 - For an equivalent amount of fat calories to be burnt at the lower intensity the subject would have to continue at the 7km / hour pace for around 48 minutes. In total the subject would still only burn 375 calories as opposed to the 569 calories burnt at the higher intensity. However the same amount of fat would be burnt.

An important point to consider is that it is easier for beginners to train at low intensity, and therefore longer, as opposed to short hard sessions or long hard session. Another consideration is those with injuries or those who would rather avoid the higher impact of running can effectively participate in a lower intensity programme that goes for a longer duration.[*46 *47]



- **Summary**

So if time is set, work at a harder intensity (but one that allows you to complete the session), if time is unlimited go slower for longer.

Considerations.

Perhaps the most important consideration is 'diet' or rather eating habits. A client should avoid 'dieting' but rather adjust eating habits, gradually and hopefully permanently, to be more nutritionally sound (as is discussed more under a nutritional module).

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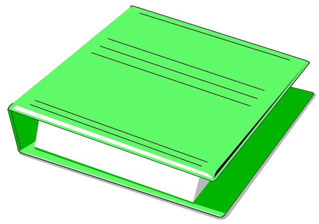

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