Chapter 3 Running Training

The three most difficult decisions to make for running training are '**what**', '**how much**', and '**how**' to train.

What to Train?

Under the Principle of Specificity, 'what' to train is comparatively simpler to decide. Although cycling and swimming can also improve cardiorespiratory (aerobic) and muscular endurance, they can never match the efficiency of running training, when taking the muscle groups and movements patterns involved into consideration.

How Much to Train?

This can be further divided into 'how much' to train 'in a session' and 'in a week'. Taking marathon training as an example, research results suggest that an average of 60 km/week is sufficient if the target time is just finishing the race in 3 to 4 hours. Even for better athletes who want to finish the race around 2:40, 90 to 150 km/week should also be sufficient. However, if the target is finishing the race in 2:20, then it may be necessary to train more than 200 km/week. Nevertheless, there are still some exceptions. For instance, Steve Jones (UK) trained only an average of 80 miles/week (about 128 km/week) when he set the new world marathon record of 2:08:05 at that time.

How much to train in a week depends on the actual running event (full marathon, half marathon, 10K or shorter) and how many sessions a runner can allocate for running training in a week. Since the total mileage required for marathon training is high, it is better to aim at shorter distances if the time available for running training is really the main concern.

How much to train in a week also depends on the purpose of running training. Based on research data, most people start running first for health and fitness purposes, and then later for competitions and performance when their levels of health and fitness have been improved.

Running for Health and Fitness

The World Health Organization (WHO) suggests that for health purpose:

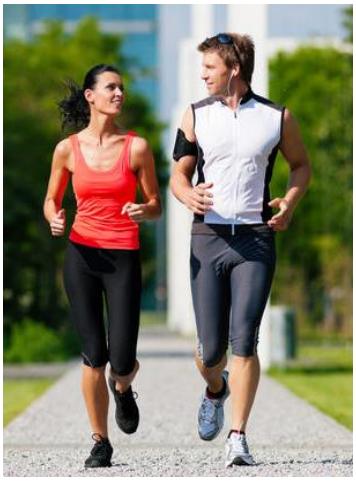
- **Children and adolescents** aged 5-17 years old should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least 3 times per week.
- **Adults** aged 18-64 years should do at least 150 minutes of moderate-intensity aerobic physical activity or 75 minutes of vigorous-intensity aerobic

physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity. (2 minutes of moderate-intensity activity counts the same as 1 minute of vigorous-intensity activity) For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity.

- Guidelines for adults are also applicable for people who are 65 years and above, pregnant, or disabled. However, when people of these groups cannot do the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow.

Definition of Moderate- and Vigorous-intensity Activity

Moderate-intensity activities expend 3.0 to 5.9 times the amount of energy expended at rest (i.e., 3.0 to 5.9 METs). A person doing moderate-intensity aerobic activity can talk, but not sing, during the activity. The energy expenditure of vigorous-intensity activities is 6.0 or more times the energy expended at rest (i.e., 6 METs or higher). A person doing vigorous-intensity activity cannot say more than a few words without pausing for a breath.



Distance and Speed to Run

With reference to the 'Compendium of Physical Activities Tracking Guide' produce by Ainsworth et, al. (2011), moderate-intensity activity can range from brisk walking at a speed of 2.5 mph (i.e., 4 km/h and equivalent to 3.0 METs) to jogging at a speed of 4 mph (i.e., 6.4 km/h and 6.0 METs).

For adults to do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week, it is equivalent to accumulate at least 2.5 × (150 ÷ 60) × 1.6 = 10 km to 4 × (150 ÷ 60) × 1.6 = 16 km of mileage. If it is not possible to run every day, then the mileage should be distributed evenly on at least 3 days (better on alternate days) throughout the week as much as possible, to avoid overtraining and running injuries. Besides, adults with lower fitness levels should exercise closer to the lower boundary of moderate-intensity activity.

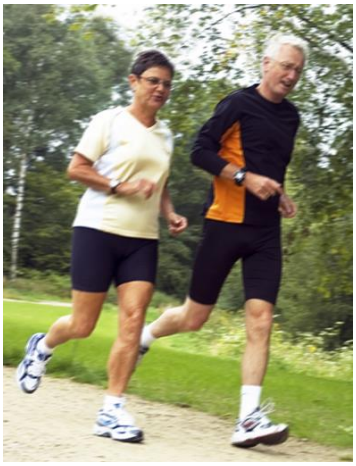
On the other hand, adults with higher fitness levels should run at 4 mph (i.e., 9:13/km or 3:43/400 m) or faster if they prefer more vigorous activity. Similarly, the mileage should be distributed evenly on at least 3 days (better on alternate days) throughout the week as much as possible. In addition, they can also use an equivalent combination of moderate- and vigorous-intensity running training approach.

For beginners and those with lower fitness levels, accumulating at least 150

minutes of moderate intensity running activities throughout the week is only an optimum goal. They can start running at a much lower intensity. They can even progress from walking to brisk walking, and then alternate with jogging, and finally to jogging or running. On the other hand, people with much higher fitness levels can accumulate more than 300 minutes (i.e., 20 to 32 km) moderate-intensity running or 150 minutes (i.e., 10 to 16 km) vigorous-intensity running throughout the week.

How Much is Too Much?

Although some animal's studies suggest that extreme workload or strenuous activities may lead to increased risks of coronary heart disease, there is still not enough scientific evidence to conclude that such kind of workload or activities is hazardous to the health of endurance athletes training for ultra-distances.



How to Increase Training Volume and Intensity?

Increasing training volume and intensity 'progressively' is important for participants of all health and fitness levels. Although there is no 'gold standard' for how to increase training volume and intensity progressively, sedentary people and those with lower fitness levels should start with moderate-intensity aerobic activities (e.g., brisk walking), and to avoid vigorous-intensity activities (e.g., running). People with even lower fitness levels may have to start with easier activities (e.g., leisure walking) or a combination of easy- to moderate-intensity activities.

When increasing the workload of the activities, duration of each moderate intensity run and the number of training sessions in a week (i.e., frequency) should be increased first, before increasing the intensity of the runs. Besides, attention should also be paid to the relative amount of work increased throughout the weeks. For example, increasing 20 minutes per week is much safer for a person who walks regularly for 200 minutes per week (an increase of 10%) than increasing the same amount of work for another person who walks only for 40 minutes per week (an increase of 50%).

Recommendations for Beginners

Beginners and those with lower fitness levels should aim at running a total of 10 km per week at first. Each run may range from 2 to 4 km and the runs should be conducted on 3 alternate days in a week. For those with higher fitness levels or being more active in the previous years, they may accumulate a total of 20 km per week, running 4 to 8 km each time on 3 alternate days in a week. If physical fitness or condition allows, it is always better to run at higher intensity (i.e., faster speed) to save time and prepare for more intensive training in the future.

Recalling my experience in leading those Marathon Running Clinics for the universities from 2007 to 2020, many participants had been sedentary for more

than 20 or 30 years. Some of them even had difficulty in jogging 2 laps (i.e., 800 m) for the warming up. Instead of asking them to run continuously, I usually ran 100-m fast-slow repetitions with them at a pace of 30-40 s/100 m or slower for the fast portions, and at even slower place for the slow portions. I also asked them to run just behind me and not to overtake me on the way. In this manner, most participants could finish 10 repetitions of 100-m fast-slow intervals (i.e., 2000 m) without too much discomfort. Some of them might even go for another set of similar fast-slow repetitions after a brief rest.

The Rationale of Interval Running

As early as 1960's, some pioneers in sports physiology (such as Åstrand, et. al and Christensen, et. al) had already found (on bicycle ergometer and treadmill) that subjects could sustain longer at the same intensity if the workout were conducted intermittently. For example, Christensen, et. al found that when the speed of the treadmill was 20 km/h (i.e., around 2:06 marathon pace), a subject could only run continuously for 4 minutes (covering about 1300 m) before exhaustion. At the end of the workout, his blood lactate concentration was 16.5 mM (normally about 1 mM at rest). However, if the workout was conducted intermittently by running 10 seconds and resting 5 seconds, the subject had run 20 minutes within a 30-minute period (covering 6670 m), and his blood lactate concentration was only 4.8 mM at the end of the workout.

Åstrand, et. al also found that the longer the work intervals, the subject would be more exhausted even if the rest intervals were proportionally extended. For example, under the same workload of 350 watts, if the workout was conducted intermittently with 3 minutes work and 3 minutes rest, a subject could work for 30 minutes in 1 hour and was totally exhausted at the end of the workout. If the workout was conducted as repetitions of 30-second work interspersed with 30-second rest, the subject had also worked for 30 minutes in 1 hour but was not that exhausted. His blood lactate concentration at the end of the workout was only 2.2 mM, which was just slightly higher than that at rest (1.0 mM) but was very much lower than that obtained when the work was conducted continuously for 9 minutes (16.5 mM) or as 30-minute intermittent work (13.2 mM).

Therefore, it is not difficult to see why interval running can be a much better approach for sedentary people or beginners of lower fitness levels, provided that the fast intervals are short (e.g., around 30 seconds or 100 m). Participants can usually run more at the same intensity. On the other hand, many beginners joined their friends or buddies (who had been training for years) when they first started their running training programs. Even their buddies had reduced their speeds for the continuous runs, most beginners still needed to further reduce their speeds or even stop completely after a

while due to cardiorespiratory or muscular fatigue. This will certainly impair their self-confidence and motivation to continue with their running training. In such case, interval running may be considered for this kind of beginners.

Exercise Progressively to Running

If 'health' is the major concern of running training, based on the guidelines from WHO and the conversions shown before, running 10 to 16 km per week (equivalent to 25 to 40 laps on a standard track) can be sufficient, provided that the mileage is evenly distributed as much as possible in a week (better to run every day or every other day). Even aiming at higher levels of fitness (if not concerning too much about competitions or performance times), accumulating 20 to 32 km per week can also be sufficient. Beginners of lower fitness levels may also start from interval running before transiting to continuous running after their fitness have been improved.

Running for Competitions and Performance

Unfortunately, there is still not any guidelines from the authorities (e.g., IAAF) about running training for competitions and performance. Coaches and athletes have been using various approaches for running training and whether a particular approach is 'successful' or not is often determined solely by the achievements of athletes using the approach without too much attention paid on the rationale behind. The following paragraphs will try to discuss middle- and long-distance running training in a more scientific and reasonable manner based on current research findings.

How to Train?

Up to this moment, 'what' and 'how much' to train have been discussed. Besides, some suggestions have also been given for running training concerning health and fitness. However, 'how' to train is comparatively complicated to understand because it involves at least the topics of training methods (e.g., continuous running, interval running, constant speed running, varied speed running, acceleration running, fartlek, hill running and resistance training, etc.) and training intensity. This chapter will focus only on determining the 'intensity' of running training.

Traditional Approach to Running Training

Coaches and athletes today mainly design their optimal running training programs based on their own experiences and knowledge in sports science. For middle- and long-distance running training, it has long been accepted that raising the maximum oxygen consumption (**VO_2max**, also known as maximal oxygen uptake or maximal aerobic capacity) and lactate threshold (also knowns as anaerobic threshold) of athletes may improve their running performance. Traditionally, low-intensity, high-mileage (volume) approach such as LSD (long slow distance) or low-intensity, high-repetition interval running has been used to improve the VO_2max of endurance athletes.

In addition, it is also quite common for coaches and athletes to use 'target heart rate' to determine the intensity of their running training. However, I do not agree too much with using heart rate to determine the intensity of training because it can be interfered by too many factors such as emotions, drugs, and rest. Besides, the calculation of target heart rate must base on maximal heart rate (e.g., 80% HRmax). Unfortunately, it is exceedingly difficult for ordinary athletes to know their 'actual' maximal heart rates without assessment in the laboratory. Maximal heart rate formulae are population dependent and certain formula such as HRmax = 220 – age does not even have scientific research data to back up.

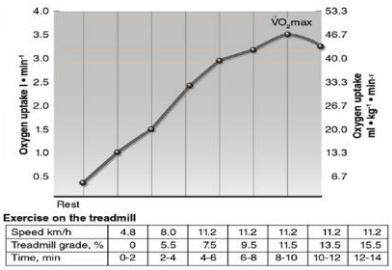
Another approach to determine training intensity is using %VO_2max (percent VO_2max). Unfortunately, assessment in the laboratory is also required to obtain the 'actual' VO_2max of an athlete. Besides, equipment such as portable gas analyzer which is expensive and not easy to purchase may also be needed and worn by the athlete when %VO_2max must be used to determine the intensity of training.

My Running Training Approach

Research results indicate that VO_2max, lactate threshold, and running economy are the three most important variables which affect endurance (aerobic) performance. Totally, they can explain more that 70% of the difference in distance running performance among athletes.

Maximum Oxygen Consumption (VO_2max)

VO_2max refers to the maximum amount of oxygen that can be consumed by the body during vigorous physical activities. VO_2max is about 45 ml/kg/min for an adolescent who is not regularly active. For 5000 m runners who can finish the race in 18 minutes, they will normally have VO_2max of 60 ml/kg/min. Most elite long-distance runners have VO_2max values of 70 to 80 ml/kg/min or higher.



Exercise on the treadmill

Speed km/h	4.8	8.0	11.2	11.2	11.2	11.2	11.2
Treadmill grade, %	0	5.5	7.5	9.5	11.5	13.5	15.5
Time, min	0-2	2-4	4-6	6-8	8-10	10-12	12-14

VO_2max is mainly limited by the rate of oxygen transported and is 70 to 85% related to maximal cardiac output. This is not difficult to understand since energy expenditure and demand for oxygen increases as the speed of running increases. Therefore, athletes must have extremely high VO_2max to become world class distance runners. Research has shown that,

VO_2max (ml/kg/min) **= 3.5 × Speed** (km/h)

Based on this formula for calculation, to finish 5000 m in 20 minutes (i.e., at a speed of 15 km/h), the athlete must have a VO_2max of 3.5 × 15 = 52.5 ml/kg/min. To finish 5000 m in 16 minutes (i.e., 18.75 km/h), the athlete must have a VO_2max of 3.5 × 18.75 = 65.63 ml/kg/min. And for world class elite

athletes who can finish 5000 m in 13 minutes (23.08 km/h), they must have VO_2max of 3.5 × 23.08 = 80.78 ml/kg/min. From the above calculations, it is obvious that VO_2max is undoubtedly a determining factor for distance running performance.

Nevertheless, although it can be observed within a group of athletes with various running abilities that the higher their VO_2max values, the better their running performance; within a group of athletes with similar running performance, their VO_2max values can have great differences. For instance, Alberto Salazar (USA, 2:08:13), former world record holder for men marathon had a VO_2max of 76.0 ml/kg/min and Derek Clayton (Australia, 2:08:34) who had similar running performance, only had a VO_2max of 69.7 ml/kg/min. On the other hand, although Graig Virgin (USA, 2:10:26) had a much higher VO_2max of 81.1 ml/kg/min, his marathon performance was obviously not as good as Alberto Salazar and Derek Clayton.

From the examples above, within a group of athletes with similar running abilities, VO_2max alone is not sufficient to distinguish among their running abilities. VO_2max can only reflect the ability of an athlete to consume oxygen for energy production during vigorous activities. Athletes with low running economy waste extra energy when running (poor running mechanics leading to unnecessary muscular tensions and movements) so that running performance cannot be enhanced even though their VO_2max values are remarkably high.

Running Economy

Running economy refers to energy expenditure at a particular (submaximal) speed. At the same running speed, athletes expending more energy have lower running economy. Athletes with higher running economy consume less oxygen and use less energy at the same speed as their opponents and can sustain that speed for a longer period of time.

In addition to running mechanics, factors affecting running economy also include wind resistance, elasticity and hardness of road surface, weight and design of running shoes, stiffness of the legs, shape of the calves and size of the feet, etc. Among these factors, running mechanics and running shoes are the two most controllable ones by the runner.

Athletes with higher running economy can run at lower %VO_2max at any speed. Therefore, it is always better to focus on **vVO_2max**, a variable combining VO_2max and running economy, rather than looking at VO_2max alone.

Minimal Velocity at Maximum Oxygen Consumption (vVO_2max)

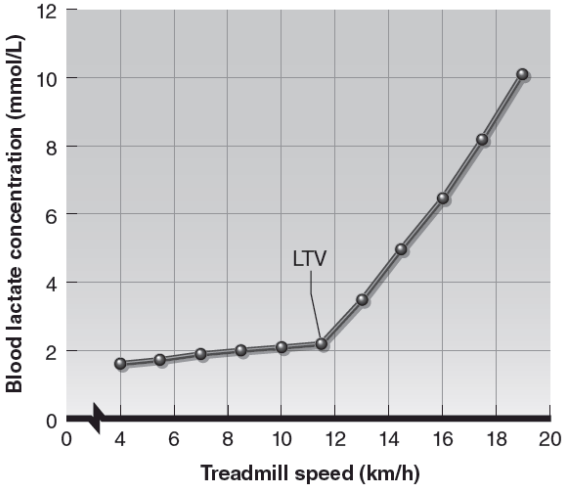
vVO_2max is the minimal velocity at maximum oxygen consumption. It is a

variable combining VO_2max and running economy, and vVO_2max can predict running performance within a group of athletes with similar running abilities more accurately than using VO_2max alone. Running performance of athletes is poor if their running economy is low even though their VO_2max is high. On the other hand, athletes with higher vVO_2max also have higher running economy and their running performance will be better even though their VO_2max values are similar with others.

Research results showed that vVO_2max can efficiently predict running performance of athletes from 1500 m to full marathon. 30 seconds to 3 minutes of intermittent running with a 1:1 work-rest ratio can effectively raise the vVO2max of athletes. Besides, running economy and lactate threshold will also be raised at the same time when vVO_2max has been improved. Furthermore, high-intensity running can raise vVO_2max better than light-intensity, high-mileage running. Research has also pointed out that vVO_2max can be estimated through a 6-minute full-effort run.

Lactate Threshold

Lactate threshold is another popular topic for investigation between 1970 and 1990 in addition to VO_2max. When running at or below lactate threshold (also known as anaerobic threshold) speed, blood lactate level remains steady. However, once lactate threshold speed is exceeded, blood lactate rises suddenly and tremendously, reflecting that certain metabolic byproducts (but not lactate or lactic acid) has also been rising remarkably at the same time, and eventually lower running performance.



Research shows that lactate threshold for untrained subjects is around their 60% VO_2max. For trained athletes, their lactate threshold can be as high as their 75-90% VO_2max. Besides improving VO_2max and vVO_2max, another purpose of running training is to raise lactate threshold speed (or velocity) because athletes always feel more comfortable when running at or below their lactate threshold speed, and thus can sustain longer at that speed. (The lactate threshold speed for most athletes is close to their 10-mile racing speed.)

Since VO_2max is limited by maximal cardiac output (70 to 85% related) and maximal cardiac output = maximal heart rate × stroke volume, and maximal heart rate decreases 1 beat/min each year after 20 years of age, maximal cardiac output and VO_2max also decrease with age. Therefore, improving lactate threshold speed and running economy are particularly important for senior or masters athletes, in addition to raising VO_2max and vVO_2max.

Traditionally, moderate-intensity long-distance running and tempo running at close to lactate threshold speed (lasting 20 to 30 minutes) have been used for improving lactate threshold speed. However, current research also indicates that high-intensity training (i.e., at speed between lactate threshold and vVO_2max), vVO_2max training, and short-distance full-effort sprints can improve lactate threshold speed more efficiently than traditional approaches.

It has long been ignored how the neuromuscular control may have affected the body's resistance to fatigue. Therefore, some experts suggest that high-intensity, high-quality runs (e.g., short-distance full-effort sprints) may help to comfort the 'central governor' so that it will let the locomotor and cardiorespiratory systems continue working under fatigue condition.

%VO_2max for Different Running Events

Research studies suggest that results for all Olympic endurance events are determined above 85% VO_2max. Certainly, most of the events also require athletes to extend their ability to resist fatigue under anaerobic metabolism. In general, the %VO_2max for different middle- and long-distance races are listed as follows:

Events	%VO_2max
Marathon (42.195 km)	75 to 85
10K and 15K	90 to 100
3K and 5K	Close to 100
1500 m, 1 mile and 2K	100 to 115

With this information in mind, athletes of different middle- and long-distance running events may select their 'major' speed (intensity) for running training with reference to the %VO_2max speed during the races.

6-min Time Trial

It has been mentioned earlier that the 6-min full-effort run can be used to estimate vVO_2max (i.e., 100% VO_2max speed). Then, different %VO_2max speeds can be calculated from the estimated result. When using interval running to improve vVO_2max, each fast portion should last from 30 seconds to 3 minutes, using a 1:1 work-rest ratio or shorter rest period. The total distance of the fast portions should cover 3 to 4 km.

Taking an athlete who had covered 1544 m in 6 minutes as an example, 6 minutes covering 1544 m is equivalent to a speed of 1544 ÷ (6 × 60) = 4.29 m/s. Using this speed to run 100 m requires 100 ÷ 4.29 = 23.31 seconds. Therefore, 4.29 m/s is also equivalent to a speed of 23.31 s/100 m.

If this athlete wants to conduct a 200-m interval run, then he/she may try
12-20 × 200 m, 46.6 s each, jog 45 s between each.

If this same athlete wants to conduct a 600-m interval run, then he/she may try
4-6 × 600 m, 2:19.9 each, jog 2:20 between each.

If this athlete wants to conduct an 800-m interval run, he/she may also try
3-5 × 800 m, 3:06.5 each, jog 3:00 between each.

However, if this athlete wants to conduct a 1000-m interval run, he needs 3:53.2 to run each 1000-m portion. If the purpose of the run is to improve vVO_2max, then 1000 m may be too long for him/her at the current fitness level. (If anyone wants to conduct 1000-m interval to improve vVO_2max, he/she must be able to finish 1000 m in 3 minutes, which has already been the level of elite athletes who can finish a 5000 m race in 14 to 15 minutes.)

Training for 1500 m and Longer Races

For 1500 m and longer distances, training for vVO_2max and lactate threshold speed are particularly important. However, training for maximal speed (e.g., maximal sprints for 50 to 100 m) should not be overlooked. This kind of maximal sprinting practice can enhance the functions of the neuromuscular system so that movements can be executed in a more relaxed and coordinated manner when running at the race pace, eventually improving running economy. Moreover, athletes with better speed also have more choices when applying race strategies at world class competitions.

For example, in the Olympic men 5000 m and 10000 m races, the final lap speed is normally under 1:00/400 m (i.e., 15 s/100 m). Even for the women races, the final lap speed is often below 1:06/400 m (i.e., 16.5 s/100 m). Taking the current men marathon world record (2:01:39) as another example, the average speed is 1:08/400 m or 17 s/100 m. For the women world record (2:14:04), the average speed is 1:16/400 or 19 s/100 m. So, speed is especially important in any race.

Therefore, training for vVO_2max, lactate threshold speed, and maximal speed are undoubtedly important for athletes of 1500 m and longer races. Coaches and athletes should distribute these kinds of practice in their training programs proportionally according to the actual characteristics of their running events. Furthermore, uphill and downhill running, acceleration running, varied speed running, time trial and specific strength training should also be introduced at proper time in their training programs to strengthen their racing capacities.

Training for 1500 m and 1 Mile

Since 1500 m and 1-mile races are conducted at 100 to 115% vVO_2max, athletes of these events should emphasize in vVO_2max training (i.e., practices at speed between 100 to 115% vVO_2max). If an athlete can train for three days in a week (better on alternate days), vVO_2max (i.e., 100% VO_2max speed) training should be conducted on 1 to 2 days. Speed and speed endurance training (particularly at 105 to 115% vVO_2max) or maximal speed training should be conducted on the remaining day(s).

Training for 5K and 10K

Since 5K and 10K races are conducted at close to 100% vVO_2max and 90 to 100% vVO_2max respectively, vVO_2max training is also an important component in the training programs. When compared with 1500 m athletes, the work distance for 5K and 10K athletes in interval running programs would be longer. When compared with 10K athletes, 5K athletes should work more at

vVO_2max or faster speeds (e.g., 105% vVO_2max). Similarly, 10K athletes should work more between 90% vVO_2max and vVO_2max speeds.

If an athlete can train for three days in a week (better on alternate days), vVO_2max training should be conducted on at least 1 day. Speed and speed endurance training or lactate threshold speed training should be conducted on the remaining days. When conducting speed and speed endurance training, 5K athletes should emphasize more on practices at 105 to 115% vVO_2max while 10K athletes should emphasize more on practices at 90 to 95% vVO_2max. Moreover, 10K athletes should also conduct more lactate threshold speed training than 5K athletes.

Training for Half-marathon and Marathon

Marathon races are usually conducted at 75 to 85% vVO_2max. For instance, elite marathon athletes usually run at 85 to 86% vVO_2max paces throughout their races. For athletes who can finish a marathon between 2:46 and 3:12, they are often running at 75 to 76% vVO_2max paces in their races.

Any practice that can improve lactate threshold speed (i.e., practices at speeds between lactate threshold speed and vVO_2max) is beneficial to half-marathon and marathon performances. For half-marathon athletes, running speed during most of their training sessions should also be faster than marathon athletes.

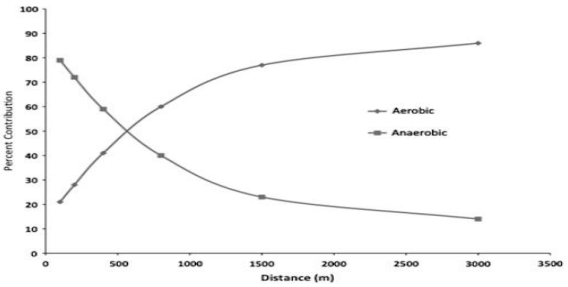
The higher the level of competitive athletes, the higher they are running at their $\%vVO_2max$. Therefore, vVO_2max training is also important for them. However, when compared with 5K/10K athletes and 1500m/1-mile athletes, training for improving lactate threshold speed is far more important for half-marathon and marathon athletes.

If an athlete can train for 5 days in a week, 1 day should be reserved for vVO_2max training or speed and speed endurance training. Another 1 to 2 days should be reserved for interval training that can improve lactate threshold speed and the remaining days should be used for continuous running that can improve lactate threshold speed.

When conducting continuous running training, if the distance exceeds 20 km, the running speed should be just under lactate threshold speed (e.g., 2.5 to 5% below). If the distance exceeds 30 km, the speed can even be slower. However, if the distance is within 20 km, the running speed should be close to or a little faster than lactate threshold speed. The shorter the running distance, the higher the speed that should be above lactate threshold speed.

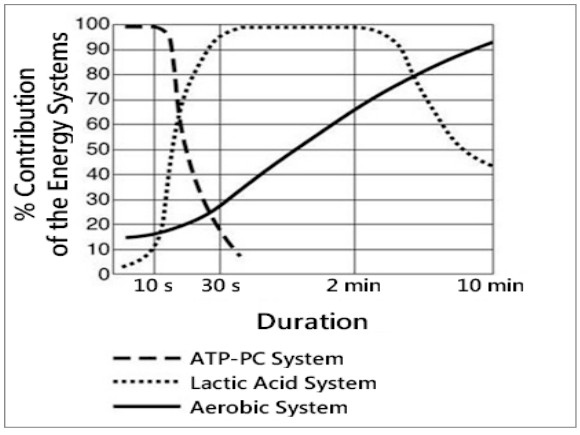
Training for 800 m and Shorter Races

Based on research data, contributions of the aerobic and anaerobic systems to the different running events (100 m to 3000 m) can be summarized as below:



It can be observed from the graph that when running 600 m in an all-out effort (such as in a race), energy contributions from the aerobic and anaerobic systems are almost the same (i.e., 50% each). For other distances longer than 600 m, the aerobic system becomes more important as the distance increases. On the other hand, for any distance shorter than 600 m, the anaerobic systems (both the ATP-PC system and lactic acid system) dominate more as the distance decreases. Therefore, aerobic training is particularly important for 1500 m and longer races.

On the other hand, 800 m and shorter races are normally finished around or within 2 minutes. Most of them have even been completed before VO_2max is reached. For these kinds of events, training for the anaerobic systems is far more important. Most of the training should be conducted at faster than vVO_2max. The proportion of maximal speed training should also be increased. Besides, the longer the distance or the faster the speed for the maximal speed training, the longer should be the rest intervals to ensure that most of the energy compounds (e.g., ATP and PC) can be resynthesized in time.



When targeting at the ATP-PC system for training, each run should not exceed 10 seconds, or the lactic acid system will start to intervene, and thus reducing the efficiency of training for the ATP-PC system.

Similarly, when targeting at the lactic acid system for training, each run should last at least 30 seconds but not to exceed 2 minutes, or the aerobic system will start to intervene, and thus reducing the efficiency of training for the lactic acid system.

Energy System	Duration for Each Run	Work-Rest Ratio
ATP-PC System	< 10 s	1:3
Lactic Acid System	30 s to 2 min	1:2

Training for 400 m and 800 m

These two events are extremely relying on the lactic acid system. Full speed 200 m and 300 m sprints and close to full speed 300 m sprints are important means of training for these two events. 800 m athletes should also add 600 m and 1000 m speed and speed endurance training to further develop their capacity in resisting fatigue under anaerobic glycolysis. In addition, vVO_2max and slightly faster than vVO_2max speed training are also beneficial to the athletes of these two events for improving their capacities in aerobic metabolism and recovery.

If an athlete can train for three days in a week (better on alternate days), 1 day should be reserved for vVO_2max training. Maximal speed training and speed and speed endurance training (particularly 105 to 115% vVO_2max training) should be

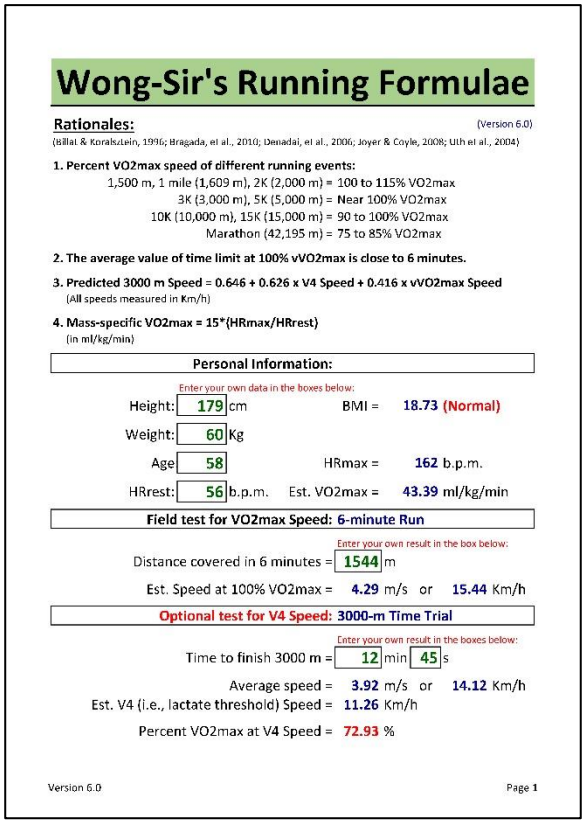
conducted on the remaining days. Proportion for maximal speed training and speed and speed endurance training should be almost the same for 800 m athletes while 400 m athletes should emphasize more on maximal speed training.

Training for 100 m and 200 m

These two events (particularly 100 m) rely mainly on the ATP-PC system for energy supply. Even the contribution from the lactic acid system becomes less important. 100 m athletes should emphasize more on 60- to 80-m maximal speed training while 200 m athletes should focus more on 100- to 150-m maximal speed training. Moreover, the shorter the distance of the race, the more important the starting technique. Besides, in order to increase speed and power, athletes of these two events should also allocate some time for plyometrics and weight training.

My Running Formulae

After having finished the 6-minute time trial, different %VO_2max speeds can be manually calculated with the estimated vVO_2max value. However, to facilitate my own training as well as my students and friends for their training, I have developed a Microsoft Excel spreadsheet named '**Wong-sir's Running Formulae**'. This spreadsheet file (formulae_v6.xlsx) is composed of two worksheets. After having entered some personal data (e.g., height, weight and age) and the time trial results (6-minute and 3000 m runs) in the ***Percent_vVO$_2$max*** worksheet, it will then generate the corresponding running speeds from 50 to 120% vVO_2max for some distances commonly used when conducting interval training.



Wong-Sir's Running Formulae

Rationales: (Version 6.0)

(Billat & Koralsztein, 1996; Bragada, et al., 2010; Denadai, et al., 2006; Joyer & Coyle, 2008; Uth et al., 2004)

1. Percent VO2max speed of different running events:
   1,500 m, 1 mile (1,609 m), 2K (2,000 m) = 100 to 115% VO2max
   3K (3,000 m), 5K (5,000 m) = Near 100% VO2max
   10K (10,000 m), 15K (15,000 m) = 90 to 100% VO2max
   Marathon (42,195 m) = 75 to 85% VO2max
2. The average value of time limit at 100% vVO2max is close to 6 minutes.
3. Predicted 3000 m Speed = 0.646 + 0.626 x V4 Speed + 0.416 x vVO2max Speed
   (All speeds measured in Km/h)
4. Mass-specific VO2max = 15*(HRmax/HRrest)
   (in ml/kg/min)

Personal Information:

Enter your own data in the boxes below:

Height: 179 cm BMI = 18.73 (Normal)

Weight: 60 Kg

Age 58 HRmax = 162 b.p.m.

HRrest: 56 b.p.m. Est. VO2max = 43.39 ml/kg/min

Field test for VO2max Speed: 6-minute Run

Enter your own result in the box below:

Distance covered in 6 minutes = 1544 m

Est. Speed at 100% VO2max = 4.29 m/s or 15.44 Km/h

Optional test for V4 Speed: 3000-m Time Trial

Enter your own result in the boxes below:

Time to finish 3000 m = 12 min 45 s

Average speed = 3.92 m/s or 14.12 Km/h

Est. V4 (i.e., lactate threshold) Speed = 11.26 Km/h

Percent VO2max at V4 Speed = 72.93 %

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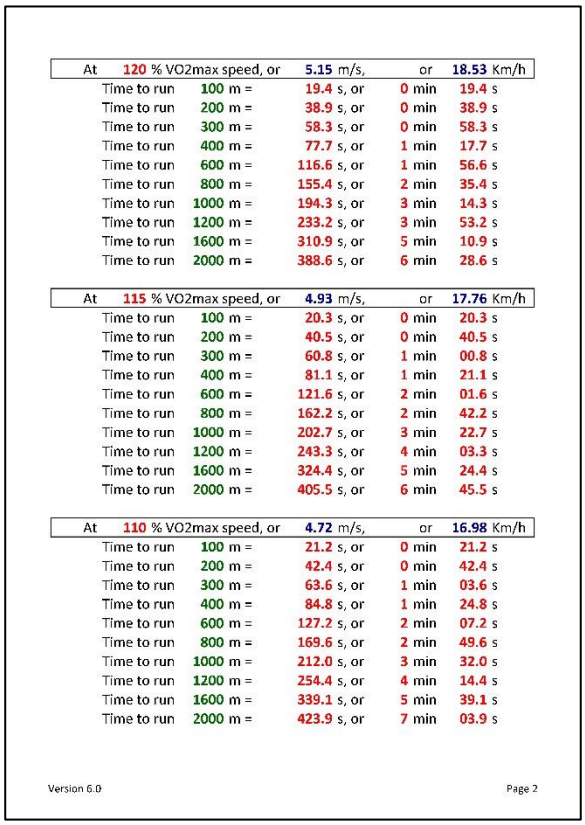

At 120 % VO2max speed, or		5.15 m/s,		or	18.53 Km/h
Time to run	100 m =	19.4 s, or	0 min		19.4 s
Time to run	200 m =	38.9 s, or	0 min		38.9 s
Time to run	300 m =	58.3 s, or	0 min		58.3 s
Time to run	400 m =	77.7 s, or	1 min		17.7 s
Time to run	600 m =	116.6 s, or	1 min		56.6 s
Time to run	800 m =	155.4 s, or	2 min		35.4 s
Time to run	1000 m =	194.3 s, or	3 min		14.3 s
Time to run	1200 m =	233.2 s, or	3 min		53.2 s
Time to run	1600 m =	310.9 s, or	5 min		10.9 s
Time to run	2000 m =	388.6 s, or	6 min		28.6 s

At 115 % VO2max speed, or		4.93 m/s,		or	17.76 Km/h
Time to run	100 m =	20.3 s, or	0 min		20.3 s
Time to run	200 m =	40.5 s, or	0 min		40.5 s
Time to run	300 m =	60.8 s, or	1 min		00.8 s
Time to run	400 m =	81.1 s, or	1 min		21.1 s
Time to run	600 m =	121.6 s, or	2 min		01.6 s
Time to run	800 m =	162.2 s, or	2 min		42.2 s
Time to run	1000 m =	202.7 s, or	3 min		22.7 s
Time to run	1200 m =	243.3 s, or	4 min		03.3 s
Time to run	1600 m =	324.4 s, or	5 min		24.4 s
Time to run	2000 m =	405.5 s, or	6 min		45.5 s

At 110 % VO2max speed, or		4.72 m/s,		or	16.98 Km/h
Time to run	100 m =	21.2 s, or	0 min		21.2 s
Time to run	200 m =	42.4 s, or	0 min		42.4 s
Time to run	300 m =	63.6 s, or	1 min		03.6 s
Time to run	400 m =	84.8 s, or	1 min		24.8 s
Time to run	600 m =	127.2 s, or	2 min		07.2 s
Time to run	800 m =	169.6 s, or	2 min		49.6 s
Time to run	1000 m =	212.0 s, or	3 min		32.0 s
Time to run	1200 m =	254.4 s, or	4 min		14.4 s
Time to run	1600 m =	339.1 s, or	5 min		39.1 s
Time to run	2000 m =	423.9 s, or	7 min		03.9 s

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At	105	% VO2max speed, or	4.50	m/s,	or	16.21	Km/h
Time to run	100	m =	22.2	s, or	0	min	22.2 s
Time to run	200	m =	44.4	s, or	0	min	44.4 s
Time to run	300	m =	66.6	s, or	1	min	06.6 s
Time to run	400	m =	88.8	s, or	1	min	28.8 s
Time to run	600	m =	133.2	s, or	2	min	13.2 s
Time to run	800	m =	177.6	s, or	2	min	57.6 s
Time to run	1000	m =	222.1	s, or	3	min	42.1 s
Time to run	1200	m =	266.5	s, or	4	min	26.5 s
Time to run	1600	m =	355.3	s, or	5	min	55.3 s
Time to run	2000	m =	444.1	s, or	7	min	24.1 s

At	100	% VO2max speed, or	4.29	m/s,	or	15.44	Km/h
Time to run	100	m =	23.3	s, or	0	min	23.3 s
Time to run	200	m =	46.6	s, or	0	min	46.6 s
Time to run	300	m =	69.9	s, or	1	min	09.9 s
Time to run	400	m =	93.3	s, or	1	min	33.3 s
Time to run	600	m =	139.9	s, or	2	min	19.9 s
Time to run	800	m =	186.5	s, or	3	min	06.5 s
Time to run	1000	m =	233.2	s, or	3	min	53.2 s
Time to run	1200	m =	279.8	s, or	4	min	39.8 s
Time to run	1600	m =	373.1	s, or	6	min	13.1 s
Time to run	2000	m =	466.3	s, or	7	min	46.3 s

At	95	% VO2max speed, or	4.07	m/s,	or	14.67	Km/h
Time to run	100	m =	24.5	s, or	0	min	24.5 s
Time to run	200	m =	49.1	s, or	0	min	49.1 s
Time to run	300	m =	73.6	s, or	1	min	13.6 s
Time to run	400	m =	98.2	s, or	1	min	38.2 s
Time to run	600	m =	147.3	s, or	2	min	27.3 s
Time to run	800	m =	196.3	s, or	3	min	16.3 s
Time to run	1000	m =	245.4	s, or	4	min	05.4 s
Time to run	1200	m =	294.5	s, or	4	min	54.5 s
Time to run	1600	m =	392.7	s, or	6	min	32.7 s
Time to run	2000	m =	490.9	s, or	8	min	10.9 s

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At	90	% VO2max speed, or	3.86	m/s,	or	13.90	Km/h
Time to run	100	m =	25.9	s, or	0	min	25.9 s
Time to run	200	m =	51.8	s, or	0	min	51.8 s
Time to run	300	m =	77.7	s, or	1	min	17.7 s
Time to run	400	m =	103.6	s, or	1	min	43.6 s
Time to run	600	m =	155.4	s, or	2	min	35.4 s
Time to run	800	m =	207.3	s, or	3	min	27.3 s
Time to run	1000	m =	259.1	s, or	4	min	19.1 s
Time to run	1200	m =	310.9	s, or	5	min	10.9 s
Time to run	1600	m =	414.5	s, or	6	min	54.5 s
Time to run	2000	m =	518.1	s, or	8	min	38.1 s

At	85	% VO2max speed, or	3.65	m/s,	or	13.12	Km/h
Time to run	100	m =	27.4	s, or	0	min	27.4 s
Time to run	200	m =	54.9	s, or	0	min	54.9 s
Time to run	300	m =	82.3	s, or	1	min	22.3 s
Time to run	400	m =	109.7	s, or	1	min	49.7 s
Time to run	600	m =	164.6	s, or	2	min	44.6 s
Time to run	800	m =	219.4	s, or	3	min	39.4 s
Time to run	1000	m =	274.3	s, or	4	min	34.3 s
Time to run	1200	m =	329.2	s, or	5	min	29.2 s
Time to run	1600	m =	438.9	s, or	7	min	18.9 s
Time to run	2000	m =	548.6	s, or	9	min	08.6 s

At	80	% VO2max speed, or	3.43	m/s,	or	12.35	Km/h
Time to run	100	m =	29.1	s, or	0	min	29.1 s
Time to run	200	m =	58.3	s, or	0	min	58.3 s
Time to run	300	m =	87.4	s, or	1	min	27.4 s
Time to run	400	m =	116.6	s, or	1	min	56.6 s
Time to run	600	m =	174.9	s, or	2	min	54.9 s
Time to run	800	m =	233.2	s, or	3	min	53.2 s
Time to run	1000	m =	291.5	s, or	4	min	51.5 s
Time to run	1200	m =	349.7	s, or	5	min	49.7 s
Time to run	1600	m =	466.3	s, or	7	min	46.3 s
Time to run	2000	m =	582.9	s, or	9	min	42.9 s

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At	75	% VO2max speed, or	3.22	m/s,	or	11.58	Km/h
Time to run	100	m =	31.1	s, or	0	min	31.1 s
Time to run	200	m =	62.2	s, or	1	min	02.2 s
Time to run	300	m =	93.3	s, or	1	min	33.3 s
Time to run	400	m =	124.4	s, or	2	min	04.3 s
Time to run	600	m =	186.5	s, or	3	min	06.5 s
Time to run	800	m =	248.7	s, or	4	min	08.7 s
Time to run	1000	m =	310.9	s, or	5	min	10.9 s
Time to run	1200	m =	373.1	s, or	6	min	13.1 s
Time to run	1600	m =	497.4	s, or	8	min	17.4 s
Time to run	2000	m =	621.8	s, or	10	min	21.8 s

At	70	% VO2max speed, or	3.00	m/s,	or	10.81	Km/h
Time to run	100	m =	33.3	s, or	0	min	33.3 s
Time to run	200	m =	66.6	s, or	1	min	06.6 s
Time to run	300	m =	99.9	s, or	1	min	39.9 s
Time to run	400	m =	133.2	s, or	2	min	13.2 s
Time to run	600	m =	199.9	s, or	3	min	19.9 s
Time to run	800	m =	266.5	s, or	4	min	26.5 s
Time to run	1000	m =	333.1	s, or	5	min	33.1 s
Time to run	1200	m =	399.7	s, or	6	min	39.7 s
Time to run	1600	m =	532.9	s, or	8	min	52.9 s
Time to run	2000	m =	666.2	s, or	11	min	06.2 s

At	65	% VO2max speed, or	2.79	m/s,	or	10.04	Km/h
Time to run	100	m =	35.9	s, or	0	min	35.9 s
Time to run	200	m =	71.7	s, or	1	min	11.7 s
Time to run	300	m =	107.6	s, or	1	min	47.6 s
Time to run	400	m =	143.5	s, or	2	min	23.5 s
Time to run	600	m =	215.2	s, or	3	min	35.2 s
Time to run	800	m =	287.0	s, or	4	min	47.0 s
Time to run	1000	m =	358.7	s, or	5	min	58.7 s
Time to run	1200	m =	430.5	s, or	7	min	10.5 s
Time to run	1600	m =	573.9	s, or	9	min	33.9 s
Time to run	2000	m =	717.4	s, or	11	min	57.4 s

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At	60	% VO2max speed, or	2.57	m/s,	or	9.26	Km/h
Time to run	100	m =	38.9	s, or	0	min	38.9 s
Time to run	200	m =	77.7	s, or	1	min	17.7 s
Time to run	300	m =	116.6	s, or	1	min	56.6 s
Time to run	400	m =	155.4	s, or	2	min	35.4 s
Time to run	600	m =	233.2	s, or	3	min	53.2 s
Time to run	800	m =	310.9	s, or	5	min	10.9 s
Time to run	1000	m =	388.6	s, or	6	min	28.6 s
Time to run	1200	m =	466.3	s, or	7	min	46.3 s
Time to run	1600	m =	621.8	s, or	10	min	21.8 s
Time to run	2000	m =	777.2	s, or	12	min	57.2 s

At	55	% VO2max speed, or	2.36	m/s,	or	8.49	Km/h
Time to run	100	m =	42.4	s, or	0	min	42.4 s
Time to run	200	m =	84.8	s, or	1	min	24.8 s
Time to run	300	m =	127.2	s, or	2	min	07.2 s
Time to run	400	m =	169.6	s, or	2	min	49.6 s
Time to run	600	m =	254.4	s, or	4	min	14.4 s
Time to run	800	m =	339.1	s, or	5	min	39.1 s
Time to run	1000	m =	423.9	s, or	7	min	03.9 s
Time to run	1200	m =	508.7	s, or	8	min	28.7 s
Time to run	1600	m =	678.3	s, or	11	min	18.3 s
Time to run	2000	m =	847.9	s, or	14	min	07.9 s

At	50	% VO2max speed, or	2.14	m/s,	or	7.72	Km/h
Time to run	100	m =	46.6	s, or	0	min	46.6 s
Time to run	200	m =	93.3	s, or	1	min	33.3 s
Time to run	300	m =	139.9	s, or	2	min	19.9 s
Time to run	400	m =	186.5	s, or	3	min	06.5 s
Time to run	600	m =	279.8	s, or	4	min	39.8 s
Time to run	800	m =	373.1	s, or	6	min	13.1 s
Time to run	1000	m =	466.3	s, or	7	min	46.3 s
Time to run	1200	m =	559.6	s, or	9	min	19.6 s
Time to run	1600	m =	746.1	s, or	12	min	26.1 s
Time to run	2000	m =	932.6	s, or	15	min	32.6 s

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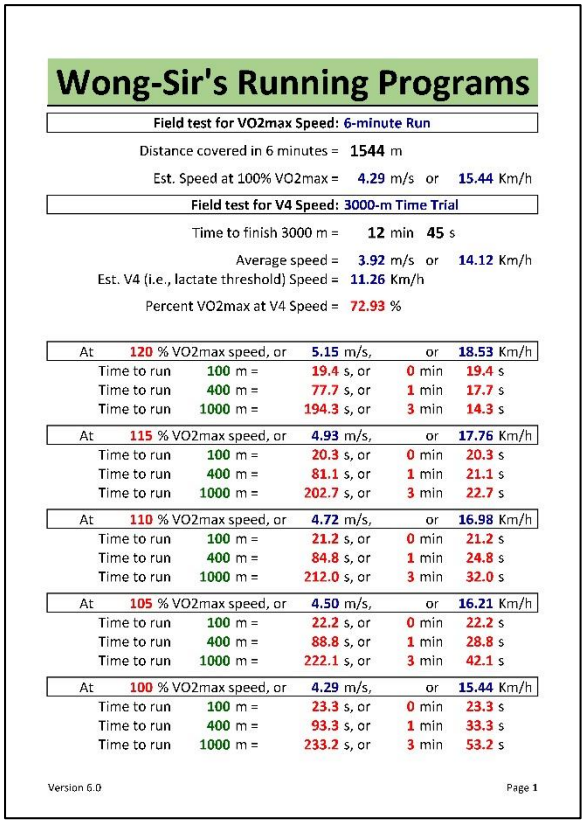
Moreover, the ***Programmes*** worksheet will also generate some suggested workouts based on the time trials results.



Wong-Sir's Running Programs

Field test for VO2max Speed: 6-minute Run

Distance covered in 6 minutes = **1544** m

Est. Speed at 100% VO2max = **4.29** m/s or **15.44** Km/h

Field test for V4 Speed: 3000-m Time Trial

Time to finish 3000 m = **12** min **45** s

Average speed = **3.92** m/s or **14.12** Km/h

Est. V4 (i.e., lactate threshold) Speed = **11.26** Km/h

Percent VO2max at V4 Speed = **72.93** %

At	**120** % VO2max speed, or	**5.15** m/s,	or	**18.53** Km/h
Time to run	**100** m =	**19.4** s, or	**0** min	**19.4** s
Time to run	**400** m =	**77.7** s, or	**1** min	**17.7** s
Time to run	**1000** m =	**194.3** s, or	**3** min	**14.3** s
At	**115** % VO2max speed, or	**4.93** m/s,	or	**17.76** Km/h
Time to run	**100** m =	**20.3** s, or	**0** min	**20.3** s
Time to run	**400** m =	**81.1** s, or	**1** min	**21.1** s
Time to run	**1000** m =	**202.7** s, or	**3** min	**22.7** s
At	**110** % VO2max speed, or	**4.72** m/s,	or	**16.98** Km/h
Time to run	**100** m =	**21.2** s, or	**0** min	**21.2** s
Time to run	**400** m =	**84.8** s, or	**1** min	**24.8** s
Time to run	**1000** m =	**212.0** s, or	**3** min	**32.0** s
At	**105** % VO2max speed, or	**4.50** m/s,	or	**16.21** Km/h
Time to run	**100** m =	**22.2** s, or	**0** min	**22.2** s
Time to run	**400** m =	**88.8** s, or	**1** min	**28.8** s
Time to run	**1000** m =	**222.1** s, or	**3** min	**42.1** s
At	**100** % VO2max speed, or	**4.29** m/s,	or	**15.44** Km/h
Time to run	**100** m =	**23.3** s, or	**0** min	**23.3** s
Time to run	**400** m =	**93.3** s, or	**1** min	**33.3** s
Time to run	**1000** m =	**233.2** s, or	**3** min	**53.2** s

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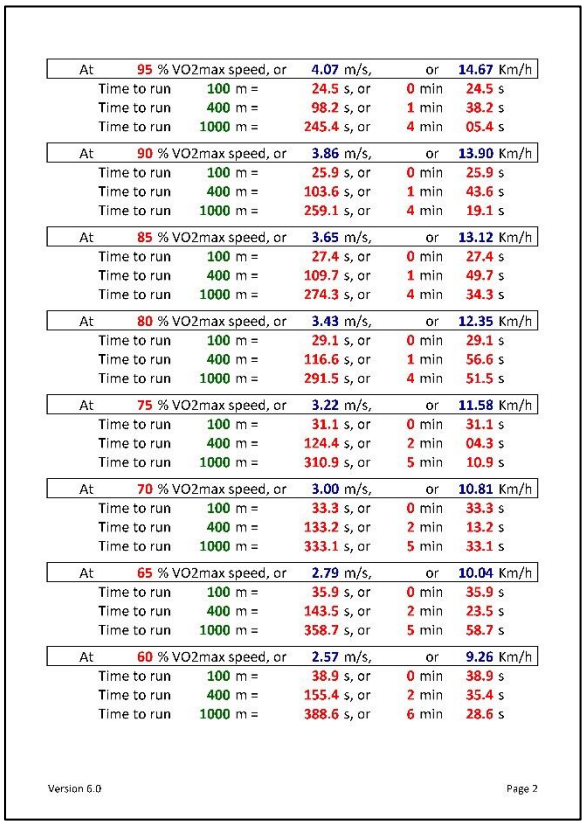

At	**95** % VO2max speed, or	**4.07** m/s,	or	**14.67** Km/h
Time to run	**100** m =	**24.5** s, or	**0** min	**24.5** s
Time to run	**400** m =	**98.2** s, or	**1** min	**38.2** s
Time to run	**1000** m =	**245.4** s, or	**4** min	**05.4** s
At	**90** % VO2max speed, or	**3.86** m/s,	or	**13.90** Km/h
Time to run	**100** m =	**25.9** s, or	**0** min	**25.9** s
Time to run	**400** m =	**103.6** s, or	**1** min	**43.6** s
Time to run	**1000** m =	**259.1** s, or	**4** min	**19.1** s
At	**85** % VO2max speed, or	**3.65** m/s,	or	**13.12** Km/h
Time to run	**100** m =	**27.4** s, or	**0** min	**27.4** s
Time to run	**400** m =	**109.7** s, or	**1** min	**49.7** s
Time to run	**1000** m =	**274.3** s, or	**4** min	**34.3** s
At	**80** % VO2max speed, or	**3.43** m/s,	or	**12.35** Km/h
Time to run	**100** m =	**29.1** s, or	**0** min	**29.1** s
Time to run	**400** m =	**116.6** s, or	**1** min	**56.6** s
Time to run	**1000** m =	**291.5** s, or	**4** min	**51.5** s
At	**75** % VO2max speed, or	**3.22** m/s,	or	**11.58** Km/h
Time to run	**100** m =	**31.1** s, or	**0** min	**31.1** s
Time to run	**400** m =	**124.4** s, or	**2** min	**04.3** s
Time to run	**1000** m =	**310.9** s, or	**5** min	**10.9** s
At	**70** % VO2max speed, or	**3.00** m/s,	or	**10.81** Km/h
Time to run	**100** m =	**33.3** s, or	**0** min	**33.3** s
Time to run	**400** m =	**133.2** s, or	**2** min	**13.2** s
Time to run	**1000** m =	**333.1** s, or	**5** min	**33.1** s
At	**65** % VO2max speed, or	**2.79** m/s,	or	**10.04** Km/h
Time to run	**100** m =	**35.9** s, or	**0** min	**35.9** s
Time to run	**400** m =	**143.5** s, or	**2** min	**23.5** s
Time to run	**1000** m =	**358.7** s, or	**5** min	**58.7** s
At	**60** % VO2max speed, or	**2.57** m/s,	or	**9.26** Km/h
Time to run	**100** m =	**38.9** s, or	**0** min	**38.9** s
Time to run	**400** m =	**155.4** s, or	**2** min	**35.4** s
Time to run	**1000** m =	**388.6** s, or	**6** min	**28.6** s

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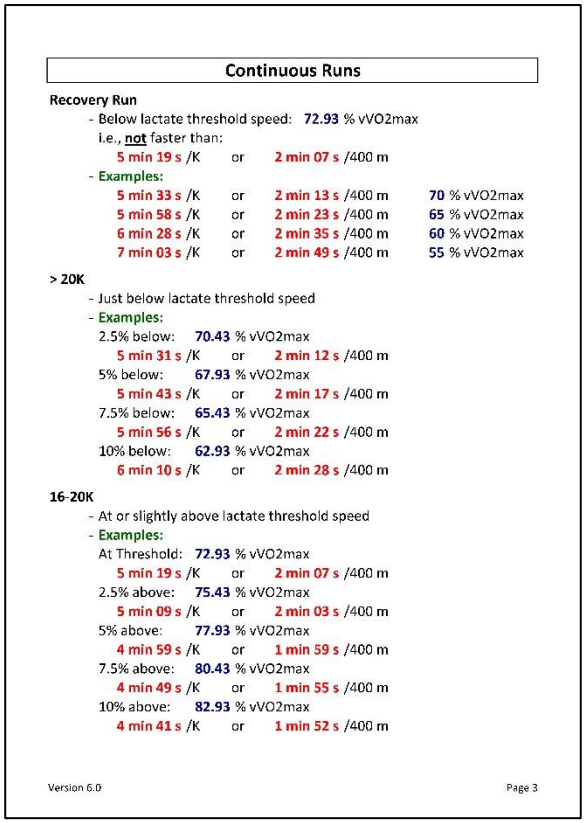

Continuous Runs

Recovery Run
- Below lactate threshold speed: **72.93** % vVO2max
  i.e., **not** faster than:
  5 min 19 s /K or **2 min 07 s** /400 m
- **Examples:**
  5 min 33 s /K or **2 min 13 s** /400 m **70** % vVO2max
  5 min 58 s /K or **2 min 23 s** /400 m **65** % vVO2max
  6 min 28 s /K or **2 min 35 s** /400 m **60** % vVO2max
  7 min 03 s /K or **2 min 49 s** /400 m **55** % vVO2max

> 20K
- Just below lactate threshold speed
- **Examples:**
  2.5% below: **70.43** % vVO2max
  5 min 31 s /K or **2 min 12 s** /400 m
  5% below: **67.93** % vVO2max
  5 min 43 s /K or **2 min 17 s** /400 m
  7.5% below: **65.43** % vVO2max
  5 min 56 s /K or **2 min 22 s** /400 m
  10% below: **62.93** % vVO2max
  6 min 10 s /K or **2 min 28 s** /400 m

16-20K
- At or slightly above lactate threshold speed
- **Examples:**
  At Threshold: **72.93** % vVO2max
  5 min 19 s /K or **2 min 07 s** /400 m
  2.5% above: **75.43** % vVO2max
  5 min 09 s /K or **2 min 03 s** /400 m
  5% above: **77.93** % vVO2max
  4 min 59 s /K or **1 min 59 s** /400 m
  7.5% above: **80.43** % vVO2max
  4 min 49 s /K or **1 min 55 s** /400 m
  10% above: **82.93** % vVO2max
  4 min 41 s /K or **1 min 52 s** /400 m

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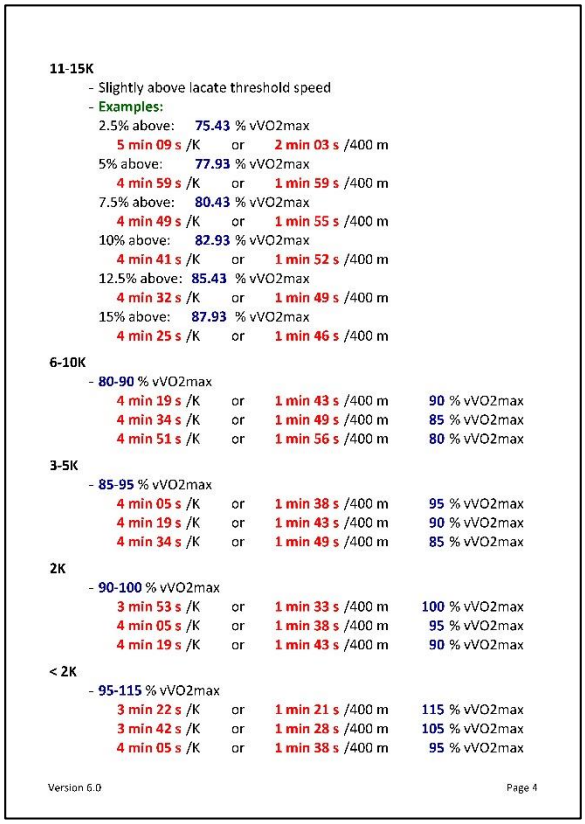

11-15K
- Slightly above lacate threshold speed
- **Examples:**
  2.5% above: **75.43** % vVO2max
  5 min 09 s /K or **2 min 03 s** /400 m
  5% above: **77.93** % vVO2max
  4 min 59 s /K or **1 min 59 s** /400 m
  7.5% above: **80.43** % vVO2max
  4 min 49 s /K or **1 min 55 s** /400 m
  10% above: **82.93** % vVO2max
  4 min 41 s /K or **1 min 52 s** /400 m
  12.5% above: **85.43** % vVO2max
  4 min 32 s /K or **1 min 49 s** /400 m
  15% above: **87.93** % vVO2max
  4 min 25 s /K or **1 min 46 s** /400 m

6-10K
- **80-90** % vVO2max
  4 min 19 s /K or **1 min 43 s** /400 m **90** % vVO2max
  4 min 34 s /K or **1 min 49 s** /400 m **85** % vVO2max
  4 min 51 s /K or **1 min 56 s** /400 m **80** % vVO2max

3-5K
- **85-95** % vVO2max
  4 min 05 s /K or **1 min 38 s** /400 m **95** % vVO2max
  4 min 19 s /K or **1 min 43 s** /400 m **90** % vVO2max
  4 min 34 s /K or **1 min 49 s** /400 m **85** % vVO2max

2K
- **90-100** % vVO2max
  3 min 53 s /K or **1 min 33 s** /400 m **100** % vVO2max
  4 min 05 s /K or **1 min 38 s** /400 m **95** % vVO2max
  4 min 19 s /K or **1 min 43 s** /400 m **90** % vVO2max

< 2K
- **95-115** % vVO2max
  3 min 22 s /K or **1 min 21 s** /400 m **115** % vVO2max
  3 min 42 s /K or **1 min 28 s** /400 m **105** % vVO2max
  4 min 05 s /K or **1 min 38 s** /400 m **95** % vVO2max

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Interval Runs

To Improve vVO2max

- Important for all middle and long distance running events, and particularly important for **1500 m**, **1 mile**, and **2000 m** runners.
- Mainly **30-second** to **3-minute** intervals at **100%** vVO2max.
- Should cover **3-4 K** fast runs.
- Around **1:1** work-rest ratio.

Example 1: (3 to 4K fast run)
2 sets of 15-20 x **100 m**, **0 min 23.3 s** each
jog 20-25 s between each,
rest 3:00-4:00 between sets.

Example 2: (3 to 4K fast run)
15-20 x **200 m**, **0 min 46.6 s** each
jog 45 s between each.

Example 3: (3 to 4.2K fast run)
10-14 x **300 m**, **1 min 09.9 s** each
jog 1:15 between each.

Example 4: (3.2 to 4K fast run)
8-10 x **400 m**, **1 min 33.2 s** each
jog 1:30 between each.

Example 5: (3 to 4.2K fast run)
5-7 x **600 m**, **2 min 19.8 s** each
jog 2:30 between each.

Example 6: (3.2 to 4K fast run)
4-5 x **800 m**, **3 min 06.5 s** each
jog 3:00 between each.

Remarks:
To use 1000 intervals to develop vVO2max, the runner must be able to complete almost 2000 m in the 6-min time trial (i.e., 6:00/2K or 3:00/K), and this will correspond to a 5000 m performance of 14:00 to 15:00.

To improve Lactate Threshold Speed

- Important for **3K or longer** distances.
- Particularly important for **master** runners because VO2max drops with age due to HRmax decreases approximately 1 beat/min each year.
- vVO2max training can also improve lactate threshold speed at the same time, and is particularly important for **3K**, **5K**, and world class **10K** performances.
- Long continuous run of **10-15K** conducted **slightly above** lactate threshold speed.
- Interval runs at **75-85%** vVO2max, covering **8-12K**.

Example 1: (4 to 5K fast run + 4 to 5K slow run, total 8 to 10K)
20-25 x **200 m**, jog **200 m** in 1:20-1:30 between each.
85 % vVO2max **0 min 54.8 s** each
75 % vVO2max **1 min 02.1 s** each

Example 2: (6 to 7.5K fast run + 2 to 2.5K slow run, total 8 to 10K)
20-25 x **300 m**, jog **100 m** in 1:00-1:15 between each.
85 % vVO2max **1 min 22.2 s** each
75 % vVO2max **1 min 33.2 s** each

Example 3: (6 to 8K fast run)
15-20 x **400 m**, jog 1:00-1:30 between each.
85 % vVO2max **1 min 49.7 s** each
75 % vVO2max **2 min 04.3 s** each

Example 4: (6 to 8K fast run + 3 to 4K slow run, total 9 to 12K)
15-20 x **400 m**, jog **200 m** in 1:30-1:45 between each.
85 % vVO2max **1 min 49.7 s** each
75 % vVO2max **2 min 04.3 s** each

Example 5: (6 to 9K fast run + 2 to 3K slow run, total 8 to 12K)
10-15 x **600 m**, jog **200 m** in 1:45-2:00 between each.
85 % vVO2max **2 min 44.5 s** each (1 min 49.7 s /400 m)
75 % vVO2max **3 min 06.5 s** each (2 min 04.3 s /400 m)

Example 6: (8 to 12K fast run)
10-15 x **800 m**, jog 1:30-1:45 between each.
85 % vVO2max **3 min 39.4 s** each (1 min 49.7 s /400 m)
75 % vVO2max **4 min 08.6 s** each (2 min 04.3 s /400 m)

Example 7: (8 to 12K fast run)
8-12 x **1000 m**, jog 2:00 between each.
85 % vVO2max **4 min 34.3 s** each (1 min 49.7 s /400 m)
75 % vVO2max **5 min 10.8 s** each (2 min 04.3 s /400 m)

Example 8: (6 to 10K fast run + 1.2 to 2K slow run, total 7.2 to 12K)
6-10 x **1000 m**, jog **200 m** in 1:45-200 between each.
85 % vVO2max **4 min 34.3 s** each (1 min 49.7 s /400 m)
75 % vVO2max **5 min 10.8 s** each (2 min 04.3 s /400 m)

Example 9: (7.2 to 12K fast run)
6-10 x **1200 m**, jog 2:00 between each.
85 % vVO2max **5 min 29.1 s** each (1 min 49.7 s /400 m)
75 % vVO2max **6 min 13.0 s** each (2 min 04.3 s /400 m)

Example 10: (8 to 12.8K fast run)
5-8 x **1600 m**, jog 2:00-3:00 between each.
85 % vVO2max **7 min 18.8 s** each (1 min 49.7 s /400 m)
75 % vVO2max **8 min 17.4 s** each (2 min 04.3 s /400 m)

Example 11: (8 to 12K fast run)
4-6 x **2000 m**, jog 2:00-3:00 between each.
85 % vVO2max **9 min 08.6 s** each (1 min 49.7 s /400 m)
75 % vVO2max **10 min 21.7 s** each (2 min 04.3 s /400 m)

Example 12: (8 to 12K fast run)
2-3 x **4000 m**, jog 2:00-3:00 between each.
85 % vVO2max **18 min 17.2 s** each (1 min 49.7 s /400 m)
75 % vVO2max **20 min 43.5 s** each (2 min 04.3 s /400 m)

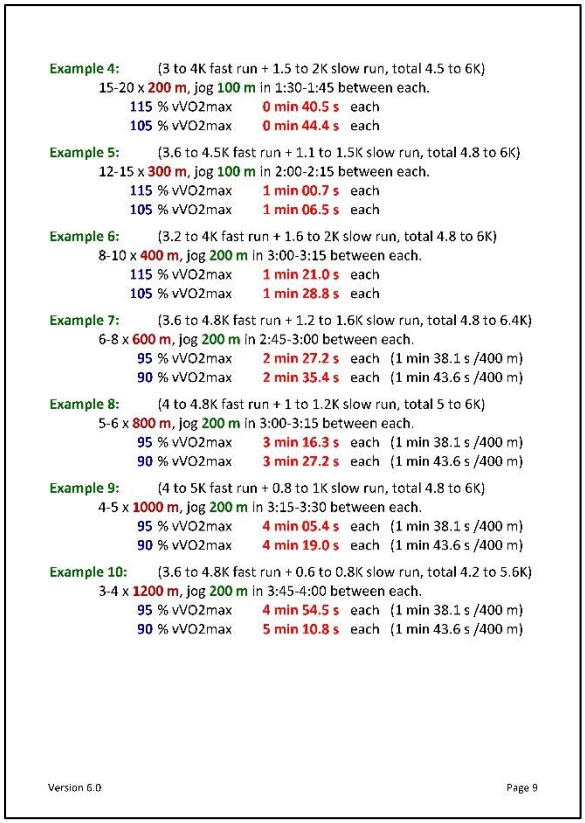
To improve Speed and Speed Endurance

- Important for the "final kick" and running strategies.
  Better basic speed makes running easier at race pace (better reserve of speed.
  - Half-marathon and marathon runners need good 10K speed
  - 10K runners need good 3K and 5K speed
  - 3K and 5K runners need good 1500 m speed
  - 1500 m runners and milers need good 400 m and 800 m speed
  - 800 m runners need good 200 m and 400 m speed
- Better speed endurance enables speed to be sustained longer.
- Besides vVO2max training, training at speeds **slightly slower** and **slightly faster** than vVO2max (i.e., **90-95%** and **105-115%** vVO2max) are also necessary.
  - **Shorter** work distances (**100 m**, **200 m**, **300 m**, and **400 m**) use faster speeds (i.e., **105-115%** vVO2max).
  - **Longer** work distances (**600 m**, **800 m**, **1000 m**, and **1200 m**) use slower speeds (i.e., **90-95%** vVO2max).
- Up to **1:2** to **1:3** work-rest ratio can be used.
  - Longer rest interval for faster speeds or longer work distances.

Example 1: (2 to 3K fast run + 2 to 3K slow run, total 4 to 6K)
2 sets of 10-15 x **100 m**, jog **100 m** in 45-60 s between each,
rest 3:00-4:00 between sets.
115 % vVO2max **0 min 20.2 s** each
105 % vVO2max **0 min 22.2 s** each

Example 2: (2 to 2.5K fast run + 2 to 2.5K slow run, total 4 to 5K)
20-25 x **100 m**, jog **100 m** in 1:00-1:15 between each.
115 % vVO2max **0 min 20.2 s** each
105 % vVO2max **0 min 22.2 s** each

Example 3: (3.2 to 4K fast run + 1.6 to 2K slow run, total 4.8 to 6K)
2 sets of 8-10 x **200 m**, jog **100 m** in 1:15-1:30 between each,
rest 3:00-4:00 between sets.
115 % vVO2max **0 min 40.5 s** each
105 % vVO2max **0 min 44.4 s** each



Example 4: (3 to 4K fast run + 1.5 to 2K slow run, total 4.5 to 6K)
15-20 x **200 m**, jog **100 m** in 1:30-1:45 between each.
115 % vVO2max **0 min 40.5 s** each
105 % vVO2max **0 min 44.4 s** each

Example 5: (3.6 to 4.5K fast run + 1.1 to 1.5K slow run, total 4.8 to 6K)
12-15 x **300 m**, jog **100 m** in 2:00-2:15 between each.
115 % vVO2max **1 min 00.7 s** each
105 % vVO2max **1 min 06.5 s** each

Example 6: (3.2 to 4K fast run + 1.6 to 2K slow run, total 4.8 to 6K)
8-10 x **400 m**, jog **200 m** in 3:00-3:15 between each.
115 % vVO2max **1 min 21.0 s** each
105 % vVO2max **1 min 28.8 s** each

Example 7: (3.6 to 4.8K fast run + 1.2 to 1.6K slow run, total 4.8 to 6.4K)
6-8 x **600 m**, jog **200 m** in 2:45-3:00 between each.
95 % vVO2max **2 min 27.2 s** each (1 min 38.1 s /400 m)
90 % vVO2max **2 min 35.4 s** each (1 min 43.6 s /400 m)

Example 8: (4 to 4.8K fast run + 1 to 1.2K slow run, total 5 to 6K)
5-6 x **800 m**, jog **200 m** in 3:00-3:15 between each.
95 % vVO2max **3 min 16.3 s** each (1 min 38.1 s /400 m)
90 % vVO2max **3 min 27.2 s** each (1 min 43.6 s /400 m)

Example 9: (4 to 5K fast run + 0.8 to 1K slow run, total 4.8 to 6K)
4-5 x **1000 m**, jog **200 m** in 3:15-3:30 between each.
95 % vVO2max **4 min 05.4 s** each (1 min 38.1 s /400 m)
90 % vVO2max **4 min 19.0 s** each (1 min 43.6 s /400 m)

Example 10: (3.6 to 4.8K fast run + 0.6 to 0.8K slow run, total 4.2 to 5.6K)
3-4 x **1200 m**, jog **200 m** in 3:45-4:00 between each.
95 % vVO2max **4 min 54.5 s** each (1 min 38.1 s /400 m)
90 % vVO2max **5 min 10.8 s** each (1 min 43.6 s /400 m)

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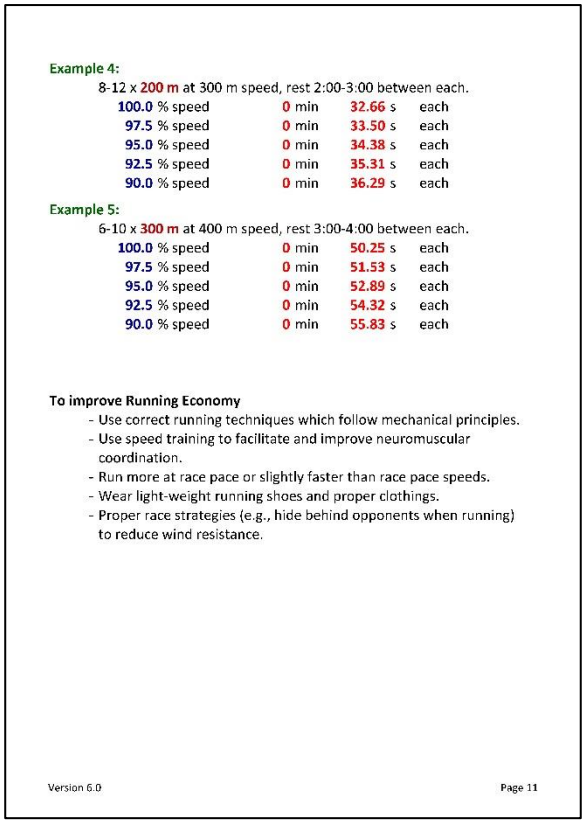

Example 4:
8-12 x **200 m** at 300 m speed, rest 2:00-3:00 between each.
100.0 % speed **0** min **32.66** s each
97.5 % speed **0** min **33.50** s each
95.0 % speed **0** min **34.38** s each
92.5 % speed **0** min **35.31** s each
90.0 % speed **0** min **36.29** s each

Example 5:
6-10 x **300 m** at 400 m speed, rest 3:00-4:00 between each.
100.0 % speed **0** min **50.25** s each
97.5 % speed **0** min **51.53** s each
95.0 % speed **0** min **52.89** s each
92.5 % speed **0** min **54.32** s each
90.0 % speed **0** min **55.83** s each

To improve Running Economy
- Use correct running techniques which follow mechanical principles.
- Use speed training to facilitate and improve neuromuscular coordination.
- Run more at race pace or slightly faster than race pace speeds.
- Wear light-weight running shoes and proper clothings.
- Proper race strategies (e.g., hide behind opponents when running) to reduce wind resistance.

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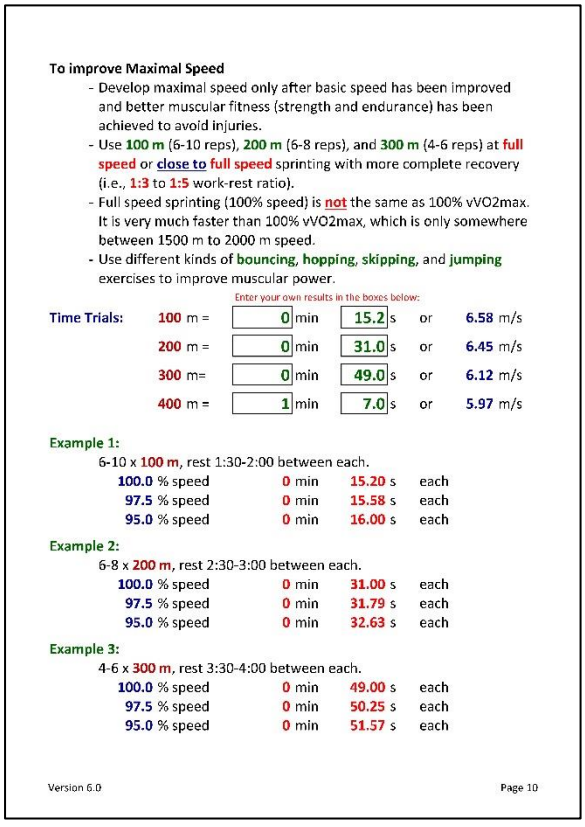

To improve Maximal Speed
- Develop maximal speed only after basic speed has been improved and better muscular fitness (strength and endurance) has been achieved to avoid injuries.
- Use **100 m** (6-10 reps), **200 m** (6-8 reps), and **300 m** (4-6 reps) at **full speed** or **close to full speed** sprinting with more complete recovery (i.e., **1:3** to **1:5** work-rest ratio).
- Full speed sprinting (100% speed) is **not** the same as 100% vVO2max. It is very much faster than 100% vVO2max, which is only somewhere between 1500 m to 2000 m speed.
- Use different kinds of **bouncing**, **hopping**, **skipping**, and **jumping** exercises to improve muscular power.

Enter your own results in the boxes below:

Time Trials:						
100 m =	0	min	15.2	s	or	6.58 m/s
200 m =	0	min	31.0	s	or	6.45 m/s
300 m=	0	min	49.0	s	or	6.12 m/s
400 m =	1	min	7.0	s	or	5.97 m/s

Example 1:
6-10 x **100 m**, rest 1:30-2:00 between each.
100.0 % speed **0** min **15.20** s each
97.5 % speed **0** min **15.58** s each
95.0 % speed **0** min **16.00** s each

Example 2:
6-8 x **200 m**, rest 2:30-3:00 between each.
100.0 % speed **0** min **31.00** s each
97.5 % speed **0** min **31.79** s each
95.0 % speed **0** min **32.63** s each

Example 3:
4-6 x **300 m**, rest 3:30-4:00 between each.
100.0 % speed **0** min **49.00** s each
97.5 % speed **0** min **50.25** s each
95.0 % speed **0** min **51.57** s each

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When new time trial results or personal bests become available (e.g., 6 or 12 months later), the ***Percent_vVO$_2$max*** worksheet and ***Programme*** worksheet will automatically regenerate the different %vVO$_2$max values and suggested workouts immediately after the related data in the ***Percent_vVO$_2$max*** worksheet has been updated.

Just as the 6-minute full-effort time trial is for estimating the vVO$_2$max (i.e., 100% VO$_2$max speed), the 3000 m time trial is for estimating the lactate threshold speed and the corresponding %vVO$_2$max. This lactate threshold speed is normally close to the 10-mile racing speed.

Using my **Wong-sir's Running Formulae** spreadsheet may avoid the process of determining 'how much' and 'how fast' to run before each training session. From now on, anyone using the spreadsheet just need

to decide whether the purpose of the training session is for improving **vVO_2max**, **lactate threshold speed**, **speed and speed endurance**, or **maximal speed**, and then select the work distance preferred, he/she can then follow the suggested number of repetitions, speed of each run, and duration of each rest intervals for the training session.

Although all estimations cannot avoid errors, I have input my current test data and personal best times (when I was an athlete more than thirty years ago) into the spreadsheet, and the lactate threshold speeds estimated are quite close to my present 10-mile pace and that when I was an athlete, respectively. Besides, most of the workouts suggested in the ***Programmes*** worksheet can 'just' be accomplished with my own capacity.

I have been using $\%vVO_2max$ listed in the ***Percent_vVO2max*** worksheet for my own training in the previous few years and have achieved satisfactory competition results. Besides, some of the suggested workouts listed in the ***Programmes*** worksheet are also 'popular' workouts carried out by me in the past few years. If you are also interested in trying out my '**Wong-sir's Running Formulae**' spreadsheet, you are welcome to download it from the URL below:

http://www.tswongsir-runners.guide/formulae_v6.xlsx

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