Magness - Training

The following training is a sample of the training I do throughout the year. It is to give you a general idea of what I think works. I don't suggest that you copy exactly what I've written below, because I feel it's important for you to know why you are doing something and not just blindly do it. Before coming up with a training program for yourself I suggest getting a basic idea of physiology and then read up on successful coaches and how they trained there athletes. I will provide a list of reading material at the end that I think will benefit you. I will try and stay away from using the scientific basis for everything, as I want everyone to be able to comprehend this guide and the science behind training is readily available., BUT my training is influence by the science of training and I have read up on it as much as I can and I highly recommend that you go read up on the science of training so that you know WHY you are doing something.

Also, this site is meant to be interactive. If you see agree, disagree, love, or hate anything about the training I have posted let me know. Post on the message board or e-mail me. I think it's of great value to learn from each other, whether your an athlete, coach, or just a fan.

Table of Contents

My philosophy

My running philosophy and training program has been melded by too many people to mention. Basically what I've tried to do is first off learn by trial and error. Throughout HS this is how we came up with my training. In addition to this I've tried to study up on all the training ideas that I could get my hands on. It's easy to get your hands on a lot of American ideas through books, but I tried to go beyond this by researching as best as I could what other nations and lesser known coaches do. Lastly, I've tried to teach my self basic physiology. I've never taken a Physiology class and my last Biology class was in HS, so it was a little rough at first, but I slowly caught on to the concepts and in fact enjoyed teaching myself much more than taking any class. After doing this, I've tried to read up on all the scientific journal information that I could find. But it's important to know that science doesn't really teach us how to train. It explains why things happen, but you need more than that to come up with an effective training program. That is why we don't see a lot of Scientists as highly successful coaches. In General, running knowledge comes before scientific knowledge.

The Build and Maintenance Principle

The basic principle of my training philosophy is that of build and maintenance of different training aspects. This idea varies somewhat from many more traditional plans in which the idea is to periodize your training so that you develop a certain fitness aspect at a certain time period and then move on to develop the next aspect once the first one is fully developed. In a plan like this you would for example build endurance then VO2max then anaerobic abilities and then taper and race. During these weeks almost all of the hard or key training would be focused on developing that specific attribute and the rest of the week would be recovery. It's a gradual progression of individual developing each training aspect and then resting up and racing at the end. While this approach does work for many people, in my opinion a better option is available.

The idea behind the build and maintenance plan is that you still build up that particular aspect of training at a certain time, but during period when that training aspect is not being built up, you do maintenance training to keep it at a certain level. In doing this, you don't have to worry about losing some of the attributes you built up because you will never be that far away from working on them. The idea behind this type of periodization is that you either use it or lose it. This applies to the various physiological factors in distance running. If you do not use something, it begins to gradually detrain, and what you built up has been lost. For example, if you never work on high end aerobic running while peaking to maintain the aerobic development that has taken place in the Fast twitch muscle fibers, then this development will start to be lost, because it hasn't been worked on. In addition to this, science has also shown that it is much easier to maintain something, than to build it up. So maintaining a particular aspect, such as lactate threshold, will take a much more reduced work load than it did to improve it. In maintaining the lactate threshold, you might only have to do one LT session every 2 weeks, while it might have taken 2 LT sessions per week to improve it. So it is much easier to maintain a particular fitness aspect then to improve it.

Because of these two things, my training is built around this idea of you are either building a particular aspect or maintaining it. The season is still broken down into periods of training like the more traditional training methods in which a certain aspect (such as LT, VO2, anaerobic, or endurance) is emphasized, but the difference is that not all of the training during this period is geared towards that aspect. Instead, the aspect you are trying to improve is emphasized so that it is the most important thing during this period to be worked on, but you also do maintenance training on the various other aspects that have been built up. For instance, while doing a base period where the object is to improve Lactate Threshold you might do 2 LT workouts per week, but also do some hill sprints or fast medium hills once during the week in order to recruit your Fast Twitch muscle fibers and maintain the anaerobic capacity. In this case, the Lactate Threshold training would be the emphasized aspect which you are building, and the hills would be used as maintenance training for your FT fibers and anaerobic capacity.

That is the underlying principle of my training. During each period, something is emphasized that you are trying to build, but the other training aspects are still stimulate so that they can be maintained. In doing this, you don't have to worry as much about losing one of these aspects unless you purposefully want to, and you don't have to start over from scratch in developing them. It's a continual progression of fitness in which you are constantly building something and maintaining the others, never losing them.

The Basics

Before we get started, I think it is best if we define a couple of things that will enhance your knowledge of the physiological part of the sport. These are basic scientific terms that need to be known. Nothing

new is presented here as all of this can be found in any physiology textbook. But textbooks are boring to most people, and I'm willing to bet you won't just pick one up, so I'll try and keep it relatively short and simple. Remember this is just a basic summary and omits a lot of details. I suggest you go pick up a book to understand the full process. I don't want to throw out too much scientific material at once as I want everyone to be able to comprehend this guide.

The Energy Powerhouse, Mitochondria:

Mitochondria are the structures in your cells where aerobic energy production occurs. In these organelles the aerobic breakdown of fuels occurs and results in the released energy being stored as adenosine triphosphate (ATP). As you can see these organelles are extremely important as they are central to energy production. Thus, one purpose of training distance runners is to increase the amount and size of the mitochondria so that you can maximize their capabilities in production of energy, which occurs through training of the aerobic system.

Another important thing to know about is how muscle contraction occurs. Basically an electrical impulse travels through the muscle cell and its various parts (which I won't go into detail about). This impulse causes calcium stored up in things called sacromeres to be released. This release of calcium allows two molecules (actin and myosin), to be able to interact, as they are blocked and not able to interact when the muscle is at rest and only the released calcium can temporarily lift this blockade. Anyway, one of these molecules (actin) have the ATP (energy) stored in them, while the other (myosin) have enzymes that allow for the breakdown of this energy. The sliding back and forth of these molecules with the Myosin heads grasping on to the actin and their interaction creates the muscle tension. Some other benefits of having a large amount of these organelles is that, it's also important to develop these because the more mitochondria you have, the better your body will be at using lactic acid as an energy source (more about this in energy systems section). Also, the more you have, the sooner your aerobic energy system is able to be used, and your body will have a tendency to use the aerobic system over the anaerobic system to produce energy (ATP).

The Muscle Fibers

Your muscles contain three types of muscle fibers. The first one is the slow twitch fibers (also referred to as red or type I fibers). Slow twitch fibers are those that rely on oxygen to produce energy. They have slower contractions, more mitochondria, and greater capillarization that the other type of fibers (Fast Twitch). Because of this, these fibers are used in aerobic activities that are at a relatively low intensity. In endurance events, these fibers are used first until as fatigue occurs, more and more FT fibers are recruited to help share the load. The other type of fibers are Fast Twitch fibers (white, or type II fibers) which can be divided further into three types, Fast twitch oxidative glycolytic (FT type IIa),Fast twitch glycolytic (FT type IIb), and FT-c. FT-c fibers are still being researched and aren't fully understood, therefore we will leave them out of the training discussion for now and leave them to the scientists. Fast twitch type IIb fibers rely on the breakdown of glycogen and glucose for energy, which then creates pyruvic acid, which is broken down further to lactic acid. This means that these fibers do not need oxygen to function. Fast twitch type IIa fibers have the capability of using either oxygen for the breakdown of fuels or glycogen. Thus they can function as either pure fast twitch or slow twitch fibers depending on the situation and how they are trained. The difference in these two types of fast twitch fibers is that one can function using oxygen and has high oxidative enzyme activity, while the other does not. Fast twitch fibers are generally thought of as those that are used during explosive exercises. Their contractions are more rapid and explosive, thus having a higher fatigability, fewer mitochondria, and less capillarization. Fast twitch oxidative fibers are sometimes thought of as "the

middle distance" fibers, because, as I stated earlier, they can function off of either oxygen or glycogen to breakdown fuels. It is important to know about the different fiber types because it can influence how you train based on what your event requires. An example of training these fibers would be if you're a marathon runner and you do all aerobic distance, you will be training your ST muscles obviously, but you will also be training the FT muscles to act as aerobically as possible. The same thing can be said for sprinters. They are training there FT oxidative fibers to train more as the explosive FT glycolytic fibers. Thus a good balance of training should be done for distances in between. That is why I stress working each different system/fiber type throughout the year. It's interesting to note that FT-a fibers can actually be trained so that they have a higher aerobic capacity than an untrained ST fiber. Training can also increase the adaptations in each of the different muscle fiber type. For example, you can increase the number of mitochondria, aerobic enzymes, etc. in all of the fibers to a point. Lots of endurance training can reduce the contraction speed and force of FT-b fibers because of a reduction in anaerobic energy release. However, through sprint training an increase in anaerobic enzymes and thus contraction speed and force can occur.

Motor Units and Muscle Fiber Recruitment

These muscle fiber types are arranged in Motor Units. Each motor unit contains many muscle fibers, but they are all the same type. For example a motor unit contains either ALL ST, or all FT-a, or all FT-b fibers. The amount of fibers in a muscle group depends on a number of things, mainly what type they are. For example ST motor units contain between 10-180 muscle fibers per unit, while FT motor units contain as many as 300-800 FT muscle fibers per unit. This is what explains why FT motor units provide so much more force or power than ST. The number of fibers per unit is vastly greater. Nerve impulses are sent from the brain to stimulate these motor units. If the impulse is "strong" enough it will stimulate a certain motor unit, and then all of the muscle fibers will contract in this unit. If a motor unit is stimulated, then all of the fibers in that unit are contracted. The brain decides how many motor units to contract based on the required force. The more force that is required, then the more motor units are stimulated. For example, if you bend down to pick up a 5 pound weight, the force requirement to pick it up is low, so only a few motor units, and thus a few muscle fibers are stimulated to contract to pick it up. If however, the weight is 100 pounds, then a greater amount of force is needed to pick up the weight, so a stronger nerve impulse is sent to stimulate more motor units and have more muscle fibers contract. However, even at maximal force requirements we never recruit all of the motor units and muscle fibers in a muscle. This would put too much force on the body. Another thing about muscle fiber recruitment to note is that to maintain work for a long duration, our body rotates the effort of supplying the needed force among different groups of motor units. This occurs so that some of the fibers contract while the other rest and when the fibers that have been contracting are fatigued, then the ones that were at rest cycle in and are used to maintain the force required. This principle of recruitment and cycling of muscle fibers shows why endurance training must be done for a prolonged time. Not all of the ST fibers for instance are active on a normal run at the same time. You need to run for a sufficiently long time in order to fatigue the first group of fibers, so that the next can cycle in, and so on. This allows for adaptations in the muscle fibers to occur in all of the ST fibers, not just a few. If a muscle fiber is not stimulated it will atrophy (or detrain.)

Speed needed to recruit muscle fiber types

Now that the reason that all muscle fibers should be trained, what speeds are required to recruit these different fiber types? It should be noted that the fibers are recruited in a ramp like effect. This means that as the force requirement is greater, the more fibers are recruited. So at 100% max force

requirement, you will actually be recruiting all three kinds (ST, FT-a, and FT-b). The following speeds show the minimum needed to produce adaptations and recruit them.

Muscle Fiber	**%VO2max needed to Recruit and Adapt**
Slow Twitch	greater than 50% VO2max
Fast Twitch-A	between 80-100% VO2max
Fast Twitch-B	greater than 100% VO2max

As you can see these speeds needed to recruit these fibers play a role in the workout types I will describe in the planning training section.

The Energy Systems

Your body and muscles use five different types of breakdown of fuels to produce energy. They are phosphagen system, aerobic lipolysis, aerobic glycolysis, oxidation of proteins, and anaerobic glycolysis.

ATP (Adenosine triphosphate) is the basic compound for which your body derives energy from. It consists of adenosine, which is an adenine molecule joined with a ribose molecule, and three phosphate groups. The adenosine and three phosphate groups are bonded with energy. An enzyme, ATPase, can release some of this energy by separating one of the phosphate groups from the ATP, creating ADP, which is an adenosine molecule with two phosphate groups. When the one phosphate group is separated by the enzyme, the energy that bonded it is released. Now that the molecule is ADP it can be converted back to ATP by adding another phosphate to it. This happens through a process called phosphorylation. The chemical reaction looks something like this, where Pi=a phosphate group:

Adenosine-Pi-Pi-Pi------>ATPase enzyme---->Adenosine-Pi-Pi + Pi + Energy

The Creatine Phosphate system

The phosphagen system is anaerobic, meaning it does not require oxygen, and it does not use the breakdown of fuels to produce energy. However, this system is Alactic, meaning no lactic acid is produced even though it's an anaerobic system. The energy produced by this system usually lasts for a maximum of 15 seconds. This system is used for brief bouts of intense work and plays an important role in sprint events. In this system ATP and CrP (Creatine Phosphate) work in unison to maintain a short supply of ATP. CrP is made up of creatine and a Phosphate group. An enzyme called Creatine Kinase is used to breakdown (or separate) the CrP into separate groups of Creatine and Phosphate. The separated Phosphate group is then added to an ADP molecule, turning the ADP molecule into an ATP molecule which can be broken down for energy. So you can see that in this system the energy comes from ATP being broken down to ADP with energy being released, then the phosphate group that came from the breakdown of CrP is added to the ADP molecule, making it an ATP molecule, and the cycle continues. So basically it's a cycle going from ATP to ADP back to ATP, etc. This continues until the CrP is depleted so that it can't convert ADP back to ATP. After the CrP is depleted another system must take over.

Anaerobic Glycolysis

The other system that does not require oxygen to function is the anaerobic glycolysis system. In this system there is an incomplete breakdown of carbohydrates as the fuel source. When the body breaks down the glycogen through 12 enzymatic reactions the end result is pyruvic acid, NAD (Nicotinamide **Adenine Dinucleotide)**, and two hydrogen atoms that are created, along with a small amount of energy (4 ATP, but it costs 1 ATP, so a net total of 3 ATP). It should be noted that glucose only produces a net total of 2 ATP during this because it costs 1 ATP to convert glucose to glycogen.

If there is enough oxygen present than these three things can then be moved to the mitochondria to create a larger amount of energy by converting the lactate back to pyruvic acid (36 ATP, more on the breakdown using oxygen below). During the breakdown of this glucose, oxygen is required for the removal of these Hydrogen ions from coenzymes (things that break down the glucose) to be able to regenerate and function. When there is no oxygen that can clear out the hydrogen, then another substance must do it for the continuation of the breakdown of glucose for fuel. This is where pyruvic acid is converted to lactate and this clears the coenzyme of its hydrogen ions and allows for glycolysis to continue. If there is not enough oxygen, then this turns into lactic acid. This lactic acid can either be buffered (anaerobic training increases a muscles buffering capabilities) or transported to the heart, liver, and muscle fibers (mostly ST or FT oxidative). This is important to know because it shows that muscles that are highly aerobic can clear lactic acid. If there is insufficient oxygen, then the lactic acid continues to get buffered and slowly builds up in the muscles. This lactate builds up in your muscles in the form of lactic acid. As more and more lactic acid is produced and the muscle becomes more acidic (i.e. the PH lowers), then its ability to function properly will severely decrease because the high acidity will impair the function of the enzymes used to breakdown the glucose and glycogen, meaning less fuel breakdown can take place. Also, the high acidity can impair the ability of calcium to bind to the actin, decreasing the muscles ability to contract fully. It should be noted that anaerobic glycolysis is 1/18 as efficient as aerobic glycolysis, meaning you are spending way more effort to produce less energy.

The acidosis is not necessarily caused by a build up of lactic acid. This has been the "traditional" viewpoint, but recent findings have shown that the acidosis is caused by other parts of glycolysis which release protons (hydrogen atoms) which then build up if not cleared. However, for coaching and training athletes this has little importance, because a build up of lactate still coincides with increasing acidosis even if it is not the cause. So, measuring lactate is still effective because of the relationship between increased lactate levels and the lowering of the pH to more acidic levels.

Aerobic Glycolysis

Aerobic Glycolysis requires oxygen so that full breakdown can occur. The breakdown of fuel sources aerobically goes through the same 12 enzymatic reactions mentioned above. The glycogen follows the same pathway as during anaerobic glycolysis, however the difference occurs when the pyruvic acid is created. After pyruvic acid is produced it is transported to the mitochondria (read above to see what this is) by several coenzymes. Then it gets converted into a compound called Acetyl Coenzyme A (Acetyl CoA). Once it is converted into this, then it goes through the Krebs cycle (or citric acid cycle). During this 10 enzymatic reactions occur resulting in the complete oxidation of Acetyl CoA. The result of the Krebs cycle is that the original substance is broken down and the end result is CO2, two ATP molecules, and a hydrogen molecule. As mentioned above in the breakdown of glycogen through glycolysis, hydrogen is released. In addition during the Krebs cycle hydrogen is released. This hydrogen increases the acidity of the cell if it is not disposed of. Since enough oxygen is present, two enzymes, NAD and FAD (Flavin adenine dinucleotide), transport the hydrogen atoms to the electron transport chain. During

the electron transport chain, the hydrogen is split into protons and electrons, and then ultimately the hydrogen combines with oxygen to form water. This prevents hydrogen build up and too much acidity in the cells. At the end of this electron transport chain, the electrons split from the hydrogen go through several reactions. At the end, they produce energy that allows for ADP to go through phosphorylation (adding a phosphate group to make it ATP). This results in a large amount of energy being produced. The total amount of energy produced by the breakdown of a carbohydrate with sufficient oxygen is 36-39 ATP.

Aerobic Lipolysis

Another system is the Aerobic Lipolysis, which is the aerobic breakdown of fats. Fatty acids can only be broken down completely (with enough oxygen) and can not be broken down incompletely (without enough oxygen) like carbohydrates can. Out of all of the fats in your body, only triglycerides are used as a major energy source. These fats are stored in fat cells and surrounding and in muscle fibers. To make triglycerides able to provide energy they need to be broken down through a process called lipolysis. During this process, an enzyme called lipases breaks down these triglycerides into three molecules of Free Fatty Acids and one molecule of glycerol. Once broken down, the Free Fatty acids serve as the source of energy. These FFA are broken down by the mitochondria in a process called Beta-oxidation. During Beta-oxidation the FFA are split into separate 2 carbon units of acetyl CoA. After it's broken down into acetyl CoA, the acetyl CoA follows the same cycle as the aerobic breakdown of carbohydrates mentioned above, as it goes through the Krebs cycle. The breakdown of fats requires significantly more oxygen because FFA contains more carbon that needs to be paired with oxygen to form the byproduct of CO2 (because as we mentioned above, when the fuel source is broken down with oxygen, the end results are ATP, H2O, and CO2). The metabolism of Fat produces significantly more ATP than does the metabolism of carbohydrate. For example the metabolism of palmitic acid produces 129 ATP. This is because of the increased amount of carbon per molecule. The increased amount of carbon allows for more acetyl CoA to be formed. But because of the increased carbon and the increase in oxygen demand per molecule of breakdown mentioned above, fats produce 5.6 ATP molecules per oxygen molecule used, while carbohydrates produce 6.3 ATP molecules per oxygen molecule used. Thus it can be seen that carbohydrate breakdown is more efficient when the use of oxygen is taken into account. Also, Fat breakdown can only occur with oxygen, thus it's seen mostly at lower intensity levels. In addition to this, the metabolism of fat cannot keep up with the demand of energy during higher intensity exercise. Essentially it's a slower process, thus this explains the "hitting the wall" feeling experienced by marathoners at around the 20 mile mark when they run out of glycogen stores and must use fat for energy.

Oxidation of Protein

Proteins are only used for 5-10% of our daily energy expenditures. The building blocks of proteins, amino acids, are what are used for energy. Amino Acids can be either converted to glucose (through gluconeogenesis), to pyruvate, or to acetyl CoA. After this occurs, the substance goes through the same aerobic breakdown as mentioned above. The difficulty with using proteins as energy is that they contain nitrogen. After breakdown, the nitrogen in these amino acids is either used to make other amino acids, or goes into your urine and gotten rid of.

We've talked about when you use aerobic and anaerobic systems during exercise, but how does your body determine whether it will burn fats, carbs, or protein for fuel? There are several factors influencing what fuel source your body chooses to use. The main factors are intensity and duration of the run. In general, the greater the intensity, the more your body uses carbohydrates as fuels. This only makes

sense after reading the above information as fats can not be broken down incompletely, so therefore once the intensity gets too high, carbohydrates are used exclusively because they can be broken down incompletely and without oxygen. Fats are used at very low intensities and actually supply the energy for most of your day to day activities. The problem with using Fat is that it requires more oxygen than carbohydrate breakdown does. At moderate intensities, duration becomes a bigger factor. The longer you go, the more fat breakdown plays a role. This happens because your body only has a limited amount of glycogen stored in your body. For example, a 143lb man with 12% body fat only has 2,563 Calories worth of carbohydrates available, while the same person has 74,833 Calories of Fat available. This shows the carbohydrate stores can easily be depleted while there is plenty of Fat to fuel your muscles. Thus long runs are important as it teaches the body how to function when more and more Fat breakdown is being used as fuel.

The use of different Energy systems in races:
200m run: 29% aerobic; 71% anaerobic
400m run: 43% aerobic; 57% anaerobic
800m run: 66% aerobic: 34% anaerobic
1500m run: 84% aerobic; 16% anaerobic

(Source: Energy system contribution during 200- to 1500-m running in highly trained athletes. M. Spenser and P Gastin. Med. Sci. Sports Exerc., Vol 33, No.1, 2001, pp 157-162)

The chart above can assist in telling you what systems need the most attention depending on what event you are training for. In general, the program outlined below can be used for 1500 to 10k runners, but it is just a general outline. A little tweaking is needed if you are on the low end 800/15 or the high end 10k of the training program. But still almost always there needs to be a balance between all systems.

Interaction between energy systems during a race

If the 1,500m is about 80% aerobic and 20% anaerobic, then what are the contributions from each system during the race? This is one of the most misunderstood concepts by athletes and coaches alike. They assume that since the athlete gets more tired as the race progresses and sometimes "ties up" that the race must be predominately aerobic at first, and then get anaerobic later on as the race progresses. This is FALSE. It actually occurs the other way around.

As you start the race, their is a very high demand for energy, as you went from a standing start where your muscles were inactive, to running at a fast speed and utilizing lots of different muscle groups. In fact in sprints, the demand for ATP(energy), can go from resting level to a demand 100 times basically instantaneous. To meet this demand, all three of the energy systems switch on at the exact same time (aerobic glycolysis, anaerobic glycolysis, and creatine phosphate). The first thing to understand is that from rest the aerobic system takes 1-2 minutes to reach maximum capabilities to produce ATP. There are two basic things that come into play when looking at energy system contribution:

1. The start of exercise-because there will be a mismatch between the demand for ATP and that produced.
2. In exercise over the maximal rate of aerobic energy production (over 100%VO2max).

At the start of exercise, the more intense the effort, the larger difference there is between the resting level and the demand for energy. So at low intensities, the demand between ATP produced and ATP

demanded is relatively small, so it takes little time for the aerobic system to rev up and meet that demand without much assistance from anaerobic or Creatine Phosphate systems. At faster and more intense speeds, that difference between ATP produced and ATP demanded increases. So the aerobic system takes longer and longer to be able to rev up and produce the amount of ATP that is needed. Well, to fill in for it until the aerobic system gets to max intensity, creatine phosphate and the anaerobic system are used to satisfy the muscles demand for ATP. Think of these two systems as picking up the slack for the aerobic system until it is fully charged.

At speeds and intensities that require ATP production at a rate higher than that which can be produced by the aerobic pathways the beginning is the same, but instead of the aerobic system taking over once it's revved up fully, the anaerobic system must prop up the aerobic system to cover for the difference in ATP demanded by the muscles and that provided by the aerobic system. So at the start of the exercise, the CP and anaerobic system produce the ATP and gradually the aerobic system takes over more and more of that production, but at these speeds it can never take over fully because it maxes out and the demand for ATP is higher than the max ability of the aerobic system to produce ATP, so the anaerobic system covers that difference.

So, you're probably wondering why people say your going "anaerobic" at the end of the race. Well that is technically wrong. What really could be happening in most cases is that the anaerobic system is "failing". It can only prop up the aerobic system for so long and because of the byproducts (lactate, hydrogen ions, etc.) produced, fatigue sets in. So at the end of the race, your really not going anaerobic, just the effects of having the anaerobic system prop up the aerobic ATP production for so long are starting to show.

For a 1,500m race the sequence looks a little like this:

Remember that the creatine phosphate system can deliver energy to the muscles the "quickest" as the other systems take a little bit longer to get to full intensity or power. So when the runner starts the race, the creatine phosphate system is the primary energy systems for a couple of seconds. After this, the anaerobic system, which is the next fastest to get to high intensity, becomes the predominant energy system. It supplies most of the energy until about 30 seconds. At this point the aerobic system has begun to catch up to the demand, and from this point on the percent of energy coming from the aerobic system increases where at the end of the race it supplies between 85-90% of the energy, with the anaerobic system supplying the rest. The aerobic system needs about 50-90 seconds to become fully activated. At the very end of the race when the athlete tries to kick it in and increase his speed, a slight increase (by only a couple percentage) is seen in the usage of anaerobic energy.

Another way to look at it is in looking at the percent intensity of each process throughout the race. This shows how "hard" each system is working throughout the race. The creatine phosphate system reaches its max intensity within a couple of seconds and then quickly declines. The anaerobic system reaches its max intensity at a little over 60 seconds, then diminishes.
(source: various talks with physiologists, **Energy system contribution to 1500- and 3000-metre track running.** by Duffield, et. al. Training My Way by Harry Wilson)

Running Economy:

Running Economy (RE) is the amount of energy needed to maintain a specific speed. It is found by measuring the amount of oxygen consumed (VO2) at a certain steady sub maximal (meaning under LT) pace and looking at the respiratory gas exchange ratio. Once you get above the LT pace your VO2 no

longer reaches steady levels as it is increasing, and therefore running economy can not be measured. The lower the ratio of VO2 to running pace, the better the Running Economy, or in simple terms the lower your VO2 is at a certain pace, the better your RE. Running economy can be improved over time through various training mechanisms. It can be improved through the improvement of your form and efficiency and an increase in capillary density. Also an increase in mitochondria and enzymes in the muscles has been shown to improve RE. Why is RE important? Because runners who have a good RE use less energy and oxygen then a runner who has a poor RE at the same pace.

Fatigue

Fatigue during exercise depends on several factors including the duration and intensity of the exercise. The issue of fatigue is not clearly solved yet as there are many factors involved. Some of the things that seem to cause fatigue are depletion of energy systems and fuel sources, lactic acid build up, the Central Nervous system, and muscle fiber failure.

Storing of Carbohydrates and Glycogen Depletion:

The amount of carbohydrates that your body can store to use for glycolysis is dependent on a couple of factors. First off, training can affect the amount of glycogen that can be stored. The amount of glycogen stored in a leg muscle in a trained person (after a 1-2 day rest period to allow the glycogen stores to replenish themselves, since training depletes them) is about 2.5 times as much as that found in an untrained person. Another factor is diet. A high Carbohydrate diet has shown to increase glycogen stores by about 50% in a trained person compared to that same person eating a low carbohydrate diet (Thus don't go on the Atkins diet if you want higher glycogen stores).

Glycogen depletion occurs when you exercise. The glycogen is used to produce energy (ATP) as described in the above sections. Then depending on recovery taken and the intensity of the exercise the glycogen stores are slowly replenished. In general the higher the intensity the more rapid glycogen depletion occurs. Therefore high intensity interval training with rest periods causes rapid glycogen depletion. The reason this occurs in interval training is because the rest periods allow for a degree of recovery that keeps the muscles from lowering the PH by too much, which would limit the muscle contractions. During long sub maximal running for over 2 hours, glycogen depletion is also severe. For instance the amount of glycogen from before a marathon to after running a marathon can fall from as high as 36g per kg of glycogen to about 4 g per kg if no carbohydrate supplement is taken during the run. Where does this glycogen depletion occur? Well for extended long runs, depletion occurs the most in ST fibers, followed by FT oxidative fibers and then with smaller amounts in the FT type IIb fibers. This occurs because as glycogen is depleted in the preferred muscle fiber type, it then moves to the next most preferred to use its glycogen stores and so on. Once glycogen stores are depleted, then your body switches to using Fat. This is where most people hit the wall. Fat requires more oxygen to be metabolized and is slower in generating energy for the muscles, thus a slow in the pace when runners "hit the wall" in marathons. After a marathon it's been shown that FT oxidative and ST fibers can be completely glycogen depleted. During intense training, that done higher than VO2max pace, it's the opposite. FT type IIb shows the greatest amount, then FT oxidative, and then ST. During east or recovery runs, ST fibers are the most depleted.

Recovery of Glycogen stores is very important, as will be mentioned later in the anaerobic training section. It takes between 24 and 72 hours to completely restore your glycogen levels after intense anaerobic intervals. After normal runs, glycogen stores should recover in less than 24 hours. Diet has a very high effect on replenishing the glycogen stores. Studies have shown that consuming a high

carbohydrate and protein food or drink after exercise speeds up the rate of glycogen replenishing. The reason recovery is so important is that if your glycogen stores are not replenished to maximum, that means that you can not perform the race or workout at maximum intensities because you will deplete your glycogen stores faster since there is less to start with, and have to use additional fuel sources, meaning slower times. Therefore if your not recovered you do NOT get the optimal benefit of the workout and you will just be depleting your glycogen stores more, meaning that you not only have to recover enough to get them to pre workout levels but you also have to recover enough to get them to the levels of before two workouts ago. Thus being fully recovered for training is important.

Lactic Acid

Lactic Acid is a by product of anaerobic glycolysis (Refer to the anaerobic glycolysis section for more information). Since it is produced during anaerobic breakdown, then Lactic Acid has a pretty linear relationship with limiting performance during intense exercise above the Lactic Threshold. This means that increased lactate may not cause the acidosis, but it is a good indicator of the amount of stress put on the muscles as increased lactate levels coincide with an increase in acidosis. Because it only occurs at more intense paces, longer races aren't affected by a build up of lactic as much as a depletion of fuel sources. For example, after a marathon, it's been shown that Lactic Levels at the end are near resting levels and have not spiked. Although Lactic Acid is often blamed for fatigue, it should be noted when there is sufficient oxygen it is actually used as an energy source. When the lactic can not be cleared however, it is converted to lactate, which causes an accumulation of hydrogen. At first this hydrogen is buffered by bicarbonate, but as more and more accumulates the high amounts of Hydrogen cause the muscle cell to become more acidic, and eventually limiting the use of the muscle. The acidity in the muscle can drop from a resting level of 7.1 PH to 6.4 PH in intense exercise. This drop inhibits the ability of the muscle. For example a PH below 6.9, inhibits enzymes used during glycolysis, thus slowing the rate of glycolysis, meaning less energy is being produced as fast. Also at PH's of 6.4 or lower, the acidity stops glycogen breakdown. In addition to this, it can affect the contractile strength of individual muscle fibers.

It's important to know that the acidity is probably what limits performance, lactate levels are just a useful marker for seeing this.

Muscle Fiber Failure

Another cause of fatigue is the inability of muscle fibers to be recruited or to "fire". This can be caused by a disturbance in the normal system of muscle contraction (explained above). What happens is that for some reason the process of the nerve impulse getting to the muscle fiber to signal a release of calcium to unblock the myosin and actin molecules so that they can interact is inhibited. Thus the fibers don't contract if this sliding and interaction of the myosin and actin can't occur. This can be caused by several things. First off there could be a reduction in the nerve impulse that signals the calcium release. When this impulse isn't strong, then the fiber won't react and muscle contraction can't occur. Another thing that might contribute to it is a lack of calcium available to release the blockade between the actin and myosin.

The Mental side of fatigue (CNS)

I'm sure that most of you have always heard that you can give 110% or push beyond your limits. Well this actually makes some sort of sense. Studies have shown that your brain tells you that you are fatigued and should shut down before your muscles and the rest of your body has actually reached its

maximal working rate and is ready to shut down. Thus it can be said that your mind always tires before your muscles, so you can always push beyond the limits of your mind telling you to slow down and that you're tired. There have been numerous studies showing that saying such simple things as "I feel great" or "I'm relaxed" during hard training allows you to go further than if nothing is thought or said at all. This just reinforces the whole idea of positive thinking, showing how powerful your mind can be. It's not exactly known why this effect takes place but one explanation is that you can force yourself to recruit muscle fibers. When an athlete enters a highly exhaustive state, your ability or desire to withstand more pain isn't at its highest. This is the point where you either give in or slow down or keep fighting. Studies have shown that when an athlete hits this feeling of exhaustion mentally, his muscles are not physiologically exhausted, meaning that there is a little bit more left in the fuel tank. Thus, it's been hypothesized that positive mental thoughts and training to endure high amounts of pain, allows you to recruit and use your muscle fibers to a more maximal level. This shows the importance of positive mental thinking, or "mental toughness," because your mind will always quit before your body.

Starting out (Developing a training program)

I start out by breaking down the year into two periods, a cross-country and a track period. This means that I am working on a two peak per year system, but with the emphasis on track. After this I break the seasons down into three categories. They are the Base period, the pre competition period, and the competition period. When creating a program, I work backwards from the race I want to peak at each season. From there I go backwards six weeks and that is my competition period. The six weeks preceding it is my Pre-comp period, and the time before that, let's say 12 weeks is my general period. I also factor in about 4 weeks of racing or sharpening after the competition period during track season.

So a typical season looks like this:

-Base (12 weeks)
-Pre-Comp(6 weeks)
-Competition (6 weeks)
-Racing (up to 6 weeks)

Before I go into each specific period there are some key points to keep in mind:

- Keep in touch with all paces and systems throughout most of the year
- Try and keep it at a maximum of 3 hard workouts per 10 day cycle. (NOTE: Training isn't just hard and easy, there are also medium days and other varying degrees of difficulty and stress used when running.)
- stay in touch with all three muscle fiber types (Fast twitch, Fast twitch oxidative, and slow twitch)
- I wouldn't suggest more than three Lactate Threshold runs per week if you do not have a sufficient aerobic base to back it up (i.e. most Americans under the age of 25 or so). I feel that this can be just as harmful as doing too much anaerobic work per week.
- Try to balance out working on all energy systems and muscle types and don't focus on solely one type.
- If you do not work a certain system of training within 10 days it will start to deteriorate, so it is important that you stay in touch will ALL systems.
- In general, your body will adapt to what you do.

- The reason we run intervals is because it allows you to run at that certain level or speed for longer than you would be able to if you just ran one repetition. It's an easy concept, but needs to be grasped. Running a 10min threshold is far less superior to running 4x5min at LT as an example.
-

Developing a Training Cycle:

Adaptation to a Training Stimulus

What do I mean by a training stimulus? This is the type of stress you put on your body. For instance running easy to moderate mileage would be used to stimulate the aerobic development of your slow twitch muscle fibers. It would stimulate these fibers to increase mitochondria, capillerization, etc. This is just one example of a stimulus. Others include anaerobic training, lactate threshold training, and the other workouts described in the sections below. It is important to know how the body adapts to this stress put on it.

When adapting to a new training stimulus, your body adapts quickly at first before then leveling off and stabilizing. According to scientist and Coach Jan Olbrecht, this quick adaptation takes place within the first 2 weeks. After this the response to the stimulus begins to stabilize and flatten out, after the initial sudden rise. This stabilization occurs from 3 to 6 weeks. After this you have to increase the stimulus to get further adaptation. So to do this you can either increase volume, intensity, frequency, or environmental change (i.e. altitude) to the stimulus. So to give you an example, if you start doing lactate threshold work once per week and you do this for 6 weeks, the first 1-2 weeks your body will adapt to the work pretty quickly and then it will level off somewhat until it reaches a flat rate. So from week 3 to 6, you have to allow for stabilization of the adaptations that took place quickly in the first 2 weeks or so to occur. After this 6 week period, then you might do 2 LT workouts per week to enhance the stimulus, then after another 6 weeks, change something else up.

According to Olbrecht, the 3-4 week stabilization is crucial to development because this period allows the adaptation that took place in the first 2 weeks to stabilize, or in other words it allows the training to "sink in." This is one of the reasons that you will notice that the training described below is broken into 6 week cycles generally. The emphasis changes every 6 weeks to promote further adaptation and prevent you from doing work without getting real benefits. The only period that is longer than 6 weeks is the base period, but during this period, the training stimulus will be increased gradually as it goes from a period of just mileage, to one containing LT work (which can be increased half way through the period), and other things such as hills and sprint work. This principle of training adaptation is crucial in planning out a training program, as it shows that spending too much time doing one thing (such as spending months jogging just mileage and nothing else), will not lead to further adaptation by your body.

This brings the question of how long does it take for adaptation to occur. This is a tough question to answer but in general structural changes and muscular adaptations take a much longer time to adapt than neuromuscular and metabolic changes. Structural and muscular changes include things like an increase in mitochondria or capillaries or an increase in aerobic or anaerobic enzymes. These changes take 6-8 weeks or longer to occur. That is one of the reasons why the base period is the longest and endurance training takes up the majority of the time during a training year. Adaptations that are neuromuscular include a better muscle fiber recruiting pattern. Metabolic adaptations that involve the blood stream and clearance of lactate and H+ generally take 10-20 days for adaptation to occur. This includes aspects

such as increased blood volume and lactate removal (Maglischo 2003). How long an adaptation takes to occur also gives us insight on how long it can be maintained. The longer it took to build up, the longer it can be maintained with reduced training. This fact must be taken into account when planning training.

The Recovery Deficit and the importance of down weeks:

It is common for coaches and athletes to divide their training year into different cycles (macrocycle, microcycle, etc.). This division occurs from general to specific. The first major cycle is the big season, for instance track or cross country. After dividing the year into seasons, the season is broken down further into cycles based on the major emphasis of training during that period. For instance a Base phase or competition phase would be the next subset of cycles that the season is broken down into. Within these phases, you then have weekly cycles that can be manipulated. Within these weekly cycles are the daily cycles which contain what you are actually going to do on a day to day basis.

The focus of this brief discussion will be on the cycles of Base, Pre-competition, Competition, and Racing Periods. The length of these periods depends on how much emphasis needs to be put on them for the development of each aspect. It also depends on how long a particular aspect takes to build up. For example, anaerobic development seems to occur more rapidly than development to improve the aerobic systems. Because of this, a longer period focusing on the aerobic system would be called for.

Within these periods, you have what is called a training (or working) phase and a recovery phase. For the following examples we will use a total cycle of 6 weeks. During the training phase, the emphasis is put on stressing the body so that it has to adapt to the training stimulus applied to it. The stimulus has to be strong enough to "overload" the system and force it to adapt. During this training phase the body is being broken down during workouts and then built up during the rest and recovery runs in between the main more intense sessions. However if the athlete is training at a high level, he will most likely not be able to, nor should he try to, get complete recovery and adaptation from a particular workout before he starts another one. This means that the body will break down during training and then repair and adapt to a suitable level to begin to train hard again. Since the athlete is training hard during this period, then he won't get the full super compensation effect (the effect where the body is stressed then allowed to recover and to increase it's adaptation to take the physiological aspect up a notch). The athlete has to for go full allowance for super-compensation because it would take too long to wait that long after every workout and he wouldn't be able to get the work in that is necessary to take him to the next level.

This training without full recovery creates a kind of recovery or adaptation deficit that needs to be paid back at some time. If the deficit is not paid back, then the athlete will never fully adapt to the training he has put on his body, and super-compensation will not occur. The athlete will only beat his body up further without enough recovery to take him to the next training level. This leads to overtraining.

To allow for this super-compensation or adaptation to occur, the athlete must insert a short period that allows for the athlete to repay the Recovery Deficit and allows his body to make all of the necessary repairs to fulfill adaptation. This period is what is called the Recovery Phase of the cycle. Coaches sometimes refer to this as a down week. It should consist of fairly significant reduction in training volume and intensity. The amount of mileage drop depends on the person and period, but in general a 20% reduction in mileage should suffice. As far as intensity goes, very few to no very hard and intense workouts should be done during this phase. That means, no full blown lactate tolerance workouts (anaerobic), or full blown VO2 workouts. Depending on the time of year, maintenance workouts of these two can be done, but it's not highly recommended. Some pure sprint work or anaerobic capacity workouts can be done so that the recovery phase isn't just easy mileage. Also, a reduced Lactate

Threshold session can be done in certain cases. A race can be done at the end of a recovery phase and in fact it may be beneficial to plan your recovery phases around meets that are somewhat more important.

A lot of what can be done depends on how long the recovery phase is. A recovery phase can last from as little as 3 days to as much as 2 weeks, with most falling in between at the one week length. For a short recovery phase of 3 days, almost all of it should be recovery to easy running. For a longer 2 week phase, some workouts may be included. Now how do you decide how long your recovery phase should be?

It depends on the length of time the athlete has been training without a recovery phase, and the intensity of that work. That is what determines the Recovery Deficit. In essence, the athlete needs as much time as needed to repay the Recovery Deficit that has been built up. The longer the amount of time without a recovery phase and the more intense the work, the longer recovery phase will be needed because the deficit is larger. As an example, during a base phase an athlete may take only a 3 day recovery phase because the training isn't that intense and there is not as much of a Recovery Deficit to pay back. If the athlete has been doing heavy anaerobic work for 6 weeks, the recovery deficit will be larger and a week might work better.

In many ways the recovery week is used as a prevention measure against Overtraining. In general a 6 week training cycle should be a 5 week training phase and a 1 week recovery phase.

Most of the time a week is the best choice for a recovery phase. If the athlete is unusually fatigued or showing signs of overtraining, then more time should be given, but I'm going to assume that the athlete is feeling and training normally. An example of a recovery phase that lasted one week would be:

Week	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Recovery	Recovery Runs	Easy Runs	Easy plus short sprints	Recovery Runs	Easy plus maintenance/ reduced LT workout	Reduced Long Run	Easy/Recovery Run

The Key Ingredients to a Training System

In looking at any given successful training program, a couple of key ingredients can always be found. They are as follows:

- Aerobic Training- Easy to medium paced running that forms the foundation of your system
- High-End Aerobic Training- Training at the very upper edge of the aerobic running. Includes Lactate Threshold running
- Aerobic Capacity Training- Training done to increase aerobic capacity. Usually 2-8minutes repeats in length with equal to near equal rest run at between 3k and 10k pace. Includes VO2max training
- Anaerobic Training- Training of the anaerobic energy system whether with Anaerobic Capacity or Lactate Tolerance training. These repetitions are fast and very taxing.
- Alactic training- Training that focuses on the Creatine Phosphate energy system. Used to develop pure speed and sprint ability. Can be done on hills
- Strength training- Whether it's through circuit training, form drills, plyometrics, or simply running up and down or on hilly courses.
- Recovery-Easy jogs or rest meant for recovery

These are the ingredients to any successful training program. As long as you mix these ingredients you will most likely get some sort of success. However, the key is to determine the right amount of ingredients for each athlete to be mixed, and where and when to mix them. To use an analogy, it's like baking a cake. As long as you put in all of the right ingredients to bake a cake, you will most likely get something that resembles a cake when you are done baking it. If you put in too much of one ingredient, it might barely resemble a cake in appearance as it might be too runny and not solid, or it might taste too sweet or sour, or it might be too crunchy if too much sugar is added. The key to baking a good cake is finding how much of each ingredient to put into it and when to put them in. For example, if you put your icing on too early before you bake the cake, it will turn into a big mess. This is similar to doing anaerobic work before a significant aerobic base is built up. Finding the right combination of ingredients for the perfect cake will take a lot of time and trial and error. The above ingredients will get you a superb cake if put together perfectly, but you can make it even better and more tasty with perhaps additional toppings such as more icing, strawberries or chocolate on top, whatever. This is similar to in training in adding nutrition, stretching, sleep, etc. These things top off your training. Even if you follow the best cook book exactly, sometimes it doesn't turn out the way you hoped. This also happens in training, but if you follow the best cook book, you have a higher chance of success than if you just randomly threw the ingredients together with no prior knowledge or experience of knowing how much of each to use. Thus in training before you start any program, you should look at it and see if it includes all of these ingredients for success. If it does not and it seems to be lacking, then you need to address this need, as you will not optimize your results without touching base with all of these. Now how do we figure out how much of each ingredient to use? Well I've tried to outline a general plan below.

Balancing The Training and Conflicting Effects of different workouts:

This is such an important concept that I inserted it near the front of this section. It may not make complete sense if you have not read through various sections of the training guide, so it will probably be wise to reread this section once you have completed the others.

To simplify the discussion I'll break down the training into a couple sections so that we can look at how each training type interacts with the others and what effects they have on each other. Too often workouts are looked at individuality and how that particular workout interacts with other training factors is ignored. The five training aspects we will look at are:

- Lactate Threshold-definition in the text
- Aerobic Endurance (also called aerobic capacity)- measure of your Aerobic abilities and how strong the aerobic system is.
- Aerobic muscular endurance- Your aerobic power or how well you can use the aerobic system that you've built up.
- Anaerobic Capacity (Also called Lactate Production)- How much energy you can produce anaerobicly.
- Anaerobic Muscular Endurance(Also called Lactate Tolerance)- Your anaerobic power or how well you can use the anaerobic system. Includes how well you developed your buffering capacity of Hydrogen ions is.

How these particular aspects interact with each other varies based on workouts. Some workouts will increase a particular aspect while others will decrease it. This interaction has been well studied and documented in such books such as **Jan Olbrecht's work The Science of Winning**. For a more in depth discussion, I highly recommend this book.

First off let's look at the types of workouts mentioned in the training section and then we will see what they improve and what they harm.

Normal Aerobic Runs- Normal endurance training generally hurts Anaerobic Capacity. This occurs for several reasons. First off aerobic running causes a greater reliance on the aerobic system. It slows the rate of contraction and the rate of anaerobic breakdown in FT and some ST muscle fibers. Also, endurance training can suppress anaerobic enzymes and reduce the size of FT-b fibers. Besides the suppressing effect it's important to note that FT-A and FT-B fibers are rarely stimulated during aerobic runs. Thus the lack of use of these fibers could explain a detraining of them if they are not worked on in some other way. What all this means is that too much aerobic running with not enough training to maintain the anaerobic capacity will lead to slower pure speed.
Obviously, normal aerobic runs enhance aerobic endurance and can also enhance lactate threshold. To see why this occurs go to the Physiological_Benefits_of_Normal_Runs section.

Lactate Threshold Runs- Threshold runs enhance the Lactate Threshold and Aerobic endurance. This occurs for a variety of reasons that are explained in the Physiological_Benefits_of_Lactate Threshold Runs section. Like aerobic runs however, running at threshold suppresses and slows the rate of anaerobic metabolism. This occurs for much of the same reasons mentioned above. In addition to this too much threshold running can harm anaerobic muscular endurance in some cases.

VO2max- VO2 work is that which includes 3k-10k paced workouts. In general this work will increase the aerobic muscular endurance as well as anaerobic muscular endurance. In some cases, because FT-b fibers are stimulated it can improve the aerobic endurance of these fibers. However this is off set by an increased reliance of the ST fibers on anaerobic pathways. Because of the body's increasing reliance on anaerobic means during this work and the fact that lactate levels can reach somewhat high levels, too much or too hard VO2 work can reduce aerobic endurance. It will harm the anaerobic capacity.

Anaerobic Capacity- This type of work refers to pure speed work and is commonly called lactate production training. The main benefit of this work is that it will improve your anaerobic capacity, your ability to produce energy anaerobicly, and thus maintain sprint speed. Anaerobic Capacity work can decrease your aerobic endurance because of an increase reliance on anaerobic energy and an increase in the activity of the enzymes and other variables associated with the anaerobic system. Because of this increased reliance on anaerobic energy, this work can lower your Lactate Threshold. These workouts will have little effect on anaerobic muscular endurance because the repetitions are short enough that little lactate is produced thus buffering isn't stimulated.

Lactate Tolerance- These workouts have the main benefit of increasing buffering capacity and thus anaerobic muscular endurance. The lactate levels are too high for an improvement in aerobic endurance to occur and these workouts can in fact harm it. Also, these workouts will harm anaerobic capacity. In fact if too much of this type of workout is done it can also hurt anaerobic muscular endurance. Therefore it is best to limit this amount of work to that which will bring the athlete up to the needed levels in buffering capacity and only emphasize this workout type for a couple (4-6) weeks at a time.

Before you start:

I have broken the year or season down into cycles in which different things are emphasized. The program shown below is a basic outline of what normally takes place during these periods, but it will vary based on how the individual responds to training and what race the individual is focusing on. You

will find more information on how to individualize the program in later sections. Individualization is VERY important and it is never wise to follow a "train by numbers" program. Even working out at these training "zones" or intensities that I described will have different effects. For instance an elite runner with a Lactate Threshold at a higher % of his VO2max will recruit more FT fibers and therefore train them more aerobically at LT pace then a beginner runner whose LT is a greater % away from VO2max.

Thus, before you start there has to be a long term plan to accomplish different things at different times of the year so that all aspects will balance out in the end for a fast race. This balance depends on the individual and the race. For example a 1,500m runner will need a much higher Anaerobic Capacity (maximum anaerobic energy generated) than a 10,000m runner. Thus, the 1,500m runner would worry more about doing too much running that suppresses the Anaerobic Capacity without enough AnCap training to maintain it. The 10,000m runner might purposefully try and suppress his AnCap before racing, therefore AnCap training would be rarely done.

Base Period

Mileage Build Up

The purpose of this period is to build your aerobic endurance and get your body prepared for the stress you will be putting on it later. By running easy to moderate paced runs you are running entirely using the aerobic system, which is your body's preferred system. Running aerobically is incredibly more efficient in creating energy than running anaerobically. During this period you are increasing your amount and size of mitochondria, increasing capilirization, and working both your slow twitch and fast twitch oxidative fibers. This period is laying a foundation for the work to be done later. In this period, you will start by building your mileage to a high level. I myself build up to about 110mpw. I suggest building to the most that you can do with still being able to have some spark in your legs where you are not slogging through all of your runs. In my opinion this is a minimum of 60mpw for someone over the age of 16. When building mileage there will be periods of time when you will feel tired or sluggish, but this feeling should go away as your body adapts to the increased load. When increasing the amount of mileage you are running, it's important not to increase the intensity at the same time. Try and do most of the runs by feel during the mileage building period. When increasing mileage I prefer to do it by adding 1 mile per day of running.

An example of how I would suggest to someone who has previously run 50mpw successfully and now wants to run 80mpw is the following build up after the season:
40, 50, 57, 64, 70, 70, 77, 84, 84

I'm guessing once you hit about 70, or sometime around then, you're going to feel tired and sluggish. Thus don't increase the mileage for a week when this happens, and let your body adapt to it, BUT make sure you get the mileage in, b/c eventually you will adapt and you'll feel normal again.

How much mileage?

This topic is up for debate. High or Low? First off, look at the benefits of high mileage. It only makes sense that the more you run, the better you get at it. The benefits of aerobic running are enormous and with more mileage you are able to get more of these benefits because of the increased workload. In addition to this you become more durable as the more stress you put on your body (gradually), the body

will adapt to it. For instance I've found after a couple years of high mileage running that I no longer have to worry about a slow mileage build up. Since I've stayed consistently high for so long, 60mpw seems like I'm doing nothing and is a huge taper for me. Of course there is probably a point of diminishing returns, so I wouldn't suggest go out and run 300mpw. What I do suggest is to build up to the near maximum you can do while still being able to do the workouts required of you and feel fresh on occasion for normal "easy" runs (I'm not talking about feeling fresh for recovery runs after workouts). If you still have enough zip in your legs to feel like you just want to drop the pace one day, then that's a good sign that your not overworking. How much is this for you? Well I don't know and the only way to find out is experiment. You should be able to read your body well enough to find this point. It should be noted that just because you feel bad (sluggish) the first week you are at a new mileage week, doesn't mean you've gone to high. You could just need another week to adapt to it. Now if you still feel sluggish after a couple of weeks then that's not a good sign.

I don't really want to arbitrarily throw numbers out there for you to follow because each person is different, but I'd suggest something along the lines of this:

14yrs old- 40-50mpw
15yrs old- 45-60mpw
16yrs old- 55-80mpw
17yrs old- 70-100mpw
18yrs old- 80-110mpw
19+- 80-120+mpw

Those are just arbitrary numbers of the amount of mileage you should be able to handle during your General or base period. As you stop growing the amount of mileage you can handle should increase a bit.

Transition: Just a small note: Going from one period to the next, or any time adding intensity requires a transition to make things go smoothly. If you just jump right into adding lots of different things, most likely you will get hurt, because your body hasn't been given time to adapt to the new thing. During this transition from mileage to the General period, it's important to slowly work in the following workouts. To transition into LT work, I like to do what I call a submax run. It's basically what others call a progression run. I do the normal distance of my easy runs, let's say 8 miles, and start out at my normal pace. I'd gradually pick the pace up as I felt like it until the last mile was at close to but a little under LT pace. This will help prepare your body for later LT workouts. For transitioning into pace workouts, start out with strides, then increase the distance and pace. For hill workouts, start out with strides up the hill, then add intensity until you are running them at sprinting speed.

Endurance Training

The purpose of endurance training is to cause aerobic adaptations in the muscles and cardiovascular adaptations. Muscle adaptations include an increase in mitochondria size and number, an increase in capillaries, an increase in aerobic enzymes, and many other adaptations. Basically you are trying to improve the aerobic capacity. Cardiovascular adaptations include and increase in cardiac output or stroke volume through changes to the ventricle sizes. I categorize endurance training as anything below the point where lactate production exceeds lactate elimination (the Lactate Threshold). Therefore, endurance training will include Normal Runs (NR), Recovery Runs (RR), Long Runs (LR), and Lactate Threshold (LT) workouts.

Normal Runs and How Fast Should They Be?

This question provokes one of the biggest debates among coaches and athletes. Should easy/normal runs be run as fast as possible or should they be kept nice and slow? It's a tough question to answer and depends on the individual athlete, but I will give my two cents and what I feel is best.

The thing to learn is that while easy runs are vitally important they are secondary in the big picture to the specific "workouts" that are planned. It fascinates me how many people get caught up on the whole idea that normal runs have to be at such and such pace, when in fact they aren't the key ingredient. They are put in there in between runs for specific reasons. Let's look at what the purpose of normal runs are. During intense training one of the reasons is for recovery benefits. Doing an easy run is very beneficial to the whole recovery process and this can not be denied, so I won't spend much time on this. The other purpose of normal runs is to increase the aerobic system, both cardiovascular system and muscular system. As discussed in other sections, normal runs help increase mitochondria content, capillerization, etc. If we look just at increasing mitochondria content it can be seen that this happens depending on intensity and muscle fiber type. If the purpose of the run is to get aerobic adaptations in slow twitch muscle fibers, then it doesn't matter a whole lot if the intensity is low or medium as slow twitch fibers are fully activated even at low intensities. Studies have shown that at low to medium speeds (from about 45% to 75% Vo2max) that an increase in mitochondria content level out at the same max values. The difference is the amount of time it takes to reach these maximum increase values. Just to give an example, you might reach the mitochondria increase ceiling level in 35 minutes at a speed of 75% VO2max, while you might reach this ceiling level in 50 minutes at a speed of 65% VO2max (these are arbitrary numbers and do not reflect the paces it takes to reach the ceiling). To produce a further increase in mitochondria, you have to recruit Fast twitch oxidative fibers, so that they can get aerobic adaptations. You can only recruit these FT-A fibers with substantial stimulation, meaning higher intensities. This has been shown to occur somewhere around AT (marathon pace) to LT. So let’s say your AT is at 5:20 pace. If you run at 5:35 pace all your doing is recruiting ST fibers and getting adaptations because the intensity isn't high enough to recruit FT fibers. So you might as well be training at 6:30 pace, because full ST fiber recruitment will be taking place there too. If the goal is to train FT fiber oxidative abilities then go run an LT session. If it's not, then don't run at a high intensity that's doing little benefit as a slower more comfortable run could do.
To sum this up a quote from Jan Olbrecht's book Science of Winning:

"Research has shown that these slow twitch muscle fibers are fully activated even at low and medium intensities...Higher training intensities will not recruit additional mitochondria in the slow twitch fibers...thus more intensive training will not lead to a larger training effect in the slow twitch muscle fibers..."

Of course this is just looking at one physiological variable of increasing endurance, but the point of it was that, the easy or normal run should serve a purpose. If the intensity is low in your training schedule such as a period of mostly just mileage, it is okay to increase the pace slightly and run at a faster pace to establish some cardiovascular fitness. However, when real training commences, the purpose of these in between runs is clear. It's to facilitate recovery and work on or maintain the aerobic system between specific workouts. That's why the most important thing is to define what you are working on. If you are just using them for recovery and maintaining the aerobic system, then they should be done comfortably. As I showed above you have to increase the intensity substantially to activate the fast twitch muscle fibers to get them to develop aerobically, and if you were trying to do that, then you would just schedule an LT workout, instead of trying to hammer an "easy" run. For a high school athlete, if 7 minute pace

feels comfortable, why increase the effort to run 6:30 pace when that's not the point of the run and it will only make you more tired for the upcoming workout. If the runs in between the workouts are hurting the workout itself then they are being done to fast. Every run needs to be looked at independently to see what the goal is. If it's to increase LT, then do an LT workout, if it's to recover, then go jog, if it's to maintain the aerobic system, then go run a comfortably 7 miles. Don't "hammer" an easy run if that's not the purpose, save the faster running for when it is the purpose.

Physiological Benefits of Normal Runs:

The benefits of normal/easy runs are the following

- -increase stroke volume and cardiac output (which doesn't happen effectively at higher end aerobic training because at faster intensities the ventricles of the heart don't fill completely w/ blood between beats)
- -increase blood volume
- -increase in capacity of pulmonary capillaries
- -improved blood shunting
- -increase in # of ST capillaries and # of myoglobin and mitochondria in ST fibers (to improve the # of these in FT fibers, you have to increase the intensity to almost LT pace)
- -increase rate of lactate removal from ST fibers
- -increase rate of lactate removal from blood
- -more energy provided by fat metabolism at submax paces
- -Facilitates recovery

(Sources: Swimming Fastest by Maglischo, Better Training for Distance Runner by Coe and Martin, John Kellogg and Kyle Heffner's web site paragonrunning.com, Physiology of Sport and Exercise by Costill and Whilmore, The Science of Winning by Jan Olbrecht)

Recovery Runs

Recovery runs have been given a bad name in many circles in American and European distance running. They have often been termed "junk miles" to further the negative connotation. Accepting these views can be a big mistake. Examples of athletes doing recovery runs can be seen throughout from the most successful athletes in the sport. There is documentation that the early morning runs of Kenyans are used as "lung opening" runs in which they trot along at almost 9-10 minute mile pace! This can be seen in both Paul Tergat's book and through the documenting of many authors and runners who have gone over to Kenya and trained. Scott Douglas wrote an article in which he trained with successful Kenyans (Augustine Choge and Isaac Songok) who ran a loop that was about 10k in 49 minutes as much as 8 times per week during their base training! The great middle distance runner Morceli used to do several recovery runs per week at similarly near 10 minute mile pace. Arthur Lydiard used to have some of his athletes do morning shake out runs for recovery purposes before the main session later in the day. One more example is that Italian coach Renato Canova who coaches many of the best Kenyans told a story of some of his athletes running at near walking pace for hours some days. He attempted to stop them from doing this and just take the day off and they reported to him that they felt worse with the day off, then the hours of jogging! These are some examples of taking recovery training to the extreme, but the point is that labeling runs like these as "junk mileage" is only hurting yourself. The Kenyans, Ethiopians, and other successful distance running groups know that there is much benefit to slowing down at times to allow for recovery, and they do not get obsessed with the idea that everything has to be fast in order to get any benefit from it.

Physiology and Science also back up the idea that recovery running is essential for success, particularly after a hard workout. Following a hard workout, the athlete goes through an adaptation cycle that consists of a stress, a response to that stress, fatigue, and then adaptation. The workout is the stressor and after the workout the body goes through that pattern. In most cases, the athlete is not through the stress response stage when he does his next run. So if he runs too fast, then the athlete will only be prolonging the adaptation process and risking overtraining (source: discussion with Eric Taylor and Hans Selye's book *The Stress of Life*). In addition to this other factors such as glycogen depletion must be taken into account. Running a hard or long workout tends to reduce the muscle glycogen to low levels. The body does not fully replenish the amount of glycogen following a workout. In many cases it needs over a day to fully replenish the glycogen stores (For more detailed info see: Glycogen in the Physiology Behind it All page). If the athlete trains to hard or fast on depleted glycogen stores, the body will have to break down structures, such as enzymes or mitochondria, to use protein as a fuel source to meet the energy demand. At this point you might be thinking that a day or morning off would be better than a recovery run.

However, the slower the athlete runs the more energy is supplied by fat. Therefore if a recovery run is done slow enough, the primary fuel will be fat, thus not lowering your already depleted glycogen stores any more. In addition to this, it has been shown that recovery runs speed up recovery by several hours compared to taking the morning or day completely off. (This might be why Kenyans can train three times per day on occasion). This speeding up of the recovery process is due to the fact that slow running does not deplete the glycogen stores much, but it allows for a high rate of blood flow throughout the body. This in turn allows for a quicker removal of the waste products in the muscles, allow for quicker replenishment of glycogen stores because glucose can be delivered to the muscles, and for more beneficial products such as vitamins and minerals to reach the muscles so that muscle tissue damage can be repaired (Maglischo 2003). It can then be seen that recovery running has a place in every successful athlete's schedule. It speeds up the recovery process and actually allow the athlete to train harder because he can recover from workout to workout faster, than if he tried to run too fast following a workout. In the end, the athlete will get more benefit taking a recovery run the morning after a hard session, then he will to try and do another medium paced aerobic run. He will be able to train harder because he will be recovered and be through the stages of adaptation quicker.

Famed coach Renato Canova pointed out another way to tell if recovery runs were serving their purpose. The following run or the day after a particularly hard session, the resting blood lactate level will most likely be elevated slightly. For our example let's say on a normal day our runner has a resting blood lactate level of 1.0 mmol. After a hard session this resting level may be 1.3 mmol when resting. It can be seen that after a particularly slow recovery run, that at the end of it after the athlete has recovered, the resting lactate is .8 mmol, a level that is lower than is normally possible. This is the definition of a good recovery run. This is one way to see physiologically the purpose of a recovery run and what is actually going on.

Adding Intensity

The Long Run:

If we are training for an event that lasts between around 3:30 to 30+ minutes, why is it required that we do a weekly or biweekly run of up to a bit over 2 hours? Well the long run provides all of the same benefits as a normal aerobic run such as an increase in amount and size of mitochondria in the ST fibers and an increase in capillerization. In addition to this your muscles will use fats as its primary fuel source and increase your muscles abilities to store carbohydrates. This is very important in the fact that it

allows you to train more without risk of overtraining and breaking down because of glycogen depletion. This occurs because long runs help increase the maximum amount of glycogen that can be stored and may help teach the body how to burn more fat at a given intensity. Think of it like upgrading to a bigger fuel tank in your car and getting better gas mileage. The gas tank size represents your glycogen storage space and the fuel economy represents your fat burning power. Instead of having a 15 gallon tank, after a year of mileage and long runs, you might have a 20 gallon tank in your car or your car might improve its economy from 15mpg to 20 mpg if you improve the fat burning abilities.

Also, if your long run is long enough your ST muscle fibers will start to fatigue, resulting in the recruitment of FT fibers and harder to recruit ST fibers. This recruitment of FT fibers at a relatively easy pace results in an increase in the oxidative abilities of the fibers (meaning increase in mitochondria). As for the pace of long runs, it varies on the intent of the run and what distance you are training for. I keep mine at a pace similar to my easy to steady days (6:30-40ish per mile), until the last 10 minutes of the run, when I gradually pick up the pace. The reasons for this are two fold. First off after being on my feet for almost 2 hours I just want to finish and down some Gatorade, and secondly, the slight increase in pace allows more FT fibers to be recruited and more carbohydrates to be used as the fuel source. As you run near 2 hours, your slow twitch fibers become fatigued and glycogen depleted, so your body has to recruit the fast twitch muscles to help take over. Thus during long runs you work on both ST and FT muscle fibers. This is why long runs are important to be done every 7 to 14 days.

In addition to the physiological benefits, long runs help to strengthen the muscles, joints, and ligaments to increase the durability of the athlete. This strengthening helps the athlete become stronger and more resistant to injuries. This only happens if the long run is built up gradually and smartly. Just like mileage, if the long run is increased to quickly, it will do more towards promoting injuries than preventing them. This is because the athlete is providing too great of a stimulus that his body can not handle yet.

Besides the physical aspects there is a definite mental component to the long run. For many athletes, a long run beyond their normal comfort zone will help to break down mental barriers and give the athlete a sense of accomplishment. While it may be hazardous to push through these barriers often, a long run that pushes the comfort zone in time spent on the athletes feet if he is afraid of racing longer distances or of doing lots of endurance training would be beneficial.

Lactate Threshold:

Once your mileage is to the desired level it's time for you to add some specifics to your training. One of the more important additions is threshold work. Lactate threshold is defined as the point where your blood lactate levels begin to increase dramatically. In scientific terms, it's usually defined as an average of around 4.0mmol. This is just the average and should not be taken as the definite LT point. The point can vary significantly from between 2.0 to 6.0 in most people. This threshold isn't really a threshold at all. It is not some magic point where you switch from using the aerobic system to using the anaerobic system. The lactate threshold (or Maximum Lactate Steady State) is in actually the point where lactate production equals lactate elimination. This means that lactate produced by the muscles is being transported and taken up by other sources (muscles, heart, etc.) at the same rate. Thus there is very little accumulation of blood lactate or the resulting hydrogen ions that accompany it. LT work is the basis for your success as a distance runner and is one of the keys for running fast. Doing LT work will allow you to increase your LT (or your %VO2 max at LT) and it will increase your aerobic (with oxygen) capabilities. By increasing your LT you are able to run at a higher % of your VO2 max (maximal

oxygen uptake), meaning that you can run at a faster pace without producing large amounts of lactic acid. In addition to this you are still running aerobically, although high end aerobic, so you get similar benefits to just logging steady mileage (such as an increase in mitochondria (your body's energy production center) and an increase in capillerization (the system of blood cells that aid in exchange of nutrients and gases throughout your body). Running at LT pace has been shown to recruit not only slow twitch fibers, but also Fast Twitch oxidative fibers. Because of this, training at LT provides sufficient intensity for an increase in mitochondria to occur in both ST and FT fibers, something that doesn't occur at lower intensities.

There are several theories of how to increase the lactate threshold. I subscribe to the idea that MOST of the work should be done trying to push the threshold up, instead of pulling it up. The idea behind this is that you run slightly slower than LT pace and thus stress the body right before it's at the point where it is producing and taking up lactate at the same rate. If you accept this view it is very important not to cross the threshold during this type of training too often, but there will be a time to do work slightly above the LT to further increase it. Work slightly above the LT is a later stimulus that can be added but for the base period and pre-competition period work right under is generally best. For advanced athletes too, occasional work right over LT may be beneficial as another stressor. The problem is that overtraining is more likely to occur when working right above, then right below the LT.

The LT somewhat coincides with the Ventilitory threshold (the point where your breathing begins to increase rapidly, or beyond the ability to talk briefly) so a good measure of if you are going to fast is if you can not say a sentence during the run. When running at LT pace you want to push the pace from your normal training zone, until you get into "the zone", where it is fast but smooth, some describe it as getting "tunnel vision". If you push the pace anymore, you start to labor and it becomes more forced, not as smooth as before. Generally speaking for a 20 min threshold run, the pace should be about what you could run all out for 10 miles (or for 55-60min). **It is very important that you do not go over LT too often. Frequent running at LT or slightly above is much more taxing then running right below LT.** When you run faster than LT you switch from focusing on aerobic development of the Fast twitch fibers and increasing threshold to developing buffers for the build up of acid. Therefore, I recommend, especially during the base period, that LT workouts should be run 5-10 seconds per mile slower than exact LT pace, or in terms of lactate values I recommend that you follow what Marius Bakken suggests and run .2-.5mmol or so below your LT lactate value. This allows you to get the benefits of LT running, without overly taxing your body, meaning you recover very fast and are able to do more LT workouts or other workouts because they do not tax your body much. LT workouts can be done as tempo runs ranging anywhere from 15 to 60 minutes long. You can also do LT fartleks or LT repeats (such as 2x3mi, or 3x2mi with 1 min. rest). It is good to vary the length of your threshold runs over the course of the season. Running 20 minutes at LT is good, but varying the intensities with 40 minute or 60 minutes at progressively sub max running speeds is better (such as marathon pace). A good workout is to do between 40 and 60 minutes at what some call the aerobic threshold (or about marathon pace). Running at that pace for a long duration is also a semi high-end aerobic workout. Meaning you'll get the benefits of aerobic running and since the duration is long enough, some benefits of Lactate Threshold too. It's important to mix these in every once in a while. The reason that LT repeats are valuable in place of the traditional 20 minute LT run is that LT repeats allow you to spend more time at LT pace, meaning more time for your body to make adaptations. It's important on LT repeats not to run above LT pace. Most people assume that since you are doing repeats, they have to be hard, but this is a wrong assumption. LT repeats should feel similar to an LT run, comfortably hard. Also with LT repeats as your season progresses you can increase the number, thus increasing the amount of time spent at LT, which can't be done with the traditional LT run. Both have their benefits though and it's important to mix and match.

Marathon pace, or Aerobic threshold work, is of course best for marathon runners or similar long distance athletes. It is specific for them, but in our case it serves as a way to connect normal/easy runs to lactate threshold runs. Marathon paced runs have many of the same benefits of LT runs but also seem to be the best speed for increasing your fat burning power (source: Scientific Approach to the Marathon).

Dangers of too much LT running

All right, so I just made a big spiel about how great LT training is. Well, like everything too much of a good thing can actually be bad. While LT serves the purpose of boosting your aerobic system and your lactate threshold, causing you to produce lower lactate values at various speeds, it also has some negative effects. LT training can lower your anaerobic capacity. Now, this isn't necessarily a bad or good thing, it depends on what event you are focused on. The shorter the event, the more important anaerobic capacity is. So for an 800m runner, anaerobic capacity is important, so limited amounts of LT should be done, maybe once per 10 days or so. For a 1,500m runner, anaerobic capacity is also important but to a lesser extent as the event is also highly aerobic. This presents us with a problem of needing a well developed LT and AnC (Anaerobic Capacity). Therefore for a middle distance runner it is vital for the coach and athlete to come up with a mix of training so that you can increase the LT while still keeping your anaerobic capacity at a high enough level. As the distance increases further, the more important the aerobic system becomes and less important anaerobic capacity is. Therefore, the longer the distance of your focus race is, the more LT work can be done. That's why individualization is needed in training. For example, if you are training for the 10k, the greater LT will be of much more benefit to you, then the effects of the lower anaerobic capacity, although some emphasis still needs to be put on that system.

To help further explain this, I'll give some examples using hypothetical lactate values. If athlete A before he starts training for the mile has an anaerobic capacity of 16.0mmol (his max lactate value) and a LT pace of 5 minutes per mile, then he trains using high amounts of LT work the following could happen. The LT work could lower his pace to 4:55 per mile which would be good, but it might also lower his anaerobic capacity, or max lactate value to 12.0mmol. So if he goes out and runs a mile he might actually race worse than before even if his aerobic system is better, because his anaerobic system has been neglected and won't "go as high." So for this athlete the trick is to increase his LT while still keeping his anaerobic capacity where it is. That might mean he has to do a little less LT work and some maintenance anaerobic workouts to keep that system in touch. Thus we come to the paradox that anaerobic capacity training lowers LT (this will be discussed later in the anaerobic section). This is part of the reason we periodize. So during the base the emphasis is on LT work, so we need to first and foremost increase the LT will minimizing the loss of the anaerobic capacity. Well if AnC work takes away from the LT, then we must do low end anaerobic work during this period because low end anaerobic workouts will help to maintain the AnC, while not harming the LT. Low end anaerobic work is workouts that just touch on the anaerobic system and produce levels of lactate that can be quickly cleared and are just above the lactate threshold level.

Progression of LT runs

As you progress in fitness and throughout the year it's important to increase the stimulus. As I will say in the progressing of workout section, it's important to increase the stimulus throughout the year as your fitness increases. It's a simple idea in that if you run 5:30 pace for a 20 minute threshold at the beginning of the year, then do the same pace for 20 minutes at the end of the year, your not going to get the same benefit because 5:30 pace is probably no longer your threshold. Thus the importance of

running by feel on LT runs. Your pace should naturally increase because you are concentrating on running at the feeling of LT instead of an LT pace. Anyway, throughout the season and years I like to increase the amount of time spent at this pace. How do you increase the amount of time spent at this pace without going over the threshold? Easy, you take a break to allow yourself to recover, then run at threshold again! Obviously, you will not recover fully during this break so you should be able to reach threshold in a shorter amount of time then when you start from full rest. Also, after the brief rest you will not be able to run as far at the same pace because you will not be fully recovered. Thus if you did a pattern of running at threshold until right before you cross over then stop for a brief period of time, then start running at threshold again, and repeat this, you'd gradually run less and less over the course of the run. For instance you might make it 20 minutes the first time, stop for 2-3minutes, then make it 10-15minutes, stop for 2-3minutes, then only make it 5 minutes. That is just a theoretical example. What I prefer to do is once you do a threshold at about 20 minutes, then start increasing the TOTAL time to be spent at threshold per session. So let's say the next session your aim is to spend 25 minutes at LT pace. Well you run as far as you can until you feel yourself about to go over the threshold (i.e. you stop being as fluid, you have to strain a bit to maintain the pace, your breathing becomes faster or harder, etc.), stop, rest for 2-3minutes, then run at LT until you get 25 minutes total of running time. So let's say you make it 17 minutes, stop for 2 minutes, and then finish off with 8 minutes at LT. Two weeks later you might increase to 30 total minutes, where you go 20 minutes, stop, then 10 minutes. Now, later on down the road when you get to let's say 40ish total minutes at LT, you most likely won't be able to go 20 minutes, stop for a couple minutes, and 20 more minutes. So you can either increase the rest a lot so that you basically are fully recovered, or do what I prefer to do which is add another stop. So you might go 20 minutes, stop for 2 minutes, 10 minutes, stop for 2 minutes, and then 10 more minutes. The goal is to spend more time at Lactate Threshold, but still not going over. Now how long should the rest periods be? Well that depends on a lot of factors. You should find that you recover fairly fast during this type of running. I suggest starting at about 2 to 3 minutes rest and seeing how you recover. Another rule is 1 minute per every 4 to 5 minutes you have run at LT pace. Obviously if you run at LT pace, stop and only have 5 minutes more at LT pace you will take less rest then if you have 10 or 15 minutes at LT to do. Also, do not set time goals, this just makes the athlete more likely to push past their threshold for too long. If you go over your LT at 16 minutes, then stop there, rest, then go on. Don't mandate that they make it 20 min, or 15 min or whatever. If they have to take 3 instead of 2 breaks, then so be it.

<u>Example of progression throughout the year:</u>

-20 minute LT
-25 minutes total LT (20 min, rest 2 min, 5 min)
-30 min total LT (20 min, rest 2 min, 10 min)
-35 min total LT (20 min, rest 3 min, 15 min) OR (15 min, rest, 2 min, 10 min, rest 2min, 10 min)
-40 min total LT (20 min, rest 2 min, 10min, rest 2min, 10 min)
This is just one example, be creative.

<u>How often to progress LT</u>

Now I've talked about progressing LT and how important that is, but how often should you increase the stimulus? Should you try and run 5 minutes further every time? No. You should follow the training stimulus adaptation as outlined in that section. This means that you should spend roughly 5-6 weeks at that LT stimulus, and then increase it. So if you are just starting the base period and you are doing 25 total minutes at LT, you continue doing this for roughly 6 weeks. After this 6 week period is up, then

increase the stimulus to let's say 30 minutes total of LT per workout, or add another LT session so that you are doing maybe 3 LT workouts per 2 week cycle as compared to doing 2 LT workouts per 2 week cycle before. Of course you don't have to follow this rule always. For instance, if you took a break after track and then built up the mileage and wanted to do LT work. So to transition into this you do 15 minutes of LT the first workout, just so that you don't jump right into the 30 minutes of LT per workout that you had built up to during track season. You don't have to spend 6 weeks at 15 minutes of LT, then increase. This wouldn't make sense as you have previously done 30 minutes successfully, so you don't have to start all over again at 15.

Combining LT/marathon pace runs

Since I suggested above that doing some runs at slower than LT pace for longer duration also provides a good high end aerobic stimulus, combining these runs with a traditional LT run makes for a good workout if done occasionally. Just remember not to go over LT. An example of the combination of these two elements might be 5-6miles at marathon pace, rest for about 5 minutes, and then do 2-3miles at LT pace. Another example might be 4mi at marathon pace, 2 miles at LT pace, 4 miles at marathon pace. This way you can change the high end aerobic stimulus up a bit as it's good to vary the stimulus delivered to the body.

Improving LT in elite trained runners

For many elite runners there LT will level off after a significant amount of training for that year. You can only increase the length of the above mentioned LT runs so much and can only add so many to your training week. Once adaptation seems like it has been maxed out using this method, then you have to seek further adaptations through other means. One means that many athletes use (whether they know it or not) is to train at altitude. This acts as a new stimulus on the body for adaptation. Thus a couple week stay at altitude can be that extra stimulus that is needed for the elite athletes LT. Another option is to do your LT work on a uphill. This will increase the fibers used for that effort level and provide for a different stimulus. To accomplish this, simply find a slight continuous uphill run that goes for at least a couple of miles. I know it's hard to find a 5k or more hill in certain areas of the country, so another option is a treadmill. This would work well for an LT run because most treadmills can go fast enough and you can control the incline. This allows you to continuously increase the stimulus (up to a point) by gradually increasing the incline of the treadmill. The progression of this should work just like you would on a normal LT run outside. One word of caution is that treadmill running may slightly alter form so be aware of that. Also, you may want to alternate a flat LT run with an uphill LT run as to maintain the feeling of running fast on flat ground at LT pace because when running an LT workout uphill your pace at lactate threshold will be significantly slower because of the fact you are running uphill.

Physiological Benefits of Lactate Threshold Training:

The benefits of LT runs are the following:

- increased percent utilization of VO2max (your LT occurs at a higher percentage of your VO2max)
- increased lactate removal from muscles and blood
- increase in # of capillaries and # of myoglobin and mitochondria in ST and FT-a fibers

(Sources: Swimming Fastest by Maglischo, Better Training for Distance Runner by Coe and Martin, John Kellogg and Kyle Heffner's website paragonrunning.com, Physiology of Sport and Exercise by

Costill and Whilmore, The Science of Winning by Jan Olbrecht)

Anaerobic Capacity and Alactic Sprint Training

Anaerobic Capacity (AC) workouts are meant to stimulate the Anaerobic Capacity, or the maximum speed which the muscle can produce energy by anaerobic breakdown. These work on all three muscles fibers because of their intensity. Sprint (SP) training is to work on maximally recruiting all muscle fibers and increasing the speed or power at which they contract.

Alactic Sprint Training

Hill Sprints

The point of Hill sprints is two fold. By sprinting up a hill you are using your Fast twitch type IIb fibers and getting the benefits of added strength work. The way muscle fiber recruitment works is that the body increases the number of motor units recruited if there is an increase in intensity (speed) or an increase in strength requirement. These short alactic sprint workouts teach the body to try and maximally increase the number of muscle fibers that an athlete can recruit. Since the sprints are at max intensity you are conditioning your Central Nervous System to be able to send a high enough frequency or signal to recruit a large number of fibers. In addition to that, since you are running up a hill the strength requirement is greater, thus more fibers recruited. These hill sprints are courtesy of a number of other coaches, particularly Renato Canova.

It's important to do these sprints during the Base period because it forces you to use the Fast twitch muscle fibers that none of the other exercises use during this period. By using them you will be developing strength and increasing your speed. If you do not have a hill, you can do the short sprints on the track, but I feel that these run more of an injury risk during the general period as you are just starting to use these muscle fibers and by running up hill you get the same benefits of recruiting these fibers, but aren't forced to run with the rapid turnover when doing them on flat ground. Try to find a hill with a 10-15% grade and sprint up them for about 60-80m. At first I suggest doing 5 or 6 to start out with and then add one repetition per week. The recovery should be full (generally about 3 minutes or so) so that you do not get lactic acid accumulation and so that you can repeat each repeat with the same effort and intensity. In scientific terms, you are using your Creatine Phosphate energy system doing this short sprint work and need to give it time to recover, which research has shown to be about 3 minutes, before completing another repetition. Examples are 6-10x80m sprints up hill with 2-3 min rest.

As mentioned above, these sprints serve to help increase the number of fibers an athlete can maximally recruit. With other work (described later) this can be parlayed into increasing both the sprint speed and the kick of an athlete. This occurs because at the end of a race when muscle fibers that have been doing the work for most of the race are failing, the athlete can recruit some high threshold fibers that are difficult to normally use. However since they have been recruited during hill sprints, the athlete can more readily use them and they will respond. In addition to this, in longer races like the marathon, these fibers can jump in and do a little bit of work when certain muscle fibers fail because they are glycogen depleted.

Speed (sprint workouts):

You also should have noted that I have added Hill sprints/speed. This means that you have the option of doing either the hill sprints or a speed workout. What I mean by speed workout is sprints on the track with full recovery. I feel it's best to start out with hill sprints to work on the creatine phosphate energy system and your Fast twitch muscle fibers in the Base period. However after a couple sessions of those to get your body used to running at such a high speed you will be most likely ready to handle full out sprints. When doing these you want to make sure you are full out sprinting for a maximum of 60m. You can build into this of course, but 60m is about the length of time you can build up to and hold your maximum speed. After each repeat you should take full recovery in order to let your creatine phosphate energy system to recover. If you go before it's recovered then you will not be performing at maximal intensity and will also probably build up lactic, which we do not want. Hill sprints and flat sprints both have there advantages and disadvantages. I've already discussed the advantages of hill sprints in that section above. The main advantage of flat sprints is that you will have a much increased turnover compared to sprinting up a hill. Thus it may be a good idea to mix these or alternate each week once you feel comfortable doing them.

In addition to doing 60m bursts, longer repetitions can be done during this period of 100m. Doing 100m reps where you gradually accelerate to 60m and then maintain until the finish line are a good way to work on your pure speed. These repetitions should be done with an eye towards track season and should be continued throughout the whole year basically. The emphasis during these runs is to run as relaxed as possible with perfect form. At first the sprints will be done at relatively slow speeds, because it is likely that you cannot maintain good form at fast speeds early in the season. Therefore you should start off with the 100's being at about 800m pace. Four to 6 repetitions should be done at first with full recovery. Again, to stress the point you want to run correctly (see the other stuff section for info on running correctly). The key is to run as relaxed as possible. Once you master one speed and can do 6-8 of them with full recovery, then the speed can be slowly increased. Then the process repeats itself at the faster pace. This cycle continues until during track season you are running these reps just as relaxed as you were at the beginning of the year running 800 pace, except now you are full out sprinting. The key to sprinting fast is relaxation and this workout teaches you how to relax and sprint correctly at slower speeds and then it gradually builds you up to where you are able to run the same way at much faster speeds. The end result is you will be able to run faster, because you learned correct form and ingrained into your head.

Anaerobic Capacity

Keeping in touch with the Anaerobic system during the base phase

You may recall that one of my key principles of training is to never stray to far from any particular system. Therefore it only makes sense that we touch on the anaerobic system a little even during the base phase. For information on why we must do this please read the "Dangers of too much LT work" section.

In order to keep the anaerobic system charged up, things like moderately long hill strides (20-40 seconds in length with 4 times as much rest), sprint workouts (100m accelerations), pace workouts, and even weight workouts or plyometrics need to be done. All of these things lightly touch on the anaerobic system to some degree. It should be noted that during the base phase, the emphasis is on aerobic development and all that we are trying to do with the anaerobic system is to maintain it or keep in touch with it. The opposite thing can be seen during the anaerobic system, when we are trying to work on the anaerobic system and moderate LT and VO2 workouts are done to keep in touch with the aerobic

system. During these anaerobic workouts the accumulation of lactic acid should be low. A small amount of accumulation is fine, but it should be able to be cleared out in a relatively short time. An example of this can be seen during 100m accelerations. The intensity is great enough that there will be a very slight use of the anaerobic system, but the rest is long enough that the lactate will be cleared fast, and the duration (only lasting 12-13seconds) is such that only 5 or 6 seconds of this are actually spent using the anaerobic glycolysis system, as the first 6 or 7 seconds is spent using the alactic creatine phosphate system. The same can be seen doing moderate hill reps.

Improving Anaerobic Capacity

During the base period is a good time to try and develop or improve the Anaerobic Capacity. The Anaerobic Capacity is the maximum amount of energy that your body can supply anaerobicly. To quantify it simply it sometimes is referred to as the maximum amount of lactate that can be produced. This quantity has to do with how much lactate can be produced, buffered, and cleared. Simplified, you can think of this as trying to improve the maximum amount of lactate you can produce (ex. increasing the lactate levels after an all out 400m from 12 mmol to 15mmol). To improve the amount of max anaerobic energy you can supply you obviously have to work anaerobicly. The maintenance of the anaerobic system mentioned above is a form of training to stimulate the anaerobic capacity. To improve the max anaerobic abilities then it's obvious that you must do more work than with trying to maintain it. Therefore if the goal is to increase the Anaerobic Capacity then you must do more of the similar work.

The way to improve this is just like in doing Anaerobic Capacity workouts during the competition period, except they are a little less intense and not as far. For example, in the base period the longest you would do a repeat is for about 300m max, with most repeats being in the 100-200m range. These repeats need to be run at near max speeds (within about 2 seconds per 200m slower than your all out sprint) with plenty of recovery. In addition to doing them on the track, you can do these on hills by sprinting 20-30 seconds up a hill, then walking back slowly for recovery.

They keep the anaerobic system "revved" up because you are generating a huge amount of energy (because of the fast pace and quick energy requirement) in a short period of time, thus the aerobic system can't activate fast enough, so the anaerobic system does. These workouts are also fast enough to stimulate all three muscle fiber types. In these you are working on sustaining your max anaerobic capacity during a period of high mileage and high aerobic running. But the key is, they are fairly short so that only a short time (in 200's about 17 seconds) is spent using the anaerobic system and their is full recovery. Because of these two keys, acidosis doesn't occur to a large extent. The pH drop is only moderate. Thus the harmful consequences of anaerobic work don't apply here. The lactate values during this type of training are usually moderate and in the 5 to 10 mmol range.

Pace or Rhythm Workouts:

Pace workouts are done to work on the muscle fiber recruitment pattern more efficient. Your body learns how many Motor Units of muscle fibers to recruit at various force or intensity levels. The more force needed, the more Motor Units of muscle fibers are recruited. You can train this effect somewhat so that less Motor Units are needed to supply the same amount of force. This allows the other motor units of muscle fibers to rest and cycle in when the first set gets fatigued. Thus you can stay at the same pace for a little longer. This is just one reason for pace workouts. They also (depending on how many done) stimulate mild aerobic adaptations in the FT-a and FT-b fibers. More adaptation would take place if these were full fledged VO2max intervals, but they do enough to maintain the fibers, and not let them detrain. They can be done on the track, but also occasionally on the hills.

Longer Hill Reps

In addition to doing short hill sprints, slightly longer ones can be gradually phased in. For my longer hill repetitions I like to use a 200m sand hill. These should be done at about mile to 3k effort, not speed, with either a walk down or slow jog down recovery. When first doing these it might be best to walk down, as you progress through the year, jogging down so that it is continuous might be better. Remember that during this period you don't want a high build up of lactic acid, so these sprints are not supposed to be too taxing. They are designed to provide a strength workout and work on the muscular system a bit. You should be able to fully recover between each repetition and should not be "sucking wind." In my training I like to start off with 10 minutes of up and down hills and as I do them more, gradually add another minute of time each session, until I've worked up to 20 or so minutes. I've experimented with much longer sessions of up and down hills, but I feel that the downhill running puts too much force and stress on the legs and it puts you had too high of a risk for an injury. Also, going much past 20 minutes at such speed and effort allows for form breakdown. When your form breaks down then it's time call it quits because there is no sense in doing this type of workout with bad form.

You can also do longer hill reps at near sprinting speeds to stimulate your anaerobic capacity. These can be from about 150-300m in length and should be run up very hard. Full rest should be taken in between, as you don't want high levels of acidosis to occur. The purpose of them is to stimulate the anaerobic system fully for a brief period of time. This stimulation will maintain your anaerobic capacity while doing lots of slower running during the base period. For more information, see Speed workouts section.

Pace (Rhythm) work

The purpose of pace work is to try and develop a rhythm at race pace. You pick your race pace that is your primary focus and then do short repeats at this pace with plenty of recovery. In doing this you are trying to ingrain this pace into your muscles and create a sort of muscle memory, or in other terms create a muscle fiber recruitment pattern. This is not meant to be a hard workout, you should have plenty of recovery and not accumulate a lot of lactic acid into your muscles. Like with the hill repeats you can start out with a relatively small number and increase the amount gradually. An example of pace work for a runner focused on the mile would be 6-8x200 at mile pace with a jog recovery in between of about 200m. The same workout can be applied to 5k or 10k pace and the distance run can be increased to 300 or 400m providing adequate rest. During later parts of the base period, these can be made slightly more intense so that they can provide for a way of keeping in touch with your anaerobic system. An example of how to do this is by decreasing the rest slightly. The workout still should not be that hard and should be smooth and comfortable the whole way. In doing these pace workouts, the goal is to learn how to run as relaxed as possible at your race pace. This will help teach relaxation during a race or hard effort.

Bridging the Gap

Towards the middle to later parts of your base period is important to start bridging the gap between predominately aerobic runs and your race distance. Up until this point you have done work at various aerobic speeds with a sprinkling of alactic work and anaerobic capacity work. These speeds are still far apart from the goal race speed and do not directly connect to it. To make this connection you have to use a variety of speeds to bridge the gap to that race speed so that you get an ever slightly increase in intensity so that your body can adapt to it. How many gaps you have to build a bridge over depends on what race distance you plan on competing at. For instance, if you want to run the mile, then to go from LT pace to the mile, you have to work through slightly faster than LT pace, to 10k pace, to 3k-5k pace, to mile pace. Now you might not go through every one of these speeds fully but each should be touched at one point or another. For example, if your goal is the mile distance, then the first part of your base

would be predominately (the main workout that is, of course there are others but for simplicities sake we will concentrate on what is emphasized for that period) LT work. The middle to later portion of the base would be LT work combined with slightly faster than LT work (some call this pace critical velocity or 15k pace) and finally some 10k paced work. The pre-comp period would consist of at first 10k paced work combined with 5k paced work, and working down towards the end of the period to 5k paced work with some 3k paced work. Then during the competition period, 3k paced work combined with specific 1500 and finally a tad of 800 paced work. Of course this makes it sound easy and throughout all the periods, you wouldn't just leave behind every pace that you've already done. They would be carried with you to an extent, just the emphasis would change. This is also based on a long build up. For most HS or college athletes who compete in 3 seasons a year, you could not go through this long build up and some paces would have to give.

When do you start this bridging of the gaps process? Once you have developed your LT to a sufficient high level. Basically this is when the LT has leveled off a little bit and it needs another kick in the rear to be improved. This is easier to tell with lactate testing but since it's rare to have access to this, then a good time is when you feel like you can not increase your LT runs any further in terms of length (for example you reach 40min spent at LT and doing anymore at this point in your career seems way too fatiguing). Once this occurs, stay at that LT length for a couple more weeks to stabilize the adaptations. Then start adding in a workout at slightly faster than LT. Do this until adaptations stabilize, then work on some 10k paced reps, and so on.

Base Period Sample week: (for an experience runner who can handle 3-4 workouts per week)
(NR=Normal Run RR=Recovery Run LR=Long Run LT= Lactate Threshold AC=Anaerobic Capacity SP=Sprint Workout Pace=Pace workout)

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1-morn	NR	RR	AC	NR	RR	LR	RR
Afternoon	LT	NR	RR	LT	Pace		
2-morn	NR	RR	AC+SP	NR	LT	LR	RR
Afternoon	LT	NR	RR	NR	RR		

Notes: Looking at this schedule, I like to classify the workouts into three categories, hard, moderate, and easy. In general, all recovery runs, easy runs, and steady runs fall into the easy category. Hill sprints and pace work fall into the moderate category , while Thresholds fall into the hard category. Long runs also fall into the medium category. The classification of these workouts doesn't really mean anything, but it is a good way to measure the intensity you have in your week. I use this method to make sure I don't exceed the 3 hard workouts in 10 days rule. It's a good way to measure the intensity of the week.

Transition: As stated above, transitions are very important. To make the transition to VO2 max workouts I suggest adding in a type of mini-fartlek to your normal training run. An example would be on a 8 mile run, in the middle 20-25minutes, increase the pace to close to VO2max pace, or around 5k pace, for 30 seconds or so, then drop the pace back down to normal training pace. You can do these 30 second surges once every 3-4minutes or so. It doesn't have to be precise, just pick it up when you feel like it basically is what I do, which ends up to being about once every half mile or so.

Pre-Comp Period

The next phase of my training is the Pre-comp period which lasts about 6 weeks. Now when going from one period to the next you want a smooth transition where you slowly introduce new training systems. You don't want to make a complete and abrupt change as you go from one period to the next. The training should build on itself. During this period I tend to work on a two week cycle. This gives me more time to fit in all the required workouts. When athletes use a one week cycle they tend to want to cram too many workouts into too short of a time. There really is little difference in the amount of cycle, I just want to make sure that I touch on all systems of training at least once every 10 or so days.

V02 max workouts

The main addition during the Pre-Comp period is that of VO2 max workouts. These workouts are fast enough so that they stimulate aerobic adaptations in ST, FT-a, and FT-b fibers. These workouts are used to increase the speed at which you can run at VO2max, your aerobic capacity, and help out in getting your body used to buffering out the lactic build up in your muscles. Think of VO2 workouts as trying to utilize the aerobic system that was built up during the base phase. You are trying to run faster speeds at a percentage of your VO2max. Also, this type of training works on both your Slow twitch and your fast twitch oxidative fibers, so keep this in mind when developing a training program(as I mentioned above, you have to keep in touch with all fibers throughout the year). Your VO2 max pace is about the pace you could run for an all out 8 to 10 minutes, or roughly about your 3k pace. It's important to limit the amount of time spent at this pace. From rest it generally takes around 90-120seconds to reach 100%VO2max. So if you do sets of 4minute reps, then you will spend approximately 2 minutes at VO2max. However, as the workout progresses, you will reach VO2max quicker because your % VO2 will not drop down to resting levels during the rest period between repetitions. Keeping this in mind, you have to balance the intensity of the workout. If the rep length is too long or the rest too short your body will not be able to buffer out the lactate that is used, because there will be insufficient oxygen. Thus it is important for VO2 max work to be done for a maximum of about 3 minutes at 100%VO2 max pace. If you go beyond this, you will start to lower the pH and get too much hydrogen ion build up, which we do not want in this type of training because if the muscle pH gets too low it interferes with oxidative enzymes. Some examples of VO2max training are 8x800s at 3k pace with equal recovery. In addition to this fartleks are a good way to start the transition to VO2max training (ex: 2 on, 2 off for 40 min). You can also do VO2max work at slightly slower paces, such as the traditional 4x1mile most people do. If you do this you should slow the pace down.. So doing this at 5k or so pace with slightly less recovery also gives you the benefits of working at VO2 max pace. In general the rest should be about equal or slightly less (70%).

In addition to the traditional VO2max work listed above, as a general rule repeats can be from anywhere from 2 to 8 minutes at paces varying between 3k and 10k pace (100-90% of VO2max) with rests up to 5-6 minutes for longer repeats. Also, VO2 max workouts can be done as hill repeats. Lactate Values for this type of training will generally be in the 2-8 mmol range.

Physiological Benefits of VO2 training:

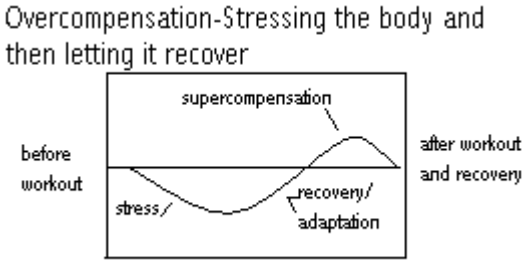
The benefits of VO2 runs are the following:

- increase in your maximum oxygen uptake in all muscle fibers
- increase in capillaries in ST, FT-a, and FT-b fibers
- increase in buffering capacity

(Sources: Swimming Fastest by Maglischo, Better Training for Distance Runner by Coe and Martin, John Kellogg and Kyle Heffner's website paragonrunning.com, Physiology of Sport and Exercise by Costill and Whilmore, The Science of Winning by Jan Olbrecht)

Mileage and Recovery:

The mileage during this phase should be done by feel. As more intensity is added, the mileage should drop slightly and the pace of your runs will probably slow a bit at first as your body gets used to the increased work load. This is a natural effect and as your body adapts the pace will most likely level out or increase naturally again. In the early parts of the Pre-Comp period I like to keep my mileage about the same (100-110). As the period progresses I will drop it to about 90mpw in the late pre-comp. The important thing to remember is to go by feel. By adding VO2 max workouts your recovery runs will be important. The basic way you improve is through compensation. You stress your body through these hard workouts and then the body compensates and adapts to the new training load put on it and you get increased fitness. The body adapts during recovery. If you do not allow the body to recover then it will not adapt, and you will just be pushing the body further into fatigue.



Amount of time required for Recovery

As can be seen above, after a stress is applied to the body, the physical parameters briefly lower, before they are allowed to recover and compensate. This is the principle of super compensation. If the recovery is not allowed to happen, then the adaptations don't occur. Thus certain workouts take different periods of time to reach optimal super compensation. If you stress the body again before this occurs, then optimal benefits may not be met, unless you give the yourself more time to recover because even more stress has been placed when the body wasn't fully recovered. Below is a list of approximate recovery times needed for various workouts. It should be said that these are general guidelines and individual adaptation varies. (Source: Jan Olbrecht's Science of Winning, and other various articles)

Stress	Easy Run	Lactate Threshold	Sprints	Anaerobic Maintenance or Capacity	Lactate Tolerance (Anaerobic work)	Races
Hours	8hrs	24 hrs	30-40hrs	36-48hrs	40-60hrs	2-3days

Pre-Comp Period Sample weeks and cycle:

week 1:	Mon: LT	Wed: Sprint work	Fri: VO2max fartlek
week 2:	Mon: Pace work	Wed: LT	Fri: Anaerobic Capacity
week 3:	Mon: VO2max	Wed: Pace work	Fri: LT
week 4:	Mon: sprint/AC	Wed: VO2max	Fri: pace work

(Hard and medium workouts listed. This should be blended with easy and recovery runs like shown in the General period sample week. Also, a long run should be included just like in the General Period. Also, some sort of strength work should be done.)

What you should notice from this cycle is that I try and keep in touch with each different workout at least once per 10 days. As you can tell from these weeks you will have harder weeks, those that include 2 hard workouts and one moderate(weeks 1 and 3), and easier weeks that include 1 hard workout and 2 moderate (weeks 2 and 4). By doing this, it leaves you with several options. You can increase the mileage slightly during easy weeks, or if you feel you are recovered enough you can add a third moderate workout every once and a while. An example of how to do this would be running a LT workout in the morning then come back and do pace work in the afternoon. This will be a taxing day, so sufficient recovery is needed, but it can be done as pace work isn't meant to be strenuous. Another thing you could do would be to add a mini-fartlek one day (explained above in the transition section). Also you can add a moderate hill session into your training. A staple workout that I did in High School is running up a hill (ours was about 150m long, but it can range anywhere from 150 to about that long depending on what you have to work with) and jogging slowly back down. I'd do this for about 10 minutes. When running up the hill it wasn't all out like in hill sprints, but controlled at approximately 3k pace I'd say. This will help use your Creatine Phosphate system a bit and you will get the other benefits of hill work, such as ankle flexibility, increased leg drive, etc. You can add this into the middle of a run, or do it in the afternoon or morning before or after a pace work run. If you feel even more inclined, you can do this with a VO2max fartlek. Warm-up and do your fartlek, then jog for a bit to recover after it, then do 10 min. of up and down the hill, or even include the ups and downs before the fartlek. With saying all this, be careful in adding to much intensity. For younger runners you want to stick with caution and always pay attention to how your body feels. You should not be stuck into a training program. Never feel like you have to do anything. The key to training is listening to your body and making adjustments

Combination Workouts during Pre-Comp Period

Sometimes it's wise to combine elements of different workouts into one session. This allows you to hit on two different systems in just one session, leaving more time for recovery or work on other things during the rest of the week or cycle. Although these are good to have, as with anything don't overuse them. Often these are long and sometimes extremely stressful, so it might take longer for you to recover then it would for a normal workout. So be smart about using these throughout your season.

Hill work/Sprints Combo

During this period, you can start varying the hill work a bit. No longer do you have to do just straight hill sprints, but you can mix in slower paced repeats where you run up and jog slowly down. These can be done at about 3k effort with a slow jog down. The length should be about 200m and these should work on both your strength and your creatine phosphate system. I find it beneficial to mix various hill sessions during this time. One mix that I like for working on pure speed is mixing hill sprints and flat sprints. For this you have to find a short steep hill with either a flat portion at the top or bottom of the hill. Then alternate sprinting up the 80m or so hill, resting 3 minutes, then doing a 60m sprint on the flat, resting 3 minutes, then repeat with the cycle. This works on your fast twitch muscle fibers and at this time of the year if you've been doing hill sprints for a decent amount of time, then you're ready to progress to flat sprints. The reason you need flat sprints is that these sprints will recruit your FT fibers the way you do when you run on a track, because of the flat surface. Also you will get the same push off, ankle flexion, recovery, etc. that you need when running fast on the track. While if you sprint up the

hill, different phases of running are emphasized more. Another combination workout is doing both up and down hills of 200m, and hill sprints. For example you could do 10x200m at 3k effort with jog down recovery, then jog for 10 minutes, and do 6x80m hill sprints.

LT/VO2max Combo

The combination of LT and VO2max workouts can produce some pretty long or tiring workouts, but it's a good way to hit on both systems and take more recovery if you have a race later in the week that you don't want to be tired for. So for instance, do a combo workout on Monday, a easy/medium workout on Wednesday, and be pretty fresh for a Friday or Saturday race. Some examples of combination work include 2 miles at threshold pace, rest 5 minutes or so, 2x1mile at 5k-8k pace with 3minute rest, rest 5 minutes after, then 4x800 at 3k-5k pace with 2-3minutes rest. Another example includes 3 miles at marathon pace, 2miles at threshold pace, rest 5 or more minutes, 4x800 at 3k-5k pace with 2-3minutes rest. In coming up with these combination workouts, a simple way to do it, is to cut both full workouts of LT and VO2max in half and then combine them, so as an example if you'd normally do 20 minutes at LT or 6x1000 for VO2max, then do 10 minutes of LT and 3x1000 in one session.

VO2/Hill(CP system) Combo

I sometimes like combining a workout to work my creatine phosphate system as well as VO2. These two workouts go together well. I start out with 10 minutes of running up a 200m hill at about 3k effort, with a jog down recovery. After this I jog for a mile to a mile and a half and then do some sort of VO2 maintenance type workout. After the VO2 workout, then I'll jog a mile or more and do 5-10 minutes of up and down hills. This provides a good stimulus for both systems and is a good way to combine two medium workouts to make it into one harder session. The reason I suggest VO2 maintenance type workouts is for the simple fact that they are normally a little less volume than a normal VO2 workout, so combining them with another workout type makes sense. You can also modify a normal VO2 session (which is basically what I mean when I say a VO2 maintenance workout) to sandwich in between the CP hill work. I prefer fartlek type sessions when doing this workout because when I do hills, I'm not near many marked courses, so it makes it convenient.

LT/Hill (CP system) Combo

Similarly to the above mentioned VO2/hill combo, the same thing can be done with an LT workout. Instead of sandwiching an LT workout between hill sessions, I prefer to do a threshold run, then jog a mile or so and do a CP hill workout. This is just another effective way to work two systems in one workout.

Pace (Rhythm) work during Pre-Comp

I've already described the benefits of this Rhythm work during the General period. It is also beneficial to carry on with this work throughout the Pre-Comp period as you don't want to get too far away from race pace. During this period, the number of repetitions can be greatly increased too. I've had success with doing up to 20x200 with a 200m jog at mile pace. You don't have to do that many, as it should be done by feel. You never want to feel dead during this type of training. You want a nice bounce to your stride, where you're not forcing anything and should be able to talk throughout for the most part. The jog in between should be easy and relaxed and you might notice as your fitness increases or as you do these more often that your jog pace increases. This is fine as long as these are kept fast and relaxed with no real strain. It should be noted that this kind of rhythm workout is sort of a throw back to the Igloi and Gerschler systems of the 50's and 60's with a little bit of longer recovery.

Transition

If you have followed what I have been saying, the transition to the competition period should go smoothly. The workouts that I've given that work on your Creatine Phosphate system (the hill sprints, the up and down hill runs, etc.) will have helped to prepare your body for the transition into the hard Anaerobic work. Also your anaerobic workouts should be progressive throughout this period. What does that mean? Well maybe your first Lactate Tolerance (explanation to follow) workout should be two sets of 6x400 at mile pace with 1 minute rest and 6-8 minutes rest in between sets. Then do a similar Lactate Tolerance workout later in the period that is 10x400 with one minute rest at mile pace. You are reducing the total volume of the workout, but you are getting rid of the rest break in between sets. This is changing the workout slightly as you progress to make your body adapt slowly to the increase in intensity.

Competition Period

This is when you start the anaerobic workouts. As I defined it above, anaerobic work is when you don't have enough oxygen to breakdown carbohydrates completely, and thus lactic acid is produced. During this time of year, you want to teach your body how to use its anaerobic system. The reason this training system isn't utilized year round in some fashion like the others, is because too much of this work can lead to "burn out." Basically when you do anaerobic work your cells become more acidic (also referred to as lowering its PH). When this acidic environment is created it needs time and recovery to bring it back to normal levels so that the muscles can function properly again. If too much of this work is done then you can become chronically fatigued and damage muscle cells if done long enough. This is the reason why I highly suggest the training above for most of the year because it does not result in significant lactic build up, thus creating the acidic environment in the body. However, the highly acidic work is required because in general the higher the lactate values, the better you are teaching your body how to buffer that lactate. That is also why it is important to listen to the advice given above of not going over your LT or making your VO2max too fast and long. Anyway, anaerobic work is used to top off the aerobic work that you've already done. As many have said before, this is the icing on the cake stuff, it's not the cake. This means that this is just the finishing touches to increase your fitness to the maximum potential that you built by doing the aerobic work. There are two types of anaerobic workouts that I like to do.

Mileage:

Mileage during this period should be dropped moderately. The drop in mileage should occur because of the increase in intensity during this period. Also, as the intensity is initially increased a slowing of pace for "easy" runs can happen. However, as after other increases in intensity, the pace should return to normal or even decrease with no extra effort after your body adapts to this. If after a while you find your normal running pace continually slowing then you most likely need to reduce the intensity a bit until the normal running paces return to normal. The normal easy run is a good way to judge how fatigued you are. I'm not talking about recovery runs done in the afternoon or morning after a hard session, but the normal easy runs that one does for aerobic benefit on days that there are no hard sessions. Also, I don't recommend dropping the mileage levels too low. A huge taper can be counterproductive and can result in detraining. Since you will most likely be racing during this period a slight reduction in mileage during that week can occur. For example if you are racing one week, run 75, the next week when you aren't racing run 85. An example of my mileage for this period would be (remember I topped out at 110 during and the general period and was consistent between 90-110 during the pre-comp period) to stay around 80 miles for the early competition period and then the last two weeks drop to 70ish before the big race.

Lactate Tolerance workouts

This is what's generally thought of when you think of a track workout. It is done to get teach your body how to breakdown it's fuels anaerobicly (without oxygen). The main goal of this type of workout is to teach your body how to run during periods of high acidosis, and thus creating a better buffer system. Think of it as trying to maximize the maximum lactate you can attain. Also, you are using both sets of Fast Twitch muscle fibers as well as ST fibers and teaching them how to work with insufficient oxygen. For this type of training you want to run repeats of between 200 and 1,000m in length with a recovery ratio of between 1:1 and 1:1.5. Thus this is where your classic 10x400 with 1 minute or 2 minutes (in Bannister's classic example) comes into play. You do not want recovery periods longer than this because this will affect your body's ability to use the lactate as a fuel, which is the whole purpose of this workout. It also should be noted that although these workouts are the killer ones where you should feel extreme discomfort, the workout needs to end before the point where you begin to slow down. For example, if you do 7x400's in 60 and the plan is to do 8 to 10. If you're going to die and run 65 for the 8th one, STOP. Call it a day at 7. It's been noted by runners and coaches who have gone over to Kenya that you don't see Kenyans on the ground lying dead at the end of workouts like you see all the time in America. This is because they know when to stop. Lydiard makes similar comments in his books that the athlete should be able to judge when he is done and should know when he hits the point where if he did one more he'd fall apart. The pace of these intervals varies, but the general idea is for them to be somewhere near mile pace. Obviously this depends on the distance run during the repeats. For example, 300's can be done faster than mile pace, while 800's can be done slower. A couple of examples of these workouts would be 8-10x400 @ mile pace with 1 minute rest, 8-10x400 at 2 seconds per lap faster than mile pace with 2 minutes rest, 4-5x800 @ mile pace plus 2-3 seconds per lap with 3 minutes rest.

The lactate levels during this type of workout should be extremely high and depending on your individual max, 9 mmol and higher.

Longer Lactate Tolerance Workouts

This type of anaerobic work is sometimes called lactate clearance or lactic capacity work. It consists of intervals ranging from 30 seconds to 2 minutes at very fast, near maximum paces with almost full recovery. By doing this type of work you are increasing your anaerobic capacity, tolerance to the acidity and buffering (clearance of the lactic) capacity. Just like in Lactate tolerance work you are also teaching your body how to function using the anaerobic system. During this type of training the lactic acid levels in your blood rise rapidly throughout the repeat, then continue to rise for up to about 5 minutes after the repeat is even finished! After this period of time the levels will slowly drop again, but this means that during each progressive repeat you are starting out with a high level of lactate before you even start running again. This allows the body to improve on its buffering of this lactate. In addition to this, this type of workout utilizes different muscle fibers, particularly your FT oxidative fibers. This training has been shown to stimulate these fibers and greatly improve their capabilities. Examples of such workouts would be 4x400m @ 800 pace or faster with 4-5 minutes rest. Another example would be 3 sets of 400,300,200 at 800 pace with 2-3 minutes between repeats and 10 minutes between sets. These sessions are extremely hard on your body and it can take anywhere from 1 to 3 days before your carbohydrate reserves are fully replenished. So make sure plenty of recovery is scheduled for after these workouts.

Combing Long and short Lactate Tolerance workouts

Like other types of workouts, the two anaerobic workouts can be combined as well. Although this will lead to some pretty intense workouts, so be careful about how much of this combination work you do. A lot of people do a sort of combination work without realizing it. Like when they do a set of 400's with short rest, then take a nice long break after the last one, and then blast a 400, they are combining elements of both workouts. The simplest way to do this is do a little less of what you'd normally do if you were doing each workout separately and combine them. Many like the approach of doing more Lactate Tolerance workout type things, then taking a long rest and blasting one or two more repeats. An example of this type of workout might be 5-6x400 with 1-2minute rest at mile pace or faster, rest 5-10min and run 2x400 with 5 min rest at 800 pace.

The Dangers of too much Anaerobic work

All right, so I've explained the benefits of anaerobic work and your thinking wow, this stuff is great, If I do it more often I'll get even better! Wrong! I'll repeat what I said before because it's so important and then add on additional reasons why too much of this is not good and what it does to your system. Basically when you do anaerobic work your cells become more acidic (also referred to as lowering its PH). When this acidic environment is created it needs time and recovery to bring it back to normal levels so that the muscles can function properly again. If too much of this work is done then you can become chronically fatigued and damage muscle cells if done long enough.

When your muscles use lactate as an energy source it needs a substance to convert it back to pyruvate acid. This substance is called Lactate dehydrogenase (LDH-M). When you do anaerobic work it has been shown that an increase in LDH-M occurs, while aerobic exercise decreases it. Now why is this a bad thing if it converts lactate back into pyruvate so that it can be used as a fuel source again aerobically? Because when too much LDH-M is present it promotes lactate formation EVEN if there is enough oxygen available to function completely aerobically. So you have to find the right balance of aerobic and anaerobic work so that you have the right levels of LDH-M. That is why it's important to balance the training and not drop the mileage too much during the competition period! Have you ever dropped the mileage a lot for several weeks expecting a huge peak because you feel fresh and springy only to bomb at the big race? This happens because of this very reason. You drop the aerobic work, do tons of anaerobic work so that your LDH-M levels rise a lot. Your anaerobic capacity is increasing, BUT your body produces lactate at slower speeds now because there is too much LDH-M present.

In short, tough anaerobic work hurts the aerobic system. So you have to balance out these effects with maintenance training to make sure that the anaerobic work is balanced with enough endurance type work. The better your aerobic abilities, the more anaerobic work you can probably handle.

Maintenance of VO2max and LT

Once you enter the later stages of the competition period it becomes important that you still do some LT and VO2max work. After spending significant time developing these systems, you now want to maintain them as your racing increases. Do not make the mistake of losing touch with these systems. These workouts do not have to be full blown (but they can be, especially during early period) LT or VO2max sessions like in the earlier season. Do just enough to touch on the systems at least every 10 days to prevent detraining. I like to do fartleks for this. Converting a full blown workout to a maintenance one is pretty easy. Simply cut the total volume of the workout by 20-30% and run them at the same speed as was done during the previous period when they were emphasized. This means that increasing the speed to try and run them faster shouldn't be done. An example of a maintenance LT

workout would be one in which you spend 20-24 minutes at LT instead of the normal 30 spent during the base period. For a VO2 workout that was 6x800 with 2min rest in 2:10 during the Pre-Competition period, a maintenance workout would be 4x800 with 2min rest in 2:10.

Running Races

Up until now I haven't mentioned racing which is of course what you are aiming for when you train. The reason for this is because everyone is on such different schedules that it's hard to make a generalized training plan that includes when to race. In general, it's fine to race near the end of the Pre-comp with some over distance racing (racing a distance that is further than your goal race pace). During the competition period you should employ a mix of race specific and under distance racing. Once you get into this racing period, I am a fan of trying to schedule it where you race one week, then don't the next. This allows for enough racing to keep your mind mentally sharp during the hard training and give you something to focus on without "burning out" mentally from racing too much. In the weeks following the competition period, you will have a couple weeks of maintaining the peak and racing every week.

Workout Progression

I have not discussed the specifics of any workouts until now. I've given examples of each type of workout and given information so that you could be creative and come up with workouts that have the same physiological benefits but are something that you enjoy. Let's face it, if you don't enjoy doing it then the chances of you having a successful workout is less. It should be noted that you can do all of these workouts on or off the track. If you wanted to you could train entirely off the track for the whole year if you hate the track that much (although I highly suggest going on the track some if you are racing on the track, because you need to create a rhythm or muscle memory at the pace you plan on running in the race). A couple examples of how you can create workouts that can be done off the track have already been given (Hill sprints, LT fartleks, VO2 fartleks). Must people do not think of doing anaerobic work off the track but it can be done. One of my favorite anaerobic workouts is an Long Lactate Tolerance workout in which I run very hard for 5x400 and 5x300 up a 400m gradual incline hill with a slow walk/jog back down. If you want to do a lactate tolerance workout off the track you can do that too. The same workout I used for anaerobic capacity of running up the hills can be used for a short rest Lactate Tolerance workout. Slow the pace slightly, run the 400m to the top, rest for the amount of time it took you to run up it, then run hard back down. This way you're getting a naturally higher turnover from the gradual downhill. Anyway, BE CREATIVE with your workout design and make sure it's something you moderately enjoy or can tolerate mentally. If you know you can't tolerate a continuous 20 minute LT run, then do long LT intervals with a short break, go for as long as you feel in the zone at LT pace, take a minute rest, and then repeat.

One of the important principles of training I haven't discussed is that of overcompensation. It's simple really, your body adapts to the stress put on it. Thus it's important as you progress through the periods to increase the stress put on your body in workouts. Now by stress, I don't mean where you try harder each week. I mean you have to increase the amount (load), pace (intensity), or decrease the rest period as you progress. Why do you do this? As you achieve better fitness you need to increase the training stimulus to get the same workout benefit. Let me give you an example of the classic 8x400 workout. Okay let's say you're in your competition period and every two weeks you decide to do 8x400 at mile pace with 1 minute rest. Well the first week you run them all in 60 seconds. It was a killer workout. Your coach measures your lactate levels at the end of the workout and it's lets say 14mmol (millimoles of lactate). Two weeks later you do the same workout, you hit the same pace and the workout was real tough but not killer. Well your coach measures your lactate levels and now they're 12mmol. You do the

same workout two weeks later, hit the same paces, and it's slightly easier. Your lactate levels are 11mmol. The reason the workouts were easier is because as your anaerobic abilities increased you taxed them the same every week. You didn't increase the training stimulus so you did not get the same benefits in the 2nd or 3rd try of the workout as you did in the first try. Remember that during anaerobic work we want to push those lactate levels high so that your body can adapt to them and increase its buffering ability. Instead of doing the same workout every week, this athlete should have increased the training stimulus so that he hit about his maximum (14mmol) every time he did the workout. He could have increased the pace, or increased the number of intervals, or decreased the amount of rest. For example he could have done 10x400 in 60 and that would have gotten his lactate levels of 14mmol the second time he did the workout. Then the third time, maybe if he ran 10x400 in 59 it would have gotten him to his 14mmol. See the effort is the same each time, but as your fitness increases and your body gets better at working the anaerobic levels, and increasing in training stimulus needs to be added to achieve the desired effort. This is why it is important for you not to get caught in doing a set number of repeats. Lydiard was an advocate of going by feel, the athlete will know when he has reached his maximum and can go no more. Well that's what you need to do. Go until you hit the desired levels then stop. If at first this means stopping at 7 when you planned 8, then do it. If it means doing 11 when your coach planned 10, then do it. You have to know your body and listen to it. I will supply more examples of increasing the training load later on. This should be done with VO2max work too.

Examples of increasing work intervals throughout period in 1 or 2 week increments:

VO2max examples:
1st time- 8x800 with 3 minutes rest at 5k pace
2nd time-6x800 with 3 minutes rest at 3k pace
3rd time-6x1000 with 3 minutes rest at 3k pace

1st time-2x3000 at about 10k pace with 5 minute rest
2nd time-3x2000 at about 2 seconds per mile slower than 5k pace with 4 minutes rest
3rd time-6x1000 at VO2max pace (3kish) with 3 minutes rest

Lactate Threshold Examples:
1st time- 5x5min at LT with 1 minute rest
2nd time-3x7min at LT with 1 minute rest
3rd time-2x10min at LT with 1 minute rest
4th time-20min at LT

Lactate Tolerance Examples:
1st time- 2 sets of 5x400 at mile pace with 1 min rest and 5 minutes rest between sets
2nd time-8x400 at mile pace with 1 minute rest
3rd time-10x400 at mile pace with 1 minute rest

1st time-12x300 with 100(60-75sec) walk alternating mile/3k pace
2nd time-10x300 with 100 jog (45-60sec) at mile pace
3rd time-9x300 with 100 walk at in between 8 and mile pace

In addition to this progressions can be done through periods. This means that workouts can change purposes from let's say LT to VO2max to Anaerobic workouts with slight variations done. For example, here is a sample of progressing throughout the year using 400m repeats:

Lactate Threshold period: 20x400m with 30 seconds rest done at LT pace.

VO2max period: 12-15x400 with 1 minute rest at VO2max pace
Lactate Tolerance: 10x400 with 1:30-2min rest at slightly faster than Mile race pace
Long Rest Lactate Tolerance: 4x400 with 5 minutes rest at 800m pace or slightly faster.

Sample Weeks of Competition period:

Now during the competition period is very important to pay close attention to how many hard days you have in about a 10 day period. As I suggested at the beginning, there needs to be no more than 3 hard workouts per 10 days, but this does mean you can have a few other medium days sprinkled in with the hard and easy days. Studies and the trial and error method (ex: Lydiard's athletes and program) have shown that your anaerobic system can be developed in as little as four weeks. The difference in this program than lets say Lydiard's is that he did a period of 4 weeks of 2 to 3 anaerobic workouts per week. I have lengthened the period somewhat to 6 weeks to allow for the spreading out of this anaerobic work. The reason I prefer to do it this way is in doing 2-3 anaerobic workouts a week you have little time to pay attention to the other systems of training. It is never a wise idea to neglect certain systems, thus I feel a better effect is had when you spread the anaerobic work out over a slightly longer period, allowing you to maintain or work on the other systems. Also, if you find yourself with too many hard days during this period there is a simple solution. Replace one hard day with two medium days, where you can do medium intensity LT and VO2max maintenance workouts. Why is recovery so important during this period? It has been shown that you need anywhere from 24 to 72 hours to bring your carbohydrate stores back to normal following intense anaerobic work. In addition to this when you rest and recover is when the adaptation in the muscles and your body occurs. There's no use in continual working out hard if there is no recovery, because your body will never adapt, and thus never improve. This right here kills the good old "no pain, no gain" American attitude. This means that recovery runs become especially vital during this period. Also during this period since if a Lactate Tolerance workout is done at race pace it can take the place of a rhythm or pace workout because you are running at race pace for these so you get a similar effect. Here is a sample schedule. Remember that progression of workouts is important!

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	Lactate Tolerance (hard)	Easy	maintenance LT (medium)	Easy	VO2max (hard)	Long	Easy
2	Long Rest Lactate Tolerance (hard)	Easy	hill sprints/speed/ creatine phosphate work (medium)	pace work or maintenance LT (medium)	Easy	Race (hard)	Easy
3	Easy	Lactate Tolerance (hard)	Easy	VO2max maintenance (medium)	Easy	Long Rest Lactate Tolerance (hard)	Long
4	LT maintenance (medium)	Easy	Lactate Tolerance (hard)	Easy	Easy	Race (hard)	Easy
5	Speed/hill	Easy	VO2 max	Easy	Lactate	Long	Easy

	sprints/ creatine phosphate (medium)		(hard)		Tolerance (hard)		
6	Long Rest Lactate Tolerance (hard)	Easy	LT maintenance (medium)	Easy	Easy	Race (hard)	Easy

(easy, medium, or hard) classification of the day to help you see how much intensity there is per week

Note: This is just a guide, be creative and remember to progress throughout the period. Also adjust accordingly to whether you are on the low end (15) or the high end (10k) of racing.

After this period of anaerobic work, the big emphasis becomes on racing. The first race during this period of anaerobic work will be rough as your body will probably not have adapted to the work load, but you should remember that these races included here count for workouts. They can count for anaerobic work depending on the length and such. After this you get into a peaking period which I will address shortly.

Racing Period:

During this period, the main focus is racing and racing fast. Of course there will be races during the competition phase, but this is the phase where you enter the championship part of the season. It can be adjusted based on races and such. I'm not a big believer in cutting the amount of mileage or frequency of training down too much. I believe that a reduction in intensity and mileage by too much will result in the athlete being stale. As I have said before, balance is the key to tapering. If you do too much on either side, the balance will become messed up and the athlete will not race optimally. During this time of the year the training is done, what you want to do is to be able to maintain the different systems, not stress them to improve them like in earlier periods. Thus during this period, the above mentioned VO2max and LT maintenance workouts become essential. You need to stress the body just enough to keep those systems intact, as well as touching on the anaerobic system too. Race pace work should be emphasized during this time too as you want to be sure to have that muscle memory. When Racing, the training frequency (amount of times you train per amount of time (week)) should remain basically the same. A slight reduction is okay, but it's not suggested to reduce frequency to less than 80% of what you have been doing. The mileage can be reduced slightly, but this should be done on how you feel. I am not a fan of big mileage drops as I feel like the mileage should be kept relatively the same as during the competition period with the only decrease coming because of shorter runs starting from 2 to 3 or so days out from the major race, any longer than this and I feel stale. Different people have shown to respond differently to mileage drops, so it is your own personal choice. Intensity should also be kept about the same, but remember that a race counts as a very intense day. During this time of year I like to use fartleks and off track things to emphasize intensity instead of hitting the paces.

Peaking

If you have a specific race where you plan to peak at, such as the state championships I suggest the following "taper". The last extremely intense workout should be done about 10 days away from your peak race. This is sometimes referred to as a "blowout workout". These are relatively short intervals with not much volume in the workout but are very intense and use the anaerobic system. Most are

longer versions of Long Rest Lactate Tolerance work. One of my favorites is 2x800 with 2:30 rest at mile race pace or faster. Another example would be 800 at mile pace, 5 min rest, 2x400 at 800 pace with 3 minutes rest, then 5 minutes rest and 4x200 at between 400 and 800 pace. These workouts require significant amounts of recovery following them. After the blowout workout I prefer to do one moderate LT workout and a pace "rhythm" workout. Normally I do the moderate LT workout 5-6 days before the competition with the pace workout 3-4 days before the competition, or the other way around depending on the distance of the race. For instance if the LT work is more specific to the race, such as in a 10k, I'll do that 3 days out, but if you're racing a mile, the pace workout is more specific so it should be done closer to the race. Neither of these should be hard with the focus on being relaxed and smooth during the workouts. The reason for my suggestion of a pace workout and an LT workout is that I believe that you need to hit on all the systems a tad to keep them in check and ready to go. With a week to go, you're not going to increase your fitness. You will be able to race faster because you're fresh and rested, but the key is to get rested without getting stale. In my experience this is done by making sure that all systems are ready to go and slightly worked on, so that it hasn't been like 10 days since you ran at a high end aerobic pace or something like that.

Why do you need to "taper" for peaking shape? The taper should help tie everything together. You've taxed your body throughout the season with a good mix of hard anaerobic and aerobic sessions. You've done everything you can to maximize both your aerobic and anaerobic capacity, but the problem is, while doing this you probably were in a pretty high state of fatigue. So to race to your maximum potential you need to cut the training load a bit and let yourself recover. The recovery will cause your body to adapt better to all the work you've put in. This recovery will allow your body to maximize the adaptations, meaning better racing performance. However, if you cut back either volume or intensity too much you can start detraining the systems you worked so hard to build. Thus it is best to find a nice blend between getting enough recovery and maintaining enough volume and intensity. For this purpose I like to do one hard session a week, with another easy to medium maintenance workout. The whole purpose of this period is to increase the recovery and maintain what you've got. So you want to touch on all of the systems enough to maintain them without taxing the body too hard. Thus the workout samples below, even if they say hard should be low in volume. They should not be the killer intense 10x400 anaerobic workouts like earlier in the season. You have to play around with the right volume and intensity workouts.

A pace workout during this time can be modified somewhat to make sure you work on both pace and keeping the muscles ready to go. So in order to work on the anaerobic and neuromuscular system a tad, I sometimes include a lap or two of in and out 50m sprint/50m cruise. You will get slightly anaerobic on these if done right, but they are short in duration, so you don't accumulate a significant amount of lactic.

So an example of a pace workout before the big race if your training for a 5k would be:

> 4x400 at 5k pace with 200 cruise rest, then recover, and 2x400m of 50m in and out sprints, you should get slightly anaerobic on this, but the duration is short, so you clear out the lactic relatively fast afterwards, then rest another couple minutes, and do a 400 or 800 at race pace as relaxed as possible

Blowout Workout

This is what I use to define the last really intense workout before a peaking race. This workout should be relatively low in volume but very intense. It should be done between 8-12 days away from the big race, 10 days being the best time to do it. One of my favorite blowout workouts is 2x800 with 2-2:30 rest with the best average you can get. The 800s should be run at or slightly faster than mile pace. That is an optimal blowout workout for the mile because you are getting an intense workout done right at or around mile pace with very little total volume. A good workout for the 5k might be 3x1200 with short rest 1-1:30min at 5k pace or slightly faster. The point is that these workouts should be very intense and over relatively fast.

Anaerobic Maintenance:

As I have already mentioned, the key here is resting and recovering. Therefore, listening to your body becomes essential. Anaerobic work during this period should not be anywhere near as hard as it was during the competition period. You should still run at race pace, but the key is to maintain what you already have built up. To maintain the system, requires a lot less work then it takes to build it up. Therefore, most of the anaerobic work should be done more relaxed during this period. By this I mean that you shouldn't try and run faster each workout and should take slightly more recovery. In addition to this the total volume should be cut by 20-30% to convert a full blown workout to a maintenance workout. An example would be if you've progressed to 8-10x400 with 1 min rest at 60, don't try and drop the pace to 59 during this period. Keep the pace at 60, keep the recovery the same or add a little bit (30sec) and reduce it to 6-8x400. Hard Anaerobic workouts can still be done, but not within 7 days of an important race. Remember that the goal is to maintain the system, not continually strive for improvement.

Sample of a 4 week Racing Period:

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	Lactate Tolerance-maint	Easy	LT maintenance (medium)	Easy	Easy	Race (hard)	Easy
2	Long Rest Lactate Tolerance-maint	Easy	VO2 maintenance (medium)	Easy	Easy	Race (hard)	Easy
3	sprint/hills (medium)	Easy	Blowout workout-hard	Easy	Easy	Medium Long	Easy
4	LT maintenance (medium)	Easy	Pace workout (medium)	Easy	Easy	Race (hard)	Easy

Additional Information:

How long does it take to reach maximum abilities for various forms of work?

You might be wondering why only six weeks is spent on VO2 work, or 6 weeks on anaerobic work, yet a base period lasts significantly longer. I've already explained why we work on a 5-6 week cycle (because that's how long it takes normally for benefits to be obtained and then stabilized), but why do I only suggest a couple weeks of each? Because on average this is how long it takes for the athlete to max out in that season for those specific capacities. Individuals obviously vary and some athletes will need

much more or much less, depending on how they respond. For instance some athletes need very little anaerobic training to see benefits and max out, this is because they are a fast responder to this type of training. That is why it's important to individualize the training.

Research has shown that it takes at least 8 weeks for the training of the aerobic system to take effect. VO2max work takes effect between 3-7 weeks, and anaerobic work takes effect in 2-6 weeks depending on the athlete. (Olbrecht, 2002)

Reason for Interval training:

Why do we run intervals? It's a simple question with a simple answer, but it is good to understand the reasoning behind the training you are doing. The simple reason to run intervals is that it allows the runner to hit specific paces or training zones (such as LT, VO2max, Lactate tolerance, etc.) for a longer amount of time then would be spent in that zone if you just ran for a continuous run. A simple example would be if you want to run a 4:00 mile, so it makes sense to practice running at about 60 second pace. Well if you went out and ran 60 second pace for as long as you could, let's say you make it 1200-1400m and are dead. Well with interval training, you can break it down to let's say 10x400 at 60 sec pace, or 20x200 with 60 sec pace. So now you are spending 4,000m at this specific pace and aren't nearly as fatigued until maybe the last repeat! As for spending time at training zones, let's say you want to increase your VO2max. Well how do you do this? Spend time at 100% VO2max. By running Intervals you are able to spend more time at this zone because you can only spend about 3 minutes at this zone before you start producing and using too much lactate to make it as effective aerobically. Let's say you do 6x3 minutes with 3 minutes rest at VO2max pace. By doing this you get to spend 18 minutes at VO2max pace (compared to about 8-10minutes at the pace if you run VO2max pace until you can not), and probably about 10 minutes or so at 100% VO2max. (You spend about 10 minutes at 100% VO2max because at the start of each interval it takes you about 1:30 to get up to that effort level since you recover during the rest period.) This same reasoning can go into why you might run LT repeats or any repeats. However with LT repeats there is a lot of preference that goes into it as some prefer to do a straight up tempo instead as running on a measured course seems more like a "hard" effort than the moderately hard effort that most LT runs are supposed to be.

When coming up with intervals for your training, use your imagination and the knowledge you have to design them. You can further break intervals into sets to get more repeats accomplished during the same training session. An example would be if you can't do 10x400 at mile pace, then run 3 sets of 4-5x400 at mile pace with a longer break in between sets and the same break in between repeats. It should be noted that there is a reason for continuous efforts too, specifically during Lactate Threshold work. During this type of training it is beneficial to mix both LT runs and LT repeats. I've described the benefits of LT repeats, as you spend more time at LT pace and such things, but LT runs keep a constant pressure on your body. Your body is gradually increasing the effort and the heart rate doesn't ever have a chance to recover, so you are running at a high-end pace. Meaning you are constantly applying a little bit of pressure to the system. Thus a good mix of LT runs and LT repeats can be done, or based on your preferences you can do more of the one you like more.

The Importance of Running by Feel

After explaining all of this science behind training, I'm now going to tell you that it's all great stuff, but the key is learning your body. You need to be able to feel different paces and different types of training stimulus. Stop watches, heart rate monitors, lactate measurers; they're all great accessories to have, and if used right can greatly aid your running. All of these items are meant to give you feedback to tell you

if you're running in the right zone or at the right pace. I mean where would we be without a stop watch to time our repeats on the track? Running accurately at race pace would be extremely hard to do most likely as we'd get zero feedback to whether we were hitting pace or not. However, one should not be a slave to the watch. It should be used just for feedback to give you additional information, not to govern your run or workout. A lot of runners get caught up in knowing their speed at all times (thus the new development of Speed Distance Monitors and GPS monitors, giving us constant speed feedback). They become obsessed with splits. If the run isn't at exactly there target pace, then they'll pick it up to hit that pace, even on easy runs. The problem with this is that on normal distance runs, some days to run 6:30 pace will require let's say 70% effort for a runner, and on others it will require 80% effort or so. So the runner is running the same pace both days, but the effort put in is vastly different, thus meaning your not getting the same response from your body even though the pace is the exact same! The change in effort could be because one run was fresh, while the other you went into it a little fatigued from training, or on one day it's hotter and more humid than the other, or you had a rough day at school and are tired out mentally. Whatever the reason, the effort changes to hit the same pace. That is why it's important to not be a slave to the watch. You need to learn how to run by feel. Learn what a recovery run should feel like. Learn what a normal run should feel like. Learn what a Lactate Threshold run should feel like, etc. Once you learn this feeling you run by feel, meaning you are more likely to run at the pace that your body needs that day and at that time, not by some arbitrary pace you or some guy in a book determined what was best.

Kenyans are excellent at this! They've been known to run as slow as 9 or 10 minute pace some mornings for recovery, while on some progression runs, they pick it up to right below LT for a bit without knowing the scientific reasons behind doing this. Running by feel is incredibly important during LT running. Without the use of a lactate monitor which 99.9% of us don't have, the best way to find this zone is by knowing your body and running by feel. You learn what it feels like to get in that zone with experience but once you truly experience you can almost always remember the feeling and get back the next time you do LT work. By running by feel you can also tell when you go over this critical threshold. This allows you to be able to judge when to stop the workout much better. It's been estimated that we can sustain LT pace for about 18-22 minutes before going over. Well that's a 4 minute range. If let's say you go over the LT at 17-18min and your prescribed workout said to do a 22 minute LT run, then you get 4 or 5 minutes where your Lactate levels are progressively rising, which isn't the purpose of the workout. By running by feel, you can tell once you are going over that edge and just stop and call it a day when you hit the point. This is one of the reasons why I don't like running a course with measured splits on it during LT runs. Too often runners, since we are competitive in nature, see mile splits, and turn into race mode and think we have to go faster and set a LT run PR. But this just leads to horrible results as it destroys the purpose of the workout! Many high school athletes run into this problem as they have the awful, no pain, and no gain attitude and think they have to race on LT runs, and splits only encourage this. Also, splits encourage runners to hit there "artificial" LT pace, the one prescribed to them by their coach or a book. Well this pace is just a guess or range of what it could be based on normally one race PR. Well it doesn't take into account the individual athlete, as this athlete could be endurance or speed based, meaning his "artificial" LT pace could be way off if he has superior endurance, or highly lacks endurance. By running at this "artificial" LT pace, the athlete risks going way over LT, or way under, not getting optimal benefits and he will never get the feeling of what it is like to run at LT pace. Thus losing touch with his body and not being able to read it. Running a measured course is all right, because it gives you feedback, but the total time should be used just for that, feedback. It should not determine the workout.

Fartleks

The word fartlek is Swedish and means "speed play." This type of training was original popularized by Swedish coach Gosta Holmer. Originally it was a very informal type of training where you vary the speed based on the athletes feel. This means you vary the speed throughout the run often times alternating fast/slow, or fast/medium, or medium/slow. The use of fartleks can be extensive. You can use fartleks as easy runs, VO2max runs, Lactate Threshold runs, and even anaerobic training. You can even do hill work or speed work fartlek style. I like using fartleks at the beginning of each period to transition into something new because it allows you to run by feel and ease into the new training. The beauty of fartleks is that they don't have to be as structured as traditional repetition training. You can alternate fast/slow based on telephone poles or hills or number of houses. It lets use your imagination, frees you from the boredom that often comes with too many repeats on the track and can be done almost anywhere. Using slight fartleks during easy runs can also be effective in getting your body ready for pace changes. For example, I have mentioned adding 30 second surges every once in a while on some easy runs as a transition workout. It still remains an easy run but with a little pace change in it.

Why run doubles?

After reading the physiology section, your probably asking the question as why I seem to advocate doubles so much when it seems like the longer you run at aerobic pace, the better your aerobic system becomes. Well as this is true, I believe the benefits of running doubles out weigh those of singles for most, but not all, people. Of course running doubles depends on how high the mileage is. If you're running 40mpw, do you need to be doing doubles? No, except for maybe a shake out run every once in a while if you feel like it. Obviously, the more mileage you run, the more important running doubles becomes. The main benefit of running doubles that I've found is that it allows you to run at a much faster pace than running singles. I'm able to run at a higher aerobic pace on some days because the run is only 7-9 miles, where as if I was doing a straight 15-18 miles, I'd have to slow it down. In my personal experience I've felt more bounce in my stride, promoting proper running form, when doing doubles, because running all that mileage at once tends to break my form down after being on the road or trail for almost two hours. Thus, when my form breaks down, I'm promoting bad running mechanics making me less efficient when I run. I also have felt more stale or "flat" when running all the mileage in one run. Doubles also come in handy as it allows you to run at a slower pace too! If you need to recover one day, you simply slow down that morning run, recover, and you are more likely to run that afternoon run at a more solid pace. It's been my experience that doubles allow you to recover more, as although you have less recover time between runs, you can have more recovery or easy runs in place to stimulate recovery. In addition to the pace and recovery aspects, I believe it allows you to implement more types of training. For example you can hit all the different systems in training during your "main runs" and then supplement that with morning or afternoon aerobic running. So that during any given day you may get a LT run and a pure aerobic run in the same day, or hill sprints and an aerobic run. You don't have to worry about packing it all into one run each day.

For younger runners I think doubles have the added benefit of letting you build up your mileage to higher levels. Most younger runners don't have the lifetime base under them to handle running 100+ mpw in singles. There bodies will break down because of all the pounding, but many runners in HS could handle higher mileage amounts if they split them into two shorter runs. In addition, the injury risk tends to be lower as you aren't on your feet for as long pounding away. Another benefit of doubles is that by running twice a day, your metabolism gets elevated twice per day, meaning you most likely burn more calories with the same amount of mileage if you run twice, because after each time you exercise your metabolism stays elevated for a bit after your done.

Finally, the most important part is that it's been done for years by Elite athletes. Granted, not all or even close to all run doubles, but I'd say a majority of them do (Remember we're talking training from the middle distances up to about 10k or so, not marathon training). Look at elite training logs and you'll see that the majority run doubles. It's been done for a long time and is a proven method. For example in the book "Run Run Run" by Fred Wilt, published in 1964, they advocate doubles! He says "Mature middle-distance runners no longer question whether they should use one or two workouts daily. If time and circumstances permit, a high percentage train twice daily...The morning training session should be lighter than the evening workout each day. (pg 35)" This shows that even back then they realized the benefits of doubles through trial and error! Also it should be seen that Wilt believed that one run should be easier than the other. The same thing can be found with Lydiard's runners often supplementing their main runs with easy jogging in the morning. Lasse Viren's training logs also show him running twice per day on most occasions. Kenyans do similar things as they supplement their runs with easy runs (sometimes as slow as 9-10minute pace) in the morning. Kenyans have been known to even run three times a day at times. I could go on with examples, but that is the best evidence. Doubles have worked with others for years, and they continue to provide benefits today.

Evaluating Weaknesses and Strengths

It's important to know the strengths and weaknesses of the athlete before you are able to individualize the program. Of course it's impossible for us to know the exact genetic makeup of each athlete because we certainly don't want to go get a muscle biopsy to find out what muscle fibers he has. So it's best to look at his performances over a wide range of distances and to see what the athlete excels at. By doing this you can see whether he has naturally more endurance or more speed or what. There are several methods to doing this. One method is to use the IAAF scoring tables (can be found at iaaf.org) and find the score for your primary event, then see what the equivalent performances are and compare them to your PR's at those events. For example my comparison would be:
7.4

	actual performance	ideal performance based on 1500	percent difference
400	50.8	47.00	7.42%
800	1:52.70	1:48.97	3.31%
1500	3:43.76		
3000	8:21	7:59	4.60%
5000	14:31	13:45	5.29%
1000	29:50 XC	28:55	3.17%

There are obvious flaws in this method, such as I haven't raced the 3k or 5k or even 10k (on the track) near as much as the shorter distances so therefore the percentages won't be quiet correct. But this does show that I need equal work in both under and over distance events as I have room for significant improvement in all events.

Just for comparison, we'll do Steve Scott:

	actual performance	ideal performance based on 1 mile	percent difference
800	1:45.05	1:43.00	1.96%
Mile	3:47.69		
3000	7:36.69	7:31.19	1.20%
5000	13:30.89	12:56.67	4.22%

From this it can be seen that Scott near maximized his abilities in the events just over and under his primary event, but underachieved a bit in the 5,000. Again this could be due to the fact that he did not run it as much or until later in his career. As a guide, you want the performances in distance other than your primary one to be within 2% or less.

Another method of comparing performances is Frank Horwill's 4 second rule. This is a simple rule of thumb and easy to remember. You take the pace of your primary event per 400m, then take off or add 4 seconds for men, and 5 seconds for women as you increase or decrease the event.
For example a runner who runs 3:45 for 1,500, or 60 seconds per lap, would have the following results for the 4 second rule:

400-52 (52)
800-1:52 (56)
1500-3:45 (60)
3000-8:00 (64)
5000-14:10 (68)
10000-30:00 (72)

This formula tends to be best used to see if you are maximizing your longer events based on the shorter ones. It's best used to judge someone's aerobic capacity in my opinion.

A third method for evaluating performance is by using the following chart (found in Univ. of Arkansas women's training guide):

1,500 time=X
400m time= 1/4x-6.5 sec
800 time=1/2x-2 secs
3,000 time= 2x+36 secs
5,000 time= 3x+154 secs

The last method I'll describe is the one mentioned in Better Training for Distance Runners by Coe and Martin. It is based on whether you are a 10k, 5k, or 1500m runner. You then input your times and compare them to find weaknesses and strengths.

To figure out this information, take Y(either your 10k, 5k, or 1500 time) and convert it to seconds, then multiply it by the number beside it to get your equivalency.

Distance	A (long distance runner 10k)	B (Distance runner 5k)	C (Middle distance runner 1500)
marathon	4.6*Y		
10k	Y	2.1*Y	
5k	.48*Y	Y	3.36*Y
3000	.28*Y	.58*Y	2.15*Y
1500	.13*Y	.27*Y	Y
800		.13*Y	.48*Y
400		.06*Y	.22*Y

These guides are all helpful in determining weakness and strengths of different athletes. Now once you determine that an athlete is weak in a particular distance what does that tell you? Well as a general guide, if he is weak in the longer distances then it tells you he is lacking sufficient aerobic development. This means that working on the athlete's aerobic capacity as well as Lactate Threshold should most likely be emphasized. If the athlete is weakest at the much shorter sprint races, then he probably needs more development in either pure speed training to work on his fast twitch muscle fibers and speed endurance. If the athlete is weaker at the shorter middle distances (800 for example) then he probably needs work on his anaerobic system and his ability to tolerate lactic acid. Thus maybe a little more emphasis is put on anaerobic development that involves some lactate tolerance work.

Adjusting your training to the event

Along with individualizing the training to each person's strengths and weaknesses, training should be tailored to the event that will be focused on. How do you do this? Simply look at which energy systems your event uses, then that forms the basis of what you focus on. For example a 1,500m runner uses about 20% of his anaerobic system during the race, while a 10k guy would use less than 5%. So it only makes sense that there is much less focus on anaerobic training (lactate tolerance and anaerobic capacity) work throughout the year for the 10k runner as opposed to the 1,500 runner. The 5,000 runner would use more anaerobic work than the 10k runner, but less than the 1,500 runner. (Now this is in general, you have to take into individual considerations, for example if a 5k runner has a strong aerobic capacity but a horrible anaerobic capacity, then he might do almost as much or as much as a normal 1,500m runner would do.) The other reason the 1,500m runner would need to do more anaerobic training is because the overriding rule is that if you want to race at a certain pace, you have to practice at a certain pace. Thus, many anaerobic workouts are done at 1,500m race pace. While it is easier to do 5k and 10k race pace workouts as VO2max workouts and slower, thus there will probably be a bigger emphasis on that for the 5k runner. Now, how do you translate this into the training program? Well a 1,500m runner might do 1, and maybe rarely 2, anaerobic training sessions a week during the Competition period, while a 5k runner might do one every week or 10 days. The 10k man might not start them until later, maybe 4 weeks out, instead of 6 weeks out from the first big race, and do them less frequently, maybe once every 10 days. You also have to adjust the other systems of training too. A 1,500m runner might do more shorter faster LT runs right at LT pace, while a longer distance runner might do sub maximum LT runs at slightly slower than LT pace but for a longer time. Also, LT runs might have more emphasis throughout the season and for a longer period of time. For instance instead

of doing maintenance LT workouts, the longer runner might do full blown LT workouts. The same can be said with VO2max. VO2max workouts could be emphasized for a longer period of time for the longer runners and even done more frequently.

In making a training program for yourself or your athlete, it's all about the art of putting it together. You have to mix and match based on a number of things. First you should look at your individual athlete's differences and focus on maximizing his strengths and improving his weaknesses. After you do this, then you further modify the program based on the chosen event that you or your athlete is going to be primarily racing. Then tweak the individual workouts based on the athlete's preferences of workouts. You don't want to force the athlete to do something he hates day after day. (Now there will be times when you are forced to do workouts you don't really like because they are necessary, but this shouldn't happen week after week after week). For example, if you have an athlete who hates the track, switch most of your VO2max workouts to off track workouts. You can get the same thing accomplished and the athlete might enjoy it more, thus having a better workout.

Individualizing Training Based on his abilities

Almost every coach will say that he is individualizing a training program for each runner he coaches. Yet how many of these training groups do the exact same hard workouts if they are training for the same event? Sure the weekly mileage may differ some, but if you're in the 1,500m runner group you do the same workouts as the other 1,500m runners. This type of training is focused on training for the event and ignoring the individual differences in the athletes. Even though all of the athletes may be training for the same event, they all have different needs, strengths, and weaknesses. That is why it is important to individualize the training based on the individual runner, and not to just train for the event. A quick example of that is that you may have two runners training for the mile, but one has a 400m background, while the other has an XC background. Should these two athletes be trained the same way just because they are aiming for the same event? Not at all.

I've already explained how to evaluate an athlete based on his performance in events shorter and longer than his preferred event. This gives the coach an idea of what the athlete's strengths and weaknesses are. To help simplify and get the point across, let's look at athletes training for the mile. If an athlete has very good performances for a miler at the 100m, then his natural speed is very good. If he has good performances over 400m-600m then he has a good anaerobic capacity (maximum amount of anaerobic energy he can generate). If he has good performances over distance races such as 3k-10k then he has a good Aerobic system. The opposite can be said if the athlete is comparatively poor at one of the aspects mentioned above. These are all generalizations but can help in accessing an athlete. The measure of his aerobic and anaerobic abilities can also be found by lactate tests or VO2max tests (look in monitoring training section).

Once you figure out what the athletes strengths and weaknesses are, then you can individualize the training to come to the optimal blend of the different aspects for his event. I say optimal blend because it's obvious that you can't have world class anaerobic capacity and world class aerobic system at the same time and expect to run fast in the distance events because these two aspects have opposite effects. As a middle distance runner, the athlete will need a great aerobic system, with a very good anaerobic capacity. If the athlete was a 10k runner, then he would need a very good aerobic system with a good but slightly less developed anaerobic capacity. This is because the 10k doesn't depend on the anaerobic system as much as the mile. So if you overdeveloped the anaerobic capacity, then the athlete would be deriving more energy from the anaerobic system than is needed for the 10k. So after evaluating the different system max, it can give you an idea of what needs to be increased. This helps tell you how

long you need to spend on each element of training. For instance if he already has a high anaerobic capacity, then the athlete needs to focus on maintaining the anaerobic capacity through anaerobic maintenance workouts, and then maximizing his ability to use that anaerobic system max through lactate tolerance workouts.

When individualizing training off of these aspects it's important to know the following:

- Low Intensity High mileage can temporarily reduce the Anaerobic capacity
- Too High of an Anaerobic capacity makes it harder to maximize the ability to use the aerobic system (VO2 work)
- Slow mileage inhibits sprint speed
- Too much anaerobic work hurts the anaerobic capacity.
- VO2 work can hurt Anaerobic capacity and aerobic system if there aren't enough recovery runs
- Lactate Tolerance workouts lowers anaerobic capacity and aerobic system.
- Too low of an Aerobic system won't allow sprinter to maximize Anaerobic capacity.
- Anaerobic capacity decreases the aerobic system (and Lactate Threshold which is a good indicator of the aerobic system)
- Aerobic system increases can decrease the Anaerobic capacity
- If anaerobic capacity is high, then VO2 work and lactate tolerance work needs be done to maximize abilities.
- If anaerobic capacity is too low, then Anaerobic Capacity work needs to be done to raise it before working on maximizing the two systems through VO2 and lactate tolerance workouts.
- Better the Aerobic system, the more frequent and higher mileage the athlete can handle
- Aerobic system can never be developed too high.
- Higher the anaerobic Capacity, the more VO2 work must be done to maximize aerobic system.
- Recovery runs maintain Aerobic system during intense training.

Treadmill Training

Training on the treadmill is seen as a recipe for boredom for most runners, however it does have its benefits. The most obvious one is that you can run on it whenever you want and the weather doesn't affect it. This allows you to still get your training in no matter what. Another advantage of treadmill training is that in many runners it will teach you the ability to focus. Because of the boredom associated with running on a treadmill, staring at a wall for an hour or so, will help improve a runner's mental toughness and ability to focus for long periods of time, which could come in handy for longer races such as the 10k or marathon. Also, by running for long period of time on the treadmill your ability to zone out might improve. In addition to helping you focus, the treadmill is a good tool to help you get into a rhythm. Since the terrain never changes it's easier to get into a rhythm and focus on your form on a treadmill. However, when running on a treadmill sometimes people flatten out there stride, meaning they get less bounce. This isn't a good thing and you should pay attention to this when doing any treadmill training. But, it can also improve your form too, because it tends to stop you from reaching and heal banging (your heal touches the ground first, creating a braking motion). It should be noted that there is no wind resistance in treadmill running, so unless you have a fan blowing on you, it's best to set the incline at about 1% or so to get the same effects and pace of outdoor running.

As for doing workouts on the treadmill, I don't advise it because then you become a slave to the pace per mile and don't run by feel as much. Some people have had success running workouts on the treadmill, but it takes a smart runner to be able to not dwell on paces when you can easily adjust the pace that you're running by pressing a button. However, it is a good substitute for long hilly runs if you don't live

in a very hilly place. Just increase the incline every so often and you have a long hill run to work on your strength a little bit, even if you life in a pancake flat place.

What to do if you are injury prone?

Now every once in a while you'll encounter an athlete for whatever reason who seems to get always injured. No matter how low his mileage is, he always gets injured. Often times younger athletes grow out of this after a couple years of training and there body gets more adapt to the pounding, but what do you do when it seems that no matter how little an athlete does he seems to get injured? Well first off injuries normally happen for a reason, whether it's too much mileage, intensity, and incorrect running form, whatever. You should search for the reason he's getting injured first before thinking about how to fix it. Now, if this athlete is motivated and wants to be a higher mileage runner, but can't at the current time for some reason, then you have to start using your imagination to improve the athlete. I had a friend who went through 4 years of running CC and track in HS and never finished one season without having an injury. By his senior year we had him swimming/water running in the morning and then biking in the afternoon. The only running he'd do would be two to three times a week he'd step on the track and do race paced hard intervals (he ran the 800) and ran 1:58 off that schedule. This athlete wasn't able to handle any mileage for some reason, no matter how small. So the program was adjusted that his most important workouts were done running and then they were supplemented with non pounding exercises to take the place of recovery or aerobic runs.

Now how do we do this. Let's say you can do 40 a week without getting injured but if you go over your bound for trouble. So what do you do to improve if you can't develop your aerobic system enough through running? Well you go to the next best thing. Maybe you do one run a day with a supplemental water running session in the morning. Or a cycling session. Sure it's not ideal or specific, but it creates less pounding, less chance of injury and allows you to increase your aerobic workload without increasing your risk of injury. I'm a big believer in to run faster, you have to do just that, run. But in certain cases, you can't run more, because for whatever reason that athlete is injury prone. So when setting up a schedule make sure that all the running is done during the important workouts such as threshold or anaerobic or VO2max workouts or race pace workouts and a semi long run. The main workouts should be run. Now if you can't supplement the main workouts with much other running because you are extremely injury prone. Then for supplementary workouts used for recovery or aerobic endurance (such as a normal 7mi recovery run or a 8 mi easy to normal pace run), then you can do some of the aerobic work on the bike, pool, or elliptical machine. It's not ideal, but it is the best you have to work with. So as an extreme example of an athlete like my friend mentioned above, a week of training during the competition period could be, anaerobic workout run on Monday, easy water running on Tuesday, a threshold run or VO2max intervals run on Wednesday, easy water running on Thursday, easy run Friday or some sprint work run, medium long run on Saturday, cycling or other activity on Sunday. And to supplement this schedule have the athlete bike, swim, pool run, elliptical, whatever, aerobically in the mornings during the week, just as someone would add supplementary aerobic runs in the morning during the week.

It's not ideal, but for those cases where you have an injury prone athlete, then it's better than the extreme low mileage with little aerobic development. It should also be noted that this should be individualized based on the severity of the athletes likelihood to get injuries. Most likely as the athlete grows and develops, he will be able to run more and will grow out of the injury prone stage. Also since most of the running the athlete would do in the extreme example is of high quality precaution should be taken. This means that depending on the athletes injury history, wearing spikes, amount of time spent on the track, etc. should be limited. Maybe tailor the runs to off track or softer surface runs.

Warming Up

When I first started this sport in junior high, I thought warming up made no sense. It was only going to get me more tired for the race so why should I jog for 5 minutes. Of course this is what you tend to think when your longest run is the race (2 miles) and you don't know any training pace except for fast and have never heard of easy runs. Now I'm sure you all know the main benefits of warming up, but just for informational purposes we'll go over a few simple reasons to warm up. One main reason is that you need to get your body temperature slightly elevated to perform optimally (thus the name "warm-up"). It's been found that certain enzymes in your body require slightly elevated body temperatures to work optimally. By running easily you activate your metabolism and get the fuel burning going and this leads to the slight rise in body temperature. The warm up serves the purpose of "getting the engine started", by increasing circulation by elevating the heart rate a bit, raising the metabolism, and by warming up the muscles and creating better elasticity in them (greater range of motion). A typical warm up should include between 10-20 minutes of slow jogging, followed by a period of stretching to get the muscles stretched out, increase range of motion, and to reduce the tightness or stiffness often felt in the muscles. I do not suggest jogging for less than 10 minutes as I don't feel this is long enough, except in extreme heat conditions. It is important to take the weather into consideration when warming up. If it is extremely hot you may need only a few minutes of jogging to warm up, while if it is cold, the warm up may need to be extended as it will take longer to raise your core body temperature. After the jog and stretching some short accelerations should be done. Depending on the person and the event racing it could be as short as 50m to as long as 200 or maybe more. I've known some people who have had great success running 200m or so at race pace 5-10min before the competition. The amount of accelerations you do should be done by personal feel. Experiment in less important meets with the warm up length and amount of strides done until you feel that you are at your optimal level. The general rule is that the shorter your warm up jog is, then the more strides you probably need to do. Practice different warm ups before harder workouts too as these should give you a good idea of what will work during race day.

Taking Days off

A lot has to be considered in whether you should take a day off once a week or once every 2-3 weeks like how long the runner has been running, his fitness level, training intensity, injury history. Days off are mostly done by preference. However, it's naive to think that your body needs a day off without actually trying for a while to run without taking a day off. You have to see how your body reacts to each way. Some people feel worse off when they take a day off, while other people it rejuvenates them. Looking back at past successful runners doesn't help much either. There is a wide variance on how often the runners take a day off. Some never took days off while others took one every week, yet both groups experienced success. Thus, it's best to look at days off on an individual basis and not prescribe an all encompassing rule about them.

The purpose of the day off is for mental and physical recovery. First let's look at it from a mental standpoint. Let's face it, training at high intensities can take its toll on even the most dedicated athlete. Because of this a mental break is sometimes needed. It's up to you to decide what a mental break is. Since I run twice a day five days out of the week, a mental break is only running once that day. If I take a whole day off then instead of giving me a mental break, I start to worry if I should run or not. Therefore in my own case, it's much more mentally relaxing to take a morning off as a break, instead of the whole day. If I take a whole day off, I feel like I should have done something and should have run. On the physical standpoint, an off day allows your body to adapt and recover. You've stressed your body to a high degree for a good amount of time and sometimes you need a down day to let yourself

bounce back, recover, and get ready for the next period of hard training. The physical recovery can be accomplished in two ways in my opinion. If you respond to days off positively then those are fine, but I find it's better to do a really easy run. The length of the run doesn't really matter, although I prefer a normal run length, so 9-10 miles. The difference is that the pace doesn't matter at all. If you want to run 10 minute pace on these days, go for it. Kenyans often do runs for recovery at extremely slow paces. This type of run has its benefits on recovery. First off, you increase the blood flow to your muscles when you run. So when you run at such an easy pace, your helping clear out some of the waste products built up in your muscles by increasing blood flow. This might explain why some people feel better after running an easy run then taking the day off.

Now, how often should these days take place? I like to have one easy day every week. My easy day is always Sunday and it consists of an 8-10 miler at a slow pace. I prefer the easy day to the day off because I'm still running and getting the benefits of running aerobically. If you like days off, I would not take more than one every week. Any more than this, you lose valuable training time and training adaptations. Maybe an even better plan for some who like days off, but don't need them every week is to take one day off every 3 weeks with 2 days during that 3 week period being very easy days. So you have one easy or off day a week. As an individual, you have to play around with this balance and find what's best for you.

Overtraining

When trying to train at such a high level, many athletes are bordering on the line of overtraining. They try and find that perfect blend where they are training as hard as they can without going over that edge. It's a difficult thing to try and do and you will inevitably cross the edge at times. They key is to recognize when this happens and give yourself enough recovery to rebound and get back to normal training. If you continue to stress your body once you've crossed this edge, then you will send yourself more and more over the edge, meaning you'll fall deeper and deeper into fatigue. Chronic fatigue, or overtraining, is much harder to recover and bounce back from then normal fatigue and may require extended periods of recovery running to completely recover from. Thus avoiding chronic fatigue is very important.

We all experience fatigue as runners. It's supposed to happen. One of the main principles of training is that you stress the body then recover letting the body adapt to the stresses that were put on it. Therefore, normal fatigue can and should be expected if you want to be a successful runner. However, this fatigue should not linger for extended periods of time. You should know your body well enough to know when your muscles or your body feels more fatigued and for a longer period of time than usual. This is a way of your body telling you that it needs adequate recovery in order to adapt and feel normal again. The problem arises when this extended fatigue becomes increasingly periodic and ongoing. This is the first sign of overtraining. This chronic fatigue normally results in either injury, decrease in training performance, decrease in racing performance, and sickness. Once the athlete enters this "fatigue valley" it is tough to come out of quickly.

The physiological aspects of this type of overtraining can also be seen. When you stress your body, several adaptations and breakdowns occur (see training section for further explanation). Two of these include micro tears in the muscles and increased glycogen use. These are normal responses by your body to training. When these occur, the body then repairs the muscle damage and in doing so adapts it to the increased stress that was put on it, in turn making it stronger and more resilient to that stress. When glycogen is used for energy in the muscles, these glycogen stores are replenished through adequate food intake. If enough recovery time is not given for these two processes to take place then the glycogen stores won't be fully replenished, thus less fuel available for the muscles, and the muscles will

not be fully repaired or adapted, meaning they won't get the benefits of the stress put on them. This also leads to chronic inflammation in the muscles, meaning the micro tears aren't being repaired and the muscles can't function optimally.

The question then arises of how you get out of this fatigue zone. The simple answer is rest and recovery. You have to give your body sufficient time to recover. The problem with this answer though is how much rest is needed and this varies on an individual basis. If you are just starting to experience this problem, then a couple days might be sufficient. If you are a little further along 3 to 5 days might be enough, but if you have pushed yourself into a state of chronic fatigue, then even longer will be needed. It should be noted that many athletes take the necessary recovery time when they are fatigued, but then jump back into training too hard and too fast when they come back which leads them to repeat this cycle. You should be careful in coming back to fast and adding too much intensity at once. Resuming normal training is usually not a problem after you've recovered, however trying to "make up" the workouts you lost or missed is a big mistake. Just forget about the lost workouts and move on.

A long period of overtraining or chronic overtraining can also happen. This usually happens when you ignore the signs of overtraining and continue to push your body, never allowing proper recovery, and you sink further and further into a deep fatigue valley. This is usually accompanied by bad race and practice performance, sickness, never ending fatigue, and mood changes. Yes, you read that right, you can become very irritable or have other mood changes during chronic overtraining. This is a very serious condition and can take anywhere from weeks to up to a year in the most extreme cases to pull yourself out of this one.

While training may be the main culprit in overtraining other things must be taken into consideration. Things such as sleep, rest, diet, school, work, social life, etc. must be taken into account. Activities such as your work or school or social life can often interfere with your running. A training load that you can normally handle without a problem over the summer months when all you do is concentrate on running, may not be able to be done when other things are added to the plate such as work or school work. Thus, it's important to try and balance your running with other activities in your life to make sure that they don't take too much away from one another. Overtraining often occurs in this way when someone puts "too much on their plate" and can't handle the mental or physical stress of running at a high intensity and studying/working at a high intensity too.

Individual Response to Training and Genetics

As you've probably heard a million times before, individuals respond differently to different types of training. This is one reason why so many different training programs all can produce successful runners. It's also why some training programs that have produced champions will fail to help another individual improve. Their is no one size fits all training program. As humans we all have various genetic differences. While we mostly think of heredity giving us such characteristics as hair color, height, eye color, or even athletic talent, whether it's foot speed or hand eye coordination. However, genetics give us more than the inherent athletic talent. It also affects how we, as individuals, respond to various stresses of training put on our body. This helps to explain why some guys thrive off long slow mileage while others seem to respond off of hammering shorter runs. This phenomenon is often described as being a responder or non responder to training.

The proof of responders and non responders has been demonstrated in various studies. Most of these studies include taking a group of men and women and train them exactly the same for a period of up to one year. Most of the studies take care to make the participants to exercise at a given percent of their heart rate for a certain duration for a certain number of days per week. The findings from such studies

have shown that % increase in VO2max has ranged from as little as a 0% change to a 50% change. It should be noted, that past training history and development no doubt plays a role in the amount of change that occurred as individuals who led a more active lifestyle would be in better shape, so therefore less likely to respond to the training as well. However, the thing that pushes the responder/non responder idea to be more accepted is when identical twins were put on similar training programs. In one such study, a group of identical twins was put on the same 20 week training program. They measured the % increase in VO2max at the end. Between the sets of twins the range was between a 0% and 40% increase in VO2max. However, the interesting thing is that within the sets of twins, each twin improved their % VO2max about the same. For example one twin improved it 10% and the other improved by 11%. Although there was some variation within the sets of twins, they responded similarly. This study is just one of many that show that genetics plays a part in determining how you respond to training.

This is very significant because it shows just how important individualizing training is. All the science in the world can tell you that some certain training program is supposed to work, but you might not respond to it as well or at all. That is why experimentation and trial and error is needed to figure out what you as an individual respond best to and what doesn't work.

Progression in training from year to year

The training advice given in this section is obviously weighted towards runners who have a significant amount of mileage behind them and have been consistently training for a year or more. The amount of training for an athlete has to be adjusted based on his running history. The basic ideas should be used throughout the athletes training from year to year, but the difference should be the amount of intensity done and amount of mileage done. As the athlete physically matures and gets more mileage behind him, he should be able to handle more work then he was previously able to. I've already discussed how mileage should be increased as the athlete matures. In this section, increasing the intensity from year to year will be discussed.

The principle of progression and long term development is easy to define, but it's sometimes difficult to implement. Think back to when you first started running. You most likely couldn't run very far or very fast and probably didn't run more than a couple of days per week. Most likely, you probably got pretty sore and tired when you started running, even though you weren't doing any highly intense organized workouts. After a while though, you are soon able to do more than just mileage, and your XC coach probably started scheduling a workout here and there. After doing some workouts, you found you were able to race, but after races you were so sore and tired that it probably took several days before you could workout again. Fast forward to a year down the road and you find yourself running every day with 1 or 2 harder workouts per week and after a race you only need a day or two before you can workout hard again. This is how progression works. You are able to handle increase training loads as your body adapts to them.

I gave you this example to show that, the more training you have under your belt, the more stress your able to handle, sometimes without knowing it. If you look at some of the Elite athletes training weeks, you might think the amount of work and the intensity that it is done at is unthinkable. However, you have to realize that they built up to this level over years of training, and that they to at one point could only handle easy runs and very few workouts. The key is they consistently worked up to the point where they could handle such heavy training loads. So what needs to be figured out is how much you can handle, and then try and gradually increase that load from year to year. First, let's look at the base phase of training from year to year.

When you first start running, the base phase should be mostly easy to steady workouts. No hard or scheduled workouts should be done as this allows for the young athlete to work on his aerobic development without too much intensity thrown on him. The base phase also provides a much needed mental break for the young runner, and since it isn't too intense and doesn't "hurt" much then the athlete is more likely to get out and run and enjoy himself. It can be suggested that the athlete do strides every once in a while. The key at a young age, such as a freshman in high school, is aerobic development, while getting the athlete to enjoy the sport. A long run can be added, but this is sometimes hard to get a young athlete to do. A typical week for a younger (14-16yr old) high school runner during the base phase.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
mileage, strides	mileage	mileage	mileage, strides	mileage	Long Run	off/cross train/or Recovery Run

As the athlete is able to handle more and more work, then more intensity can be added such as hill sprints, pace work, or lactate threshold work. The amount done should depend on how much the athlete can handle. Remember, that it is still the base period, and that high school athletes still need part of the base phase as a mental recovery period from the hard work put in during the track season. So, early in the period, just mileage is fine, but as the period increases more and mo e intensity can be added. Below is a week sample for an older high school runner.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Lactate Threshold	mileage	short hill sprints(60m)	mileage	mileage	Long Run	Recovery Run

As the athlete can handle more and more, you can progress to the schedule that appears in the base training phase that includes a threshold run, a short hill sprint, and either some strides or pace work. It should be noted that these are just examples and that the week can be changed up and done on cycles. For example, you can go one week including a threshold run and hill sprints, then the next week just hill sprints and strides, and alternate this cycle. By now, you should get the idea of how to progress from year to year. At some point though, no more workouts should be added, as it would be counterproductive to do 7 workouts per week and no mileage days. Sticking with the examples already given, in a couple of years, the above athletes base phase could look something like below, where he is now able to handle 3 organized workouts per week, with two being at medium intensity (lactate threshold).

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Lactate Threshold	mileage	short hill sprints(60m)	mileage	Lactate Threshold	Long Run	off/cross-train/ or Recovery Run
Lactate Threshold	mileage	longer hill strides (200m)	mileage	pace work OR mileage with strides	Long Run	Recovery Run

Physiological Adaptations to Training

The Heart

One of the major adaptations noticed by runners is a decrease in heart rate. This normally occurs following endurance training partly due to an increase in stroke volume. Stroke volume is the amount of blood ejected from the left ventricle in the heart. Or to further simplify, the amount of blood pumped per heart beat. In technical terms it's defined as the End diastolic volume minus the end systolic volume. Diastolic refers to the relaxation phase of your heart beat. During the diastole phase, your heart chamber is filled will blood. The systole phase is the contraction phase in which the heart expels the blood. Another important thing in regards to heart adaptation during distance running is the Ejection Fraction. This is defined as the percentage of total blood ejected after systole. So if 100ml was in the heart after filling (diastole) and then 40ml was left in it after expelling (Systole), that gives a stroke volume of 60ml, and the ejection fraction would be 60% (60(SV)/100(original total)* 100). Stroke Volume increases due to several factors including an increase filling of the left ventricle and increased total blood plasma volume. Also the more blood entering the ventricle increases the stretching of the walls and subsequent "elastic recoil effect", which basically means it contracts stronger.

Generally those with a lower heart rate have a higher stroke volume, meaning more blood is pumped out of the heart. So if more blood is pumped out of the heart, then the heart doesn't need to beat as often to meet the needs of the muscles, tissues, etc.

To further simplify it look at this hypothetical model.
Cardiac Output is the total amount of blood pumped per minute. To find this you multiply the Heart Rate by the Stroke Volume.

So, just pulling numbers out of nowhere to illustrate what happens between an untrained and a trained athlete:

untrained person=
resting heart rate=70bpm
stroke volume=70ml
Cardiac Output=4.9 L/min

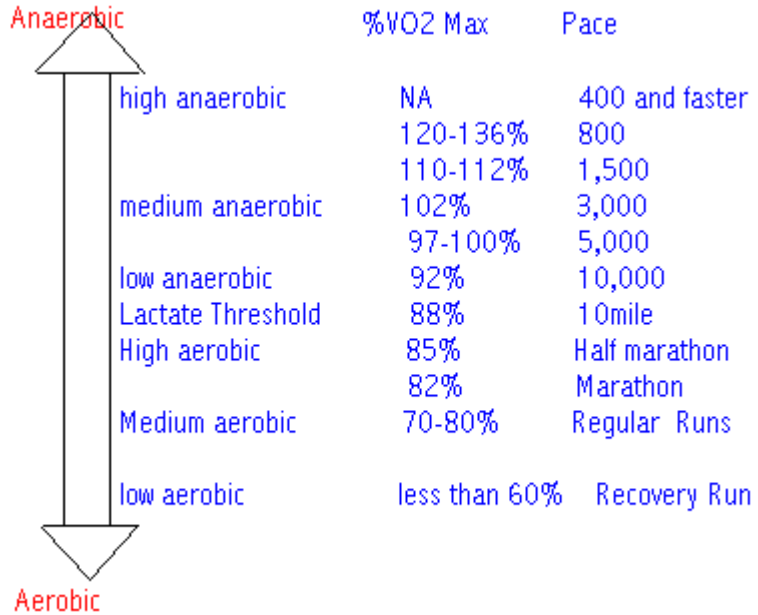
trained person=
resting heart rate=40bpm
stroke volume=123
Cardiac Output-4.92 L/min

So as you can see, because of athletes increased stroke volume, they can produce similar cardiac outputs with less beats per minute.

Training Type Chart:
This can be used as a quick reference guide for workouts.

Workout Type	Repetition Distance	Repetition Time	Pace used	Recovery
Aerobic endurance	steady runs from 3-20miles	20-120minutes	Easy to steady by feel	none
Lactate Threshold workout (submax Aerobic threshold in parenthesis)	around 4miles (6-12miles)	18-22minutes (40-70minutes)	LT pace-about 10mile pace (marathon pace)	none-unless you divide them into LT repeats, then short recoveries
VO2 max	800-3000m	2-8minutes	3,000m-10,000m pace	1:1 ratio to 1: 70% work to rest ratio
Lactate Tolerance	200-800m	30sec-2minutes	800 to mile pace	1:1 ratio to 1:2 ratio
Long Rest Lactate Tolerance	200-800m	30sec-2minutes	400 to mile pace	full; 1:5 ratio or more
Pure Speed (ex: Hill sprints)	20-100m	4-15seconds	All out; max speed	Full recovery

Aerobic/Anaerobic Training Chart



Should be noted that the %VO2max values differ for everyone significantly. The ones used above would be someone with a pretty solid aerobic background, and are derived from the USATF coaches education guide.

Summary of Training Program:

Training Phase	Emphasis	Support	Little to None of
Base (long time~ 12 weeks)	-aerobic development through mileage -Lactate Threshold development	-Pure Speed Work and Hill work -Pace workouts -Anaerobic Capacity improvement/ maintenance	Medium to high end Anaerobic
Pre-Competition (6 weeks)	-vVO2 development	-Lactate Threshold -Pure speed/ hill work	High End Anaerobic
Competition (6 weeks)	-Anaerobic development (Capacity and tolerance)	-Lactate Threshold maintenance -VO2 maintenance -Speed Endurance (longer sprints)	
Peaking (2-6 weeks)	Feeling good, Maintaining everything	-Anaerobic maintenance -Lactate Threshold maintenance -some VO2 maintenance -pace work	

Base:
emphasis-aerobic development through mileage, Lactate Threshold work
secondary support- pure speed work(60m sprints) and hill work
not much at all of-medium to high end anaerobic work and for younger guys no VO2 work either for most of the base.

Pre-competition:
emphasis-aerobic capacity (VO2) development
secondary support- Lactate Threshold, pure speed work/hills
not much at all of- high end anaerobic work

Competition:
emphasis-Lactate tolerance workouts
support=maintenance: Lactate Threshold, aerobic capacity, speed endurance (longer sprints, full rest)

Peaking:
emphasis-feeling good
maintenance-more relaxed anaerobic work, lactate threshold, aerobic capacity

Workout Examples and Progression Guide:

VO2max Sessions:

Sample	Workout
Session 1	8x800 with 3 minutes rest at 5k pace
Session 2	6x800 with 3 minutes rest at 3k pace
Session 3	6x1000 with 3 minutes rest at 3k pace

Session 1	2x3000 at about 10k pace with 5 minute rest
Session 2	3x2000 at about 2 secs per mile slower than 5k pace with 4 minutes rest
Session 3	6x1000 at VO2max pace (3kish) with 3 minutes rest
Session 1	5x1mile at 8k pace with 5min rest
Session 2	4x1mile at 5k pace with 5min rest
Session 3	4x1mile at 5k pace with 3-4min rest
session 4	4x1mile alternating 3k and 8k pace every lap with 4min rest
	Other VO2max workout examples:
pace change	4x 2400 alternating 5k and 10k pace each lap, 6min rest
pace change	8x400 at 10k pace with 200 recovery cruise at around aerobic threshold (marathon pace)
Fartlek	3x(3,2,1, 30sec fast) with equal slow run for each (so 3,2,1, 30sec)
Fartlek	1,2,3,4,5,4,3,2,1 fast with equal slow run for each

Lactate Threshold Examples:

Sample sessions	Workout
Session 1	5x5min at LT pace with 1 minute rest
Session 2	3x7min at LT with 90sec rest
Session 3	2x10min at LT with 2minute rest
	15min at LT
	20min at LT
	20min at LT, rest 2min, 5min at LT
	20min at LT, rest 3min, 7min at LT
	20min at LT, rest 4min, 10min at LT
	20min at LT, rest 4min, 15min at LT
Session 1	4x1mi at LT pace with 2min rest
Session 2	5x1mi at LT pace with 2min rest (and so on, you can go up to 8 or 9 or whatever, or you can start adding stuff in between the rest, such as below)
Session 3	4x1mi at LT pace with a 400m cruise at a little faster than normal easy run pace in between
Other LT examples:	fartleks such as: 5on, 2off, 4on, 1off, 3on,45sec off, 2on, 30sec off, 2on, 1min off, 4on

Lactate Tolerance Examples:

Sample sessions	Workout
Session 1	2 sets of 5x400 at mile pace with 1 min rest and 5 minutes rest between sets
Session 2	8x400 at mile pace with 1 minute rest
Session 3	10x400 at mile pace with 1 minute rest
Session 1	12x300 with 100(60-75sec) walk alternating mile/3k pace
Session 2	10x300 with 100 jog (45-60sec) at mile pace
Session 3	9x300 with 100 walk at in between 8 and mile pace
Other Lactate Tolerance examples:	
broken into sets	3 sets of (500,400,300) at mile pace with equal run to rest time and 4-5min between sets
breakdown	600,500,400,300,300, 200,200 with equal rest to run ratio at mile pace
400's	10x400's at 1-2sec per 400 faster than mile pace with 2minutes rest
200/300s	5x(200,300) with 1-1:130 minute rest between at 800 pace

Long Rest Lactate Tolerance Examples:

Sample sessions	Workout
Session 1	4x400 with 5minute rest where you go 300m at mile pace, 100 fast for the first one, 200 at pace, 200 fast for the 2nd one, etc. Fast means close to all out
Session 2	4x400 with 5minute rest, best average (at or faster then 800 pace)
	800 at mile pace, 5-7min rest, 2x400 at 800 pace with 4min rest, 5min rest after, 4x200 at faster than 800 pace with 2min rest
	600, jog 100, sprint 100, 10min rest, 500 same pace as 600, jog 100, sprint 200, pace for 600 and 500 should be a little slower than 800 pace
	5x400, 5x300 up hill with slow jog down hill recovery
	2 sets of (400,300,200) with 3min rest in between at 800 pace and faster, 5-10min rest in between sets
	2x800 at goal mile pace with 2:30 recovery
	500,400,300,200,200 at 800m pace or faster with 5min, 4min, 3min, 2min recovery (or about the time it would take you to walk the distance just ran slowly)
	800 (mile pace), 5-7min rest, 600 at 1200 pace, 5-7min rest, 400 at 800 pace, 4-5min rest, 200 at 400 pace