Science-Based
Performance Improvement Training

The Fundamentals

July 5, 2006

This is the first of a series of articles that will succinctly cover the basic elements of a program to improve running performance. All of the principles covered will be based on modern research science. Occasionally, I will interject a personal opinion; when I do, it will be specifically noted.

Principal beneficiaries of this program are seasoned runners who wish to improve their performance, perhaps to qualify for Boston, break 40 or 45 minutes for a 10K, etc. We will be recommending a training program that is quite different from, and often contrary to, what most of you are familiar with. However, you should expect a significant improvement in performance and a minimum of overuse running injuries.

I am not a coach, nor to I aspire to be one. My sole purpose in publishing this material is to aid my fellow fellow amateur runners in their quest to improve their race performance. The topics covered are a synopsis of the key elements of the research science, that I've been studying for 10 years, and those which I believe are most important for self-coached amateurs.

"Self-coached"? Most of our members do not have a professional coach and thus they are self-coached. Hopefully, the series will make you a better coach; at a minimum you'll learn the fundamentals based on modern scientific discoveries. The series will also provide you with recommendations to help you make informed decisions. Application of the principles and recommendations will be up to you.

In order to effectively train it is critically important to understand exactly what physiological components are to be improved and what is the best way to train them. We all know that traditional training programs include intervals, hill workouts, and long slow runs, etc. Most published programs do not explain the why and simply provide a schedule of workouts. You have probably observed that there is very little consistency among the programs. Thus, it is a safe assumption that they are not based on research science findings.

In this paper, we will address the question of "what physiological components are to be improved and what is the best way to train them."

All I ask is that you consider the program with an open mind. Consider me to be simply the reporter; I did not do the research. If you doubt the accuracy of my reporting and/or the research findings, I suggest that you check the references I've listed below. Then if you are not satisfied, this program is not for you.

The material covered in this series has been distilled from several sources. However, you will find virtually everything in the series is covered, in considerable depth, in the following publications.

The first is Dr. Tim Noakes', PhD, book "Lore of Running," 4th edition. This book is a must for every serious runner. It is, in essence, an encyclopedia of running, covering everything from the history of competitive running [this is a fun read], injury prevention and cure, physiology of running, training principles, etc. Dr. Noakes is considered the foremost running-physiology researcher and authority by

most researchers and professionals in the field.

Running Research News, this is a monthly publication edited by Owen Anderson, Ph.D. I recommend this newsletter for those who wish to keep up with the latest research findings. [www.runningresearchnews.com] Basically, Owen's monitors worldwide research and reports the findings in layperson language and context. I've found this publication very interesting and informative and it's only $39 per year, no ads. Unless, you have an academic interest, you can skip this for our series. However, I do recommend that everyone subscribe to his weekly, free eNewsletter. Sign up here www.runningresearchnews.com

The third publication is Jack Daniels' Ph.D. book "Daniels Running Formula." Dr. Daniels is one of the U.S.' premier coaches, having coached Jim Ryun, Joan Benoit Samuelson, Alberto Salazar, etc. In my opinion, I've found most training books by famous coaches and runners are recycled, obsolete, and anecdotal. Dr. Daniels is one of the few exceptions, he has a doctoral degree in exercise physiology and was a world class runner in his early years. "Daniels Running Formula" is the best training manual I've seen for the serious runner and one who prefers a regimented program. His book predates some significant research findings in the last 5 years, or so. Most notable is his emphasis on tempo training; I'll discuss this in a later installment.

From this point on, I recommend that you refer to "Lore of Running," to confirm and clarify anything in this series that seems incomplete or at odds with your understanding.

Now, I am going address several topics that will be the foundation of the program; "Overreaching and Rest," "Running Economy," " Fatigue Resistance," and "Overtraining Syndrome."

Overreaching and Rest

The basic principle of all sports improvement effort is embodied in the following paragraph.

"It is no secret among athletes that in order to improve performance you've got to work hard. However, hard training breaks you down and makes you weaker. **It is rest that makes you stronger. Physiologic improvement in sports only occurs during the rest period following hard training.** This adaptation is in response to maximal loading of the cardiovascular and muscular systems and is accomplished by improving efficiency of the heart, increasing capillaries in the muscles, and increasing glycogen stores and mitochondrial enzyme systems within the muscle cells. **During recovery periods these systems build to greater levels to compensate for the stress that you have applied.** The result is that you are now at a higher level of performance." [Mark Jenkins, MD] The emphasis is mine.

This sounds simple and has been recorded since ancient Hellenic Greek times; but, it does not provide any clues about the distribution of "hard work" and "rest." The technical term for "hard work" is "**overreach**" and we'll use it frequently. Most running physiological research in the 20 years has attempted to answer the question: "What is the optimal distribution ratio of overreaching and rest and the intensity level of overreaching"? For example, should intervals be run at 400m, 800m, 1200m, how many in a set, how often, etc.? When training for a marathon, how many long runs, what should be the longest run, etc.? You've read dozens of different answers to these questions. That should give you a clue, that what you've read is NOT based on any science-based, controlled research; otherwise the answers would be rather consistent.

Runners are very finely tuned machines. Your 10k race times are consistently within +/-1%! Got that,

one percent? [e.g., 45minutes x 60 seconds/minute = 2700 seconds. 1% of 2700 seconds is +/-27 seconds]. +/-2% for a 4 hour marathon is just under +/- 5minutes.

Running Economy

This is a qualitative measure of your body's ability to convert oxygen and glucose to energy that propels you. The unit of measurement is VO_2 per kg of body weight per second. This is an extremely important concept and one we will constantly refer to throughout this series. We all have a VO_2max. This is simply the maximum conversion rate our systems can achieve. Essentially, your VO_2max is inherited; however, it can be improved somewhat with training, typically by 5% to 50%. About 20 years ago researchers thought it was THE ideal predictor of performance, this was before they started measuring the VO_2max of non elite athletes. Certainly, to be an elite runner, you must have a very high VO_2max; however, ordinary runners can have a high VO_2max and not be great.

If you think about this for a moment, you'll see something is missing. Just because you can burn a lot of fuel doesn't mean you will go fast. Thus, another measurement unit is needed. It's called VVO_2max or velocity at VO_2max. [Technically it should be called speed at VO_2max, but it isn't.] This makes sense; if two runners have the same VO_2max but one's VVO_2max is greater, he/she can run faster. VVO_2max has been proven to be an excellent predictor of road running performance. To be accurately measured, VVO_2max must be done in a laboratory. However, a good approximation can be done on the track and we'll discuss that later in the program.

A key point relative to this discussion is the fact most well trained folks run 5Ks at about 95% of VVO_2max , 10Ks at 92%, 10milers at 85% and marathons at 65%. World class runners can do somewhat better for longer races. So, if you can improve your VVO_2max by just 3%, your marathon time will correspondingly improve by 3% or about 6:20min for a 3:30 marathon.

Your VVO_2max is determined primarily by your bio-mechanics: your weight [notice, VO_2max is per kg of body weight], your cardiovascular transport system and the ability of your muscles to utilize lactate [lactic acid]. Most running research in modern times has concentrated on improving VVO_2max, though the stated objective may have been different.

It should now be obvious that a principal focus of the training program will be on improving your VVO_2max. The goal will be to improve your running economy without introducing injuries and getting you into the overtrained state. I'll discuss "Overtraining State" further on.

There is a subtle point that needs to be addressed, do we all have an innate <u>maximum</u> running economy [i.e., a limit to your VVO_2max]? The answer is yes. Your training simply pushes you closer to your innate limit. No amount of training by the worlds best coach will make you a world class runner. All elite runners were considerably faster than all of their friends at a very early age, long before they did any formal training. Your current performance level is simply a degradation below your innate level. As a practical matter, you can expect to get within 2% to 5% of you limit, depending on how smartly you train.

Earlier, I stated that we will address what physiological components are to be improved and what is the best way to train them. If you consider VVO_2max, it is obvious that your VO_2max must be improved. It is primarily determined by your cardiovascular system's capacity and in particular your cardiac-output [stroke volume x heart rate]. [There is an important caveat here. Don't assume that I've implied that our

performance is limited by our cardiovascular system; modern research has definitely proven that it is not.]. Our maximum heart rate [HR] is controlled by our heart's electrical system and is inherited; training has little effect on the maximum rate. Training increases the stroke volume. If you compare a well-trained runner with an untrained person and their running mechanics are about the same, both running with a HR of, say 140bpm, the trained runner's stroke volume will be considerably higher and his speed will be faster. Incidentally, as your stroke volume increases, your resting HR must decrease; otherwise you would over oxygenate your brain and organs. Consider the stoke volume between a resting HR of 45 [a good runner] and 70 [the couch potato]. The cardiac-output must be the same, so the stroke volume difference is 70/45 = 150%.

How do you improve your stroke volume, and thus the cardiovascular system? It can only be done with high intensity workouts, intervals and hills, etc. You can run an incredible number of long slow miles and it will not materially improve your cardiovascular capacity. Think of it like this: you can do dozens of repeats with 20lb weights for months and it won't help you lift 150lbs. As you improve your heart's stroke volume, there is a corresponding increase in your vascular system to handle the increased volume. Elite runners can pump 10 + gallons per minute when running at full bore.

In addition to VO_2max, the second major component determining VVO_2max are your bio-mechanics. Your mechanics are principally inherited; however, they can be materially improved with training. We'll discuss this subject in more detail later in the program. However, for now, you can best improve your bio-mechanics the same way as your VO_2max, with high intensity workouts. The same principle as for improving your cardio system applies; long slow stuff doesn't help. You must stress your muscles so they are overreached and then rest them.

In summary, we've covered two important concepts: Overreach/rest and running economy. I strongly recommend that you read this first section several times and read the first few sections of chapter 2 in Noakes' book.

The bottom line for improving Running Economy: hard work. We'll get into exactly what "hard work" is later in the series.

Fatigue Resistance

Fatigue resistance has intrigued researchers for eons. It is what keeps us from running a marathon at our 10K race pace and the illusive, famous 20 mile wall in marathons, etc. Researchers have never been able to measure anything objective, we just slow down or "hit the wall."

One prevailing theory assumed the cause was due to hypoglycemia [declining blood glucose levels]. It can be a cause; but, based on extensive research, it is very rare. Field studies show only about 2% of runners develop hypoglycemia in a marathon, and only about 10% in a 50mile ultra. Furthermore, the symptoms are quite distinct, in coordination, inability to concentrate or think clearly, and extreme physical weakness.

Another theory was that most of our muscle cells have been spent and there are not enough left to carry on. Muscle biopsies conclusively show no sign of this. And, if it were the case, we'd never be able to sprint to the finish line. There have been numerous controlled experiments that throughly debunked this theory.

A personal note about my observations when I "hit the wall" in a marathon. I felt fine, I just couldn't run. I'd walk for 200 or 300 yds., wonder why I was walking, and start running again. I'd only get about 100 yds. and find myself walking again, for no apparent reason. I didn't feel particularly fatigued, I just couldn't run.

The answer came in 2001, when Noakes, Lambert, and St. Clair Gibson developed a new definition of Fatigue and presented it the first time at the Annual Congress of the American College of Sports Medicine [ACSM]. Basically their theory states that our brain contains a "Central Governor" [CG] which controls running. It basically keeps us from killing ourselves by monitoring all the appropriate blood components and neurological signals from our muscles, etc. When it decides we've done enough running, it simply slows its signals to our muscles. This theory has had a major impact on the understanding of running physiology and performance training. I highly recommend everyone read "Central Governor's Role During Prolonged Exercise." page 144, "Lore of Running," for more detail.

Bottom line is the "Central Governor" readily explains the fatigue phenomena we experience. For, example, it explains the marathon wall walk/run phenomenon. Our Central Governor has decided we have done enough running for the day, based on previous experience and the vital signs it monitors. Thus, it decides we are to walk to the finish line, whether we like it or not. Consciously, we can try to override the Governor and force ourselves to run; but, the Governor puts a stop to it in short order. Its mission is to keep us from doing something stupid and killing ourselves. Note, just above, I said "based on previous experience." That's the secret to fatigue resistance training. We can teach the Central Governor to safely handle higher levels of fatigue.

The Central Governor also answers a VVO_2max mystery, which I purposely neglected to mention in the Running economy section. Coaches and researches have found several cases where runners with the same VVO_2maxs have different race times. The Central Governor theory explains this, the faster runner has taught his Governor how to deal with fatigue better.

There is another component of fatigue resistance which needs to be addressed. Mechanically, our running systems must be strengthened and learn to cope with the repetitive motion and impact associated with running long distances [Most of us pound the ground about 40,000 times in a marathon]. The solution is obvious, hills, speed-work and long-slow-runs. Research has shown that resistance training can also be very helpful.

It may be that the Central Governor plays a role in preventing certain types of running injuries. I've attached a copy of Owen Anderson's May 20th e-newsletter describing some research that shows we can train our brain to prevent injuries caused by overreaching "eccentric" contractions of the quadriceps muscles. RRNquad.pdf

I highly recommend everyone read "Central Governor's Role During Prolonged Exercise" page 144 in Dr. Noakes book "Lore of Running."

Overtraining Syndrome

Our running performance degrades when we enter into this state. The degree of performance loss and recovery time can vary greatly. Notice that it's a syndrome, meaning the symptoms and cure are not well defined and there are no specific, physiological tests to provide a qualitative assessment.

Elite athlete coaches say that one of their biggest challenges is keeping their charges from getting into the overtrained syndrome state. The basic problem is that the athlete is usually the last one to recognize the symptoms. Coaches have a standard set of questions they ask their athletes to answer daily in their log book [mood, orthostatic HR, libido, etc.]. Changes generally predict the onset of Overtraining Syndrome.

Dr. Noakes is one of the world's experts on the subject and I recommend everyone read "Avoiding Overtraining," chapter 7 in "Lore of Running."

It is unlikely that amateurs will get into a full-blown case of serious Overtrain Syndrome. However, it is likely, and I've observed what seem to be mild cases of, the syndrome among my fellow running club members.

Even a mild case of Overtraining Syndrome can degrade performance by several percent. Recall, earlier I said "Runners are very finely tuned machines."; and, that just 1% is almost 30 seconds in a 45 minute 10K race. Just a loss of 3% or 4% can be quite dramatic. Unfortunately, in the early stages, there are no apparent symptoms and our training and racing may seem good, though falling off just a bit. The normal reaction is to increase the training load to restore our speed. Of course this is exactly the worst thing to do and will exacerbate the situation.

Our program will include safeguards to help keep you out of even a mild case of Overtraining Syndrome. The best insurance is to follow Noakes' advice in his chapter "Avoiding Overtraining." I'll leave that up to you. The program will have good rest intervals and will not have monotonous periods.

Dr. Noakes states on page 487, "The combination of a high training load with a monotonous training schedule is more likely to induce overtraining."

I made the statement earlier "In order to effectively train it is critically important to understand exactly what physiological components are to be improved and what is the best way to train them." If you fully understand these concepts, the purpose of the training routines will be obvious when we discuss them later.

What's Next?

The next installment, "Practical Considerations," will discuss the practical applications of the fundamentals covered in this paper.

Al.....