TheElite Training Group track club

Expanding the area of what is possible

In Track & Field Distance Running & Competent Self-Care in medicine and psychology

TheETG
background science info

TheETG Training Packets

Mission: Expand the area of what is possible for human performance in distance running. One of TheETG methods of achieving that is to proliferate applied science based information by way of –free– packets containing plain language info for "the average joe" seeking to move themselves or others forward

As you continue to acquire and apply more information you continue to expand the area of what is possible.

The functioning of brain cells, muscle cells, blood cells, -all cells- are governed by the laws of nature. The laws of nature -are- the underlying mechanisms of how everything works. The laws of nature that control human cellular function are -not- governed by your chosen belief system or the dogma you have been indoctrinated into, or the dogma you refuse to set aside.
"Nature, to be commanded, must be obeyed." —[Francis Bacon]

Data-less conclusions founded upon faulty assumptions are the mother of all screw-ups. They lead to human belief systems that quickly get set in stone insuring that new information gets shouted down as pride, ego, and resistance to change supplant data, logic and reason. Put data ahead of dogma. Follow the data -not- the crowd.
"In God we trust…Everyone else must bring data." —[W.Edwards Deming]

To be a good track coach one must **-first- be a good physiologist.**
To be a good medical doctor one must **-first- be a good physiologist.**.
To be a good physiologist one must -first- be willing to……
— put data ahead of dogma, follow the data -not- the crowd
— put science ahead of indoctrinated tradition
— put logic and reason ahead of faulty assumptions
— put mechanisms ahead of correlations and "risk factors"
— put critical thinking and clinical reasoning ahead of a memorized set of "if–then" statements
— read and apply large amounts of published research
— accept outcomes as the judge and jury of your work

Order Of Presentation

--- New Understanding of "Aerobic vs Anaerobic"

--- The Basics, research quotes, & anecdote quotes

--- Controllability.....training program design

--- Training Velocity

--- Sprint events.....aerobic training

--- The Brain....mechanisms of fatigue

--- Mechanisms Of Strength & Power

--- Stay Anabolic.....overtraining

--- Red Blood Cells.....say no to "altitude training"

--- Marathon Training

2

Human Cellular Function

You're either with it or against it.

Everyone must choose.

TheETG Training Principles

Do these things and you remove the major limitations that are embedded in the design of traditional training programs in track & field distance running.

1 --- Standardization

Think standardization.....Choose a group of workouts and stick with those workouts all year around.
In human physiology and the subject of training stimuli, variety is -not- always your friend.
Thus road workouts should be repeated on the --same-- course. Tracks or type of track surface should be the -same- from one workout to the next. Workouts, rest days, and break periods should be standardized.....rather than "making it up as you go".
And the presence of potent training stimuli should be permanent in the training program.
Never "periodize" those workouts out of the training program across the course of a season or year.

2 --- Progressions

Base building workouts should be designed in a standardized manner such that over time, as the body responds via training adaptations, the target times can be reset for progression to faster target times.
Provides greater control to the coach to create a stepwise progression of the training stimulus.
This should be a permanent characteristic in workout design.

3 --- Most training in interval form, 2 to 4 mile corridor on mega-sized hills

Workouts designed in interval form increase the runner's ability to train faster. Faster training increases the potential for achieving higher levels of fitness, and thus running faster times in races. Targeting the 2 – 4 mile corridor forces design of workouts containing relatively high intensity sustained effort training on courses with mega-sized hills. These are a velocity oriented version of what is called a "tempo run", or a "long run", and/or "altitude training" in traditional training programs. In terms of physiological training adaptations "altitude training" is more about hills that come with mountains than the air at altitude. At the cellular level both endurance and speed emanate from relatively high velocity aerobic training. You'll have "speed" whether you do sprints or not, you'll have endurance whether you do "long runs" or not. And the multitude of workouts in a traditional training program from the 8 to 12 mile fast runs, to mile repeats, to 15 mile long runs, to the 6 to 9 mile fartleks.....should -all- collectively be viewed as a multitude of different ways a personal trainer has a client do sit-ups.
You don't need a multitude of different ways to do sit-ups.
You can and should choose one or two effective ways, stick with those.....and ditch the rest.

4 --- Goal Pace workouts -every- month, all year around

You get the most fit at the paces you train on the most. Do goal pace workouts all year around.

5 --- Rest Days, Stay anabolic

Nutritionally, the focus is protein and micronutrient intake….not carbo loading.
Keep the body in an anabolic state.
If you get that done everything moves forward.
If you don't get that done, nothing else matters.
You should permanently place days off in your training program in a standardized, non-"make it up as you go along" manner.
That's days, as in the plural form of that word.
In a velocity oriented training program there should be multiple days rest between run training workouts.
In designing a training program, faulty assumptions are the mother of all screwups.
Training less requires less rest.....is a faulty assumption.
Higher intensity training requires less training but more rest between workouts. That's -not- a faulty assumption.

6-- Stay ahead of tissue tightening and tissue strength needs

In sprinters, distance runners, etc.…hamstring, calf, quad, cramping & muscle strains.
Issues tend to occur at times when your fitness level is moving forward, and because your fitness level is moving forward.
Use Range Of Motion exercises to stay ahead of tissue tightening. The rate of tissue tightening as your fitness level progresses in any given week/month may exceed the rate and frequency of stretching sessions and/or the effectiveness/potency of your stretching protocols [range of motion exercises = ROM's]. Look to successfully address that.
If the level of tissue strength necessary to endure your training loads exceeds what your tissues have, the tissues that are the weakest link in the chain may require you to improve the effectiveness of your strengthening protocols or reconsider the design of your training program.

Accept No Limitations

What you don't know about the human body can limit….
--- your thinking
--- your reasoning
--- and the design of your training program

This in turn, can limit your rate and magnitude of improvement.

Avoid <u>blindly</u> accepting the prevailing view held by the majority on any given subject matter related to human functioning in sport.

As we continue to acquire and apply more information, we continue <u>to expand the area</u> of what is possible for us to achieve.

"Nature to be commanded, must be obeyed."

[Francis Bacon]

Everything works in accordance with the laws of nature. The laws of nature are the underlying mechanisms of how things work.

Science identifies and describes the laws of nature. Problems may occur with the interpretation and application of science, rather than with science itself. The laws of nature apply to everything, thus science applies to everything.

The functioning of brain cells, muscle cells, blood cells....all cells...are governed by the laws of nature. Purposely doing things in a manner that is consistent with the laws of nature makes improvement faster, easier.....and certain.

--- The "science doesn't explain everything" argument cannot be inserted each time one's comfort zone is challenged.
--- The "its genetic" or "individuality" argument cannot be inserted each time one cannot explain something.
--- The laws of nature that control human cellular function are not governed by one's chosen belief system.

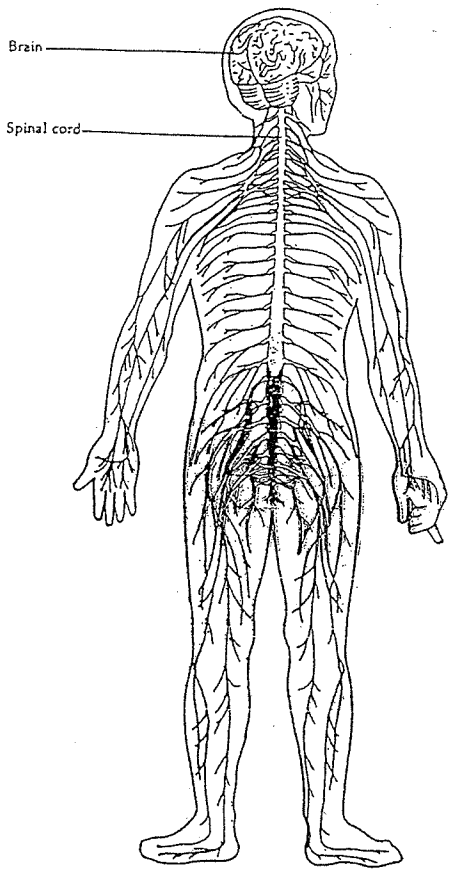
"As we learn to abide by the laws of this creation, we learn how to use those laws to our own good...As we use these talents, we learn how to work with, and eventually understand, the laws and overcome the limitations of this life."
[Betty Eadie....Embraced By The Light]

"I don't know that there is any magic level of interest in science that people ought to have. But the more they understand, the more they will be able to control their destiny and achieve their other aims."
[Stephen Hawking]

"As you become involved in continuing education, you increase your knowledge base and you increase your options."
[Stephen Covey]

"Society's future depends on a citizenry that can think and reason creatively and deliberately; develop sound judgments of information, and understand and contend effectively with rapid and constant change."
[1983 National Report On Education

"Nothing is given automatically. Neither knowledge, nor self-confidence, nor inner-serenity, nor the right way to use your mind. Every value you need or want has to be discovered, learned, and acquired."
[Ayn Rand]



Train The Brain

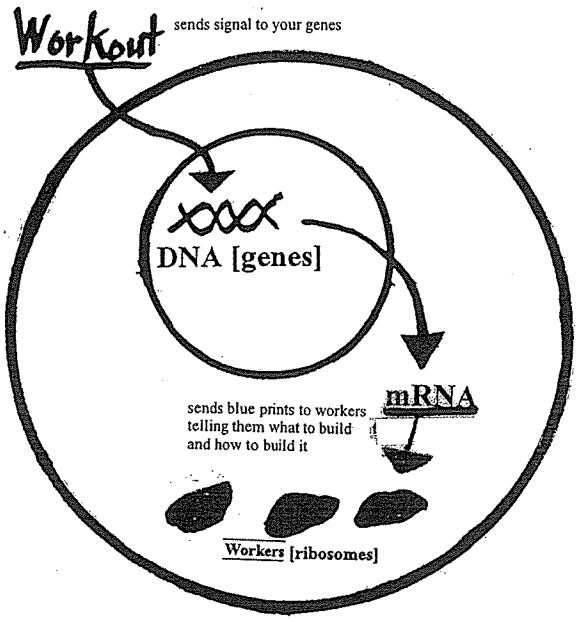
"Nature.....to be commanded, must be obeyed."

Francis Bacon

The Human Body Is A Construction Site

--- blue prints & instructions of what to build
--- building materials
--- maintenance & repair

ETG



Facts

1 – workout
2 – build new parts of cells and/or new cells

Questions

1 – what needs to be built
2 – what workout design causes this

Gene Translation:
Mechanism Of Training Adaptations

A training stimulus is a chemical signal produced by a workout that causes the production of proteins (a process called, gene translation) that results in adaptations to training that increase fitness and performance. Proteins are comprised groups of things called amino acids, that have been placed together in a specific order. There are around 20 different amino acids. Genes are codes or instructions for the builders of proteins to follow, telling them which amino acids are to be placed together, and in what order, to build needed proteins.

Translation
A training stimulus is a chemical signal produced by a workout and received by the genes inside specific cells (ie. nerve cell, muscle, etc.). The training stimulus is a signal. The signal causes the gene to make copies of itself (a process called, gene transcription). These copies of the gene, called mRNA, are sent to the builders of new proteins (called ribosomes) at the construction site. The process of placing the amino acids together (building proteins.....protein synthesis) is called, translation. The genes.....the codes, are translated.....by some protein builders called, ribosomes. The builders follow the instructions detailing which of 20 amino acids to place together and in what order, to build specific types of proteins. Improvements in nerve cells, muscle cells, blood cells, etc., are adaptations to training which are the result of this production of new proteins.

Translation Initiation Factors
There are regulators of the process of translation, called Translation Initiation Factors. Their role in translation (protein synthesis) is to help attach the copy of the gene [mRNA] to the ribosome [builder of the protein]. Eukaryotic Translation Initiation Factors (eIF's) attach mRNA to the ribosome, so that translation of the mRNA code into protein can take place. If the mRNA does not attach to the ribosome, protein synthesis cannot take place.

The 4 steps of Translation.....
1) Ribosome becomes two subunits.

2) The t-RNA (transfer-RNA, the rna responsible for grabing amino acids) binds to one of the subunits, to make a pre-initiation complex. eIF2 causes step 2 to occur.

3) mRNA can now bind to this Ribosome subunit. eIF4F causes step 3 to occur. Energy production (ATP) processes cause eIF4E to be phophorylated (a phosphate is produced and placed on it). eIF4E phosphorylation causes it to bind to mRNA.... the first thing that must happen in step 3. eIF4E bound to mRNA can now attach to the combination of eIF4G & eIF4A
This forms an active complex, which is called eIF4F [this completes step 3].

4) eIF4F active complex can now bind to the Ribosome to initiate Translation. The two subunits now recombine to reform the intact, and now active, Ribosome

Translation repressor
There is a manner by which protein synthesis can be reduced/impeded. There is a translation repressor.....a "binding protein" called 4E-binding protein-1 (4E-BP1). It can attach to a spot on the Translation Initiation Factors, which will prevent mRNA attachement to the ribosome. If the mRNA cannot attach to the ribosome, protein synthesis cannot take place. Thus 4E-BP1 is a translation suppressor, "repressing" protein synthesis. Energy production (ATP) processes are very important to translation (protein production). Phophorylation (a phosphate is produced and placed on something) affects protein synthesis enormously. When production of phosphates is low, 4E-BP1 is un-phosphorylated, and can thus bind to eIF4E to prevent it from binding to mRNA. When glucose supply is low, production of phosphates will be low, thus phosphorylation of 4E-BP1 will be low, thus translation will be repressed. Thus one must supply glucose following workouts. When amino acid supply is low, especially essential amino acids [the branched chain amino acids...leucine, isoleucine, and valine] translation is low as well.

There are several eukaryotic Translation Intitiation Factors
- eIF4A - eIF4E - eIF4F - eIF4G - eIF2 - eIF2B

The Future Of Sport Performance
Supplying essential amino acids along with carbohydrates for training adaptations should be a high priority. Substantial differences in the magnitude of adaptation to workouts can be seen in high vs. low protein intakes. To be able to compete well in the future, it will be important to know which proteins are important to running performance. It will be important to know what kinds of workouts will target and "turn on" the genes for these proteins in the most potent manner. And It will be important to know what nutrients to ingest and when to ingest them will that will optimize the building of these proteins following each workout.

protein
protein
protein
protein

hot jacuzzi, hot bath
autogenic Relaxation
down-time

Keep the body in an anabolic state.

If you get that done everything moves forward.

If you don't get that done, nothing else matters.

Accurately Applied Concept Of "Base Building"

In this "Accurately Applied Concept Of Base Building", the term "base building" does not describe a period of time in one's training year for doing elevated volumes of work, or a few weeks at the beginning of a track season.....but a specific type of workout that is done in a training program, preferably.....all year around. The traditional manner in which the concept of "base building" has been applied is physiologically unnecessary. The "Accurately Applied Concept Of Base Building" is one where the purpose of "Base Building".....is to have a – "bottom floor"- of power output which you are able to maintain for long distances. The objective should be, over time, to gradually **raise the –"bottom floor"- of power output**. There should be a velocity **below which you will-not go in your training**. This is your bottom floor. That floor should be raised over time.....by design, on purpose, not by accident or by default.

Your Long Workouts -Are- Your "Base Building" -----

You don't have to "lay down a base".....first.....you just have to have some sort of "base building" in your training program. The purpose of a "base", isn't to "prepare" a runner to progress.....but rather to "cause" the runner to progress. Progressions in bottom-end and top-end power output lead to progressions of everything in between. Distance runners, regularly training for multiple years at velocities slower than what they might run for a marathon, creates the chronic situation of failing to provide an adequate "base" from which to progress. Failure to have an abundance of training [all year around] surrounding one's event distance insures that the runner cannot fully develop at his/her event distance. This lack of a true "base" is why [for example] a 1500m runner is typically unable to run a good time for 10,000m, and a Marathoner is typically unable to run a good time for 1500m.

Its Not The "Mileage"...It's The Workouts -----

Traditionally, the belief is that "Base Building" is necessary to **prepare the runner to progress** on to more specific training for his/her event distance. It has been asserted that the required adaptations to this "base building" training are; ------production of capillaries-----depletion of glycogen stores to facilitate greater storage capacity-----increasing the number of red blood cells. It has been generally asserted that these adaptations come only from this method of "base building" and/or that this method is the most effective. However.....the physiological reality is that prolonged training runs ---- or ---- repeated high velocity intervals.....that deplete glycogen stores to some threshold level.....are effective stimuli for increasing--maintaining Glucose Transporter levels [thus increasing-maintaining glycogen storage capacity].....not "mileage" per se. Prolonged training runs ---- or ---- repeated high velocity intervals.....that create a high demand for ATP [energy], are effective stimuli for production of blood vessel capillaries, red blood cells, mitochondria, etc, etc, etc.

Use Your Time Wisely -----

Since it takes more glycogen, more ATP, more capillaries, and more red blood cells to run fast than to run slow, runners would do well to train at a variety of velocities surrounding their event distance as much as possible, all year around. Thus it carries purpose to abandon the traditional concept of "base building", in favor a "power output" focus. Neurological recruitment patterns are velocity specific. **Glycogen storage** capacity, **capillary** and **red blood cell** production, **are specific to training velocity.** The concept of "base building", applied in the traditional manner, forces runners to focus multiple weeks/months of training on workouts run at velocities that are well away from goal paces for event distances. This inherently leaves less time per training year to train at those goal paces for their event distances, and leaves less time, or prevents entirely, training at far higher velocities that are necessary to train adaptations related to nervous system recruitment and recruitment rate.

Abandon Arbitrarily Determined Workout Distances -----

The reason [for example] a runner whose main event is 1500m cannot do –only- workouts at his/her 1500m goal pace, is because that runner will be unable to fully develop at the 1500m distance. This is because.....

--- he/she won't have the workouts that progressively, over time, **raise the --"bottom floor"-- of power output** that they can maintain for long distances well beyond 1500m, which will facilitate development of fitness at **future** higher velocity goal paces

--- he/she won't have the workouts to get fit at higher power outputs that facilitate development of fitness at **future** higher velocity goal paces

Arguably, a high fitness level for the 1500m race distance is the combination of a high fitness level at races distances that are....slightly above...and well below....the 1500m race distance. **Future improvement** beyond current goal paces, is dependent upon **raising the --"bottom floor"-- of power output** that can be maintained for long distances, in combination with improvements in the top-end power output. They should have in their training program, 10,000m and marathon goal pace workouts in their training program. These workouts are the application of the "Accurately Applied Concept Of Base Building", in a 1500m runner's training program. By not allowing their slowest workouts to go below Marathon goal pace, they begin with a reasonable **bottom floor of power output** from which to progress their "base". The 10,000m, and Marathon goal pace workouts provide a more disciplined, less arbitrary method by which to choose workout distances, allowing a focus more on **event specific—goal pace relevant**...power output, and less focus on arbitrary, non-goal pace relevant "weekly mileage". Since we know that many of the fastest marathoners tend to be those who can run very fast for shorter events such as 10,000m, arguably, a high fitness level for the marathon race distance is the combination of a high fitness level at races distances that are....slightly above...and **well below**....the marathon race distance. One can argue that for a marathoner.....marathon goal paces should be the **bottom floor**, and that there should be an abundance of goal pace training relevant to shorter race distances comprising their training programs.

New Understanding Of....

"Aerobic....vs....Anaerobic"

The current psychology of our sport says that there are sprint events, and there are endurance events. They are separate entities. We are required to look at that assumption in a critical thinking manner. The question to ask at this point is;

------- Is the 100 meter dash an endurance event. Yes, or no?

To answer that question, look at the 10 meter splits of the top 100 meter sprinters in the world in the finals of each World Championship and Olympic Games since the mid-1980's. Has it been demonstrated that the athletes get slower from the 80 or 90 meter mark to the finish, and do many of them slow from the 60 meter mark to the finish.

The answer is yes. Thus, the 100 meter event is an endurance race. This statement is consistent with both the title of this thread, the content of information in this thread, and the reality of the split times of the 100 meter dash.

Its also consistent with what we've seen with the advent of Carl Lewis and subsequent top sprinters replacing the bulked up footballers of yester-year. In today's world, a sprinter is as likely to look like a middle distance runner as they would a football player [ie. Frank Fredricks 150 lbs., ran 19.66 at 200 meters, 9.86 100 meters]

Change In Thinking [A] ----- In the 100 meter sprint, if the running related cells have enough mitochondria to produce all of the energy necessary to perform the task, then the task will be performed via....aerobic....means.

Change In Thinking [B] ----- If there are an insufficient number of mitochondria to supply all the energy required for the task, then the running related cells will attempt to compensate by use of their default system [ie. anaerobic energy production].

Major Concept 1 ----- The default system is the default system. By definition, a default system is not a preferred system. A runner who runs the 100 meter sprint with their default system supplying most of their energy, is a runner who does so because there are not enough mitochondria.

Major Concept 2 ----- Thus they run the 100 meter sprint "anaerobically", with most of their energy coming from anaerobic means because they –don't—have enough mitochondria, rather than because they **–can't—**have enough mitochondria.

Major Concept 3 ----- One can rather easily prove this point by simply having them run the 100 meters at slower than a sprint. The slower pace lowers the demand for energy. If the pace is low enough, the amount of energy necessary to perform the task can be supplied predominantly by the preferred energy system rather than by the default energy system. Thus the physiological aspects of the subject ---aerobic vs. anaerobic---is little more than a supply and demand concept.

If the 100 meter dash is an endurance race, then it must follow that each of the races below is an endurance race;
--- 100 meters
--- 200 meters
--- 400 meters
--- 800 meters
--- 1500 meters/mile
--- 5000 meters
--- 10,000 meters
--- Marathon

Looking at these events from this perspective requires that we look at them as a continuum, rather than as separate events, sprint....vs....endurance. If all of these events are endurance races, then it must follow that all have either similar or the same Major mechanisms of performance. I assert that they all share the same [-3-] Major mechanisms of performance

1 --- How many muscle fibers can you recruit
2 --- How quickly can you recruit them
3 --- How long can you maintain a high level of recruitment

High Velocity Training

Cheetah's [in the wild] are known as the fastest land animal in the world. They have a maximum velocity of around 70 miles per hour. From observations of animals, and from research on humans in the 1970's, the norm is to believe that sprinting and distance running don't mix. Cheetah's have an enormous drop off in velocity after the first few seconds of a chase, so this type of observation tends to reinforce the prevailing belief system. Throw in the belief that Fast Twitch muscle fibers are not good for endurance, and here we are.....fast runners can't run well for longer distances [the propulsive muscles of Cheetahs are comprised of approximately 100% Fast Twitch muscle fibers].

This is an easy belief system to accept until one looks deeper. A highly motivated Cheetah, well trained by multiple chases early in life and a reduction in the number of available prey, well continue a chase for up to 10 minutes. It can do so while running at slightly more than 60% of its maximum velocity. This says that a Cheetah will cover a 5k (5000 meters, 3.2 miles), running at an average velocity of approximately 45 miles per hour. In the world of a runner, this is like running a 5k road race at.....2 minutes.....per mile pace, even though nearly all of your muscle fibers are supposedly that of a sprinter.

Pronghorn Sheep [pronghorn antelope] are generally known as perhaps the second fastest land animal in the world, second only to the Cheetah. However, it's reputation is mainly about endurance. Pronghorn Sheep have a maximum velocity of around 60 miles per hour. Their reputation for endurance is based on the fact that they can run for over a 10k at an average velocity of around 30 – 45 miles per hour. Their training comes in the form of chasing each other for territorial rights, and out running predators such as coyotes and bob cats.

Since humans in most countries no longer chase down their prey in order to eat, training programs are the only method of developing either speed.....and.....endurance. If the training program fails to have the necessary components of training.....embedded in it.....then the speed, endurance, or both, will go under-developed, and over all performance and large advancements in comprehensive fitness will suffer.

Sprinters whose training programs contain significant levels of.....high velocity.....endurance training [ie. Michael Johnson] tend to out-perform those whose training programs do not. Distance runners whose training programs contain significant levels of.....high velocity.....endurance training along with significant levels of sprint training [ie. Haile Gebrselassie] tend to out-perform those whose training programs do not.

".....muscle fibers are not inalterable but are highly versatile entities capable of changing their phenotype from fast to slow or slow to fast. "
".....muscle fibers adjust their phenotype to meet the altered functional demands."

D.Pette
Historical Perspectives: Plasticity Of Mammalian Skeletal Muscle
Journal Of Applied Physiology
Volume 90 #3.....March 2001.....page 1119 – 1124

"Mitochondrial adaptations will not occur in skeletal muscles, which are not recruited during the exercise bout."

".....endurance training programs must be geared, in part, toward the recruitment of fast-fatiguable motor units containing typeIIb (fast-twitch white) fibers if any mitochondrial adaptation is expected in those fibers."

D. Hood.....March 2001
Invited Review: Contractile Activity-Induced Mitochondrial Biogenesis In Skeletal Muscle
Journal Of Applied Physiology.....Volume 90 #3.....March 2001....pages 1137 - 1157

"We conclude that their performance is achieved by an extraordinary capacity.....to support a predicted running speed greater than 20 meters per second (over 40 miles per hour), attained without unique respiratory-system structures."

S.L. Linsdstedt...et.al.
Running Energetics In the Pronghorn Antelope
Nature.....Volume 353 #6346.....October 24, 1991.....pages 748 - 750

"Current developments in the training of 400m sprinters showed that aerobic training had a positive effect on competition performance."
D.Wallner....et al.
Interdependence Of Aerobic And Anaerobic Performance And Its Consequences For Training In Sprinters And Endurance-Trained Runners
Journal Of Sport Sciences.....Supplement....page 551 (Volume 17 #7, July 1999)

The Basics

[current day] physiology of running

From Brain To Muscle.....The Big Picture
1-- During the propulsive phase of the stride, your leg muscles produce force, propelling you forward down the road or track.

2-- The more force those muscles produce, the faster you run.

3-- The brain and nervous system make the muscles produce force by sending electrical signals to muscle.

The Bottom Line.....
-- To run better times in your races, the brain and nervous system must be able to produce and maintain a higher level of muscle force outpu during the propulsive phase of the stride.

----- The Basics.....of Training The Brain & Nervous System -----

Its the brain....not muscle.

Generally speaking, the muscle will produce force, if the nerve tells it to. Thus the nervous system reduces it's activation of muscle, prior tc the muscle reaching a state of fatigue.

The significance of this is that it corrects a 35 year mistaken belief that the fatigue related decrease in power output by runners and other athletes originates in muscle. We now know with -----100% certainty----- that such is -not- the case. This certainty has the following consequences on traditional belief systems about training, how to train, and how to design a training program.....

1 --- Brain/nervous system don't respond well to high volume training.

2 --- forces a change in belief system about how best to train, [regardless of what "the elites" are doing now.....what they have done in the past....or will do in the near future

3 --- It is appropriate to **abandon everything having to do with weekly mileage**, heart rate, Vo2max, and any other traditional manner of measuring training stimuli. The --only- thing that matters is **Power Output**.

Training program design, ---must--- focus on training the brain and nervous system, whether you're training to break the world record in the marathon, training to get out of a wheel chair, or in a nursing home training to live as long as you should.

It's a new era. The old one is gone. Time to get on with it.

If you've ever gone a few days with little sleep, you've been a position to realize that your brain and nervous system, not your muscles or heart, are in-charge of everything. You've probably learned that its best to behave accordingly, by intentionally placing more time for sleep in your daily life schedule.

The same approach must now be implemented when you design your training schedule, and training program. It must be centered around your brain and nervous system, not muscle or heart rate.

The brain and nervous system respond best to gradual increases in ----- **standardized** ----- workloads, that are centered around **Power Output**.

Power Output is best measured in pace per mile, or meters per second. Gradual increases in the duration of a set Power Output, followed by an increase in the set level of Power Output, is the **most functional** manner in which to train the brain and nervous system.

"Based on EMG and force data, one may conclude that the decrease in force is a result of reduced CNS drive to muscle....."

J.Z.Liua, et.al
Nonlinear Cortical Modulation Of Muscle Fatigue: A Functional MRI Study

Brain Research.....Volume 957 #2.....December 13, 2002.....page 320 - 329

---------- The Basics.....of Energy ----------

Energy Is Everything
1-- The brain and nervous system send electrical signals to muscle
2-- This requires energy.
3-- The more improvement you want to see in your race times, the more energy you will require. If you can't produce that energy, you won't run the better race times.

What Is Energy?
Energy is a substance called ATP [A-deno-sine Tri Phos-phate].

What is Energy Production?
Energy Production is the production of ATP.

What are Energy Producers?
Energy Producers are things inside Brain cells, nerve fibers and muscles.....that produce ATP.
Those things are called Mitochondria [mito-kon-dria].

The Bottom Line.....
-- Whether your event is the 100 meter dash or the marathon, to run faster race times you must increase Energy Production, and to increase Energy Production, you must increase the number and size of Energy Producers.

---------- The Basics.....of Energy [ATP] ----------

What Is Energy [ATP] ?
ATP consists of an Adenosine, linked by a chain (bonds) to 3 phosphates (hence the term "Tri"-phoshate). When a bond is broken, a phosphate is no longer linked by the bond to the Adenosine and the two other phosphates. So the word - Tri - is no longer in the "Tri-phosphate", since there are now only 2 phosphates. So the term changes to Adenosine "Di"-Phosphate (ADP). A phosphate must be produced, either "aerobically", or "anaerobically", to make the ADP into ATP, so that nerve and muscle can use it.

What Is Energy [ATP] For.....In Nerves
Nerves conduct electrical signals from brain, to muscle, which causes the muscle to produce force. The nerves conduct these electrical signals by causing sodium and potassium to move into and out of the nerve fiber. At a microscopic level along the covering (membrane) of nerves, there are small tunnels (called channels) that allow sodium and other particles to move into and out of the nerve fiber. Following each electrical signal that travels down the nerve fiber, the sodium and other particles must be moved back to their original positions, so that another signal can be sent. There are some pumps (called sodium/potassium pumps) that are responsible for this process.

The pumps are located in the membrane (covering) of the nerve. They grab the sodium, turn, and dump it outside the nerve. It does the opposite with potassium, dumping it inside the nerve. Energy (ATP) is needed to cause the pumps turn. The frequency of which signals are able to travel down a nerve fiber determines the amount and velocity of force production by the muscle.

This (power) is fairly important in track and road running events. The athlete's ability to provide high levels of ATP for the pumps, allows the pumps to function at high levels, resulting in maintaining high muscle force outputs. Researchers have shown that fatigue in the nerve precedes the fatigue in muscle. Generally speaking, the muscle will produce force, if the nerve tells it to. Thus the nervous system reduces it's activation of muscle, prior to the muscle reaching a state of fatigue.

What Is Energy [ATP] For In Muscle
At a microscopic level inside muscles, small arms (myosin) attach and pull on a set of pillars (actin), to produce muscular force. After pulling on the pillar, the arm must detach to reset itself, so it can attach and pull again. This cycling process occurs several times per arm, per muscle contraction. And there are several hundred arms per muscle fiber. Energy (ATP) is needed to push the arms back into the reset position, in between pulls on the pillar. As the runner gets low on ATP (fatigue), the brain and nervous system activation of muscle is reduced, thus muscle force output is reduced.

10

---------- The Basics.....of Energy Production ----------

Aerobic Energy [ATP] Production by Mitochondria ----------

After glucose/glycogen is broken down and produces ATP, there is a substance left over called Pyruvate (or pyruvic acid). This substance can be broken down by an enzyme (Pyruvate De- hydrogen-ase), so it can go into a small oval shaped thing in the nerves and muscles, called mito-chon-dria. The mito-chon- dria combine the broken down pyruvate with a B-vitamin (vitamin B3), to produce a substance (acetyl CoA) that can be used to produce ATP in a process commonly refered to as the Krebs Cycle, or TCA cycle. This process not only produces ATP, but also produces things called hydrogens. These hydrogens are collected and transported to another part of the mitochondria, where they can be used to produce even more ATP. These ATP-s are produced in a system called the Electron Transport Chain. The hydrogens have things called electrons circulating around them.

The electric charges that these electrons produce are used to produce very large amounts of ATP in the Electron Transport Chain, which takes place inside the mitochodria. The ATP production (Krebs cycle & Electron Transport) that take place inside the mitochondria are collectively called the "Aerobic", or "Oxidative" energy production method.

Anaerobic Energy [ATP] Production: ATP-CP Method ----------

When a bond is broken, a phosphate is no longer linked by the chain to the Adenosine and the two other phosphates. So the term changes to Adenosine "Di"-Phosphate (ADP). A phosphate must be produced to make the ADP into ATP. A phosphate can be donated from a substance (creatine-phosphate) floating around in nerve and muscle. An enzyme will separate the creatine, from the phosphate, allowing the phosphate to be linked by a bond to the ADP, thus forming ATP. The quantity of ATP that can be produced by the ATP-CP method is limited to the amount of creatine-phosphate in the nerve and muscle. These amounts are relatively small. Some athletes attempt to increase them by ingesting creatine supplements. Research is mixed as to the effectiveness of this practice. Creatine is an amino acid, a part of a protein. Generally, the only athletes who will benefit from creatine supplements are those who have an insufficient protein intake to match their training loads.

Anaerobic Energy [ATP) Production: Glyco-lysis Method ----------

The term Glyco-lysis, means to breakdown glucose (sugar) for ATP production. Glyco, refers to glucose, a sugar used to produce phosphates for ATP production, and lysis, generally means to breakdown. Glucose is the only form of sugar (from the carbohydrates eaten) that nerve and muscle can use as a fuel for ATP production. It doesn't matter whether the carbohydrates eaten are from an expensive pasta meal, from fruit, or from table sugar or candy. The digestive tract and/or liver convert it all to glucose. Following a meal or ingestion of a sport drink, glucose is stored (in nerve and muscle) as a bunch of glucoses hooked together. A bunch of glucoses hooked together is called Glycogen. Enzymes float around in nerve and muscle that breakdown glycogen during a race, which immediately yields phosphates for production of ATP. This method of ATP production is called Anaerobic Glycolysis.

Unlearn Outdated Belief Systems -----

-- Set aside what you think you know about the term "aerobic"
-- Set aside what you think you know about the terms "anaerobic", and "lactic acid"

Modern Day Information -----

-- There is no "Aerobic vs. Anaerobic", there is only Energy Production....period!
-- Lack of Energy Producers, not running velocity, is what determines Energy Source ["Aerobic vs. Anaerobic"].
-- Energy source ["Aerobic vs. Anaerobic"] is not determined by running velocity or distance [ie. 100 meters vs. distance event].

"Little data exist that specifically and accurately evaluate energy system contributions.....Considerable information can be found that attempts to do so, but this has generally been based on data in the 1970's that inappropriately used oxygen debt to quantify anaerobic energy release."

"The crossover to predominately aerobic energy system supply occurred between 15 and 30 seconds for the 400, 800, and 1500 meter events."

"These results suggest that the relative contribution of the aerobic energy system during track running events is considerable and greater than traditionally thought."

Energy System Contribution During 200 To 1500 Meter Running In Highly Trained Athletes

Medicine & Science In Sports & Exercise.....Volume 33 #1.....January 2001.....page 157

"These results indicate that lactate has only a relatively small inhibitory effect on normal excitation-contraction coupling [muscle force output], indicating that lactate accumulation per se is not a major factor in muscle fatigue.

Effect of Lactate On Depolarization-Induced Ca Release In Mechanically Skinned Skeletal Muscle Fibers

American Journal Of Physiology..... Volume 278.....pg C517 – C525.....2000

"Clearly, the muscle pH results do not support a role for intramyocellular Hydrogen ion accumulation as the cause of fatigue during repeated intense exercise."

"The present findings agree with some reports dissociating Hydrogen ions from muscle fatigue in animals and humans."

"Rather than being a direct cause of muscle fatigue, the elevation of intramyocellular total Pi, dipronated Pi, and Hydrogen ion concentrations during exercise might be metabolic consequences of the duration and intensity of the contraction....."

"The present results indicate that human muscle fatigue during repeated intense isotonic exercise is not due to.....intracellular accumulation of hydrogen ions."
J.Rico-Sanz
Progressive Decrease Of Intramyocellular Accumulation Of H+ and Pi In Human Skeletal Muscle During Repeated Isotonic Exercise
American Journal Of Physiology....Volume 284....2003.....page C1490 – C1496

".....the rate of lactate production is determined by the balance between pyruvate production and oxidation. When pyruvate production exceeds the rate at which it can be converted to acetyl-CoA via pyruvate dehydrogenase [PDH], it begins to accumulate.....it is converted to lactate".

"These data concur with the findings of Timmons et al., suggesting that the provision of oxidative substrate is one factor limiting oxidative metabolism early in exercise, and that increasing the availability of substrate early in exercise allows for increased oxidative metabolism...."

R.A.Howlett, et al.
Effects of Dichloroacetate Infusion On Human Skeletal Muscle Metabolism At The Onset Of Exercise
American Journal Of Physiology....Volume 277....1999.....page E18 – E25

--------- The Basics.....Increasing The Number Of Energy Producers ----------

Energy Producers
Mitochondria are the cell organs (organelles) that produce ATP (chemical form of energy) aerobically by using a fuel (glucose, glycogen or fat) and oxygen. Increasing the number and/or enzyme content of the mitochondria increases the amount of ATP that can be produced.

Increasing The Number Of Energy Producers
There are many ways to increase the number of energy producers [mitochondria]. However, the focus here is on identifying the method(s) that lead to the largest scale increases in energy producers, which in turn lead to the largest scale increases in energy production which in turn leads to the largest scale increase in running performance. The higher the demand for energy production [ATP] during workouts, the greater will be the number of energy producers [mitochondria] once the body adapts to the training. It takes a low level of energy demand to run a low velocities, and a higher level of energy demand to run at higher velocities.

Training at low velocities creates a low demand for energy production. Training at high velocities creates a high demand for energy production. The higher the training velocity, the greater the demand for energy production [ATP]. The greater the demand for energy production, the greater will be the body's response of increasing the number of energy producers [mitochondria].

Definition Of "High Velocity" Training
High velocity training at goal pace or faster, is the most effective method of creating the demand for energy that will be needed to race at goal pace or faster. This training can be done in interval/fartlek form to facilitate high velocity running. Frequently training at velocities that exceed VO2max [velocities that exceed what you can hold for 5 - 10 minutes] is more important than training volume in producing an increase in energy [ATP]production potential.

What Is --Not-- The Definition Of High Velocity Training
High velocity training is -not- about all out sprinting. High velocity training is -not- about "pushing hard". High velocity training is -not- about "you don't train hard enough". High velocity training is -not- about "go hard or go home". High velocity training is - not- about "no pain, no gain". High velocity training is -not- about "put the hammer down".

High velocity training is -not- about any of the cliches or stereo-typical behavior that is code terminology for "running oneself into the ground". High Velocity Training is about training at velocities that are fast for "you" for durations that are "comfortable" to maintain. Training at these....."Comfortably Fast".....velocities is what is meant by High Velocity Training.

--- Weekly mileage is --not-- a mechanism of performance.
--- Heart rate is --not-- a measure of nerve//muscle power output.
--- Outdated belief systems are --not-- mechanisms of the future norms of training for the sport

The magnitude of mitochondria production is dependent upon the magnitude of demand for energy (ATP)].
High demands for ATP, yields high demand for mitochondria.
Low demands for ATP, yields low production of mitochondria.
Training fast = high demand for ATP.
Training slow = low demand for ATP.

"....the purpose of this study was to compare the energetic and training factors that contribute to the marathon performance time of top class...versus high-marathon runners."

'"The high energy output seems to be the discriminating factor for top class male marathon runners who trained at higher relative intensities."

V.LBillat, et.al.....2ool Physical And Training Characteristics Of Top-Class Marathon Runners Medicine & Science In Sports & Exercisc.....Volun #12....2ool....page 2089 - 2097

"Progressively intense endurance training, particularly that which includes high intensity training to recruit large fast-twitch muscle fibers, can acl impressive changes in mitochondrial synthesis within a few weeks."

D.A. Hood, M.Takahashi, M.K.Connor, D.Frcyssenet April 2000
Assembly Of The Cellular Powerhouse: Current Issues In Muscle Mitochondrial Biogenesis
Exercise And Sport Sciences Reviews_ _Volume 28 #2 April 2000....pages 68 – 73

"Mitochondrial adaptations will not occur in skeletal muscles, which are not recruited during the exercise bout."

"endurance training programs must be geared, in part, toward the recruitment of fast-fatiguable motor units containing typellb (fast-twitch white) fibers i mitochondrial adaptation is expected in those fibers."

D. Hood
Invited Review: Contractile Activity-Induced Mitochondria] Biogenesis In Skeletal Muscle
Journal Of Applied Physiology.....Volume 90 #3.....March 2001.....pages 1137 - 1 157

"The magnitude of the effectiveness of the signal for mitochondrial synthesis is proportional to the work load imposed on the muscle."

"The signal for the adaptive process can only be modified by a change in the initial standardized work load."

Flood, Balaban, Connor et al Mitochondria] Biogenesis Canadian Journal Of Applied Physiology
Volume 19 # I.....March 1994.....page 12 - 48

"The initiation of mitochondrial biogenesis in muscle begins with the signals brought about by muscle contraction. The magnitude of the signal(s), up point, is undoubtedly related to the intensity and duration of the contractile effort."

".....it is likely that an increased rate of ATP turnover is sufficient to provoke mitochondrial biogenesis."

"....the increase in mitochondria] respiration, or the deficit between cellular ATP demand and mitochondrial ATP supply, provides a stimulus for the sequ induction of a variety of genes involved in the biogenesis of the organelle."

D. Hood
Invited Review: Contractile Activity-Induced Mitochondrial Biogenesis In Skeletal Muscle
Journal Of Applied Physiology.....Volume 90 #3.....March 2001.....pages 1137 - 1 157

"studies have proposed that motor neurons innervating more active muscle fibers have higher oxidative enzyme activity.....than those innervating less a muscle fibers."

Brain Research Bulletin.....Volume 43 #2.....1997

"When the rate of pyruvate production through glycolysis exceeds its rate of oxidation through PDH, it is converted to lactate....."

"The balance between the activities of Phos and PDH determines the accumulation of lactate."

M.L. Parolin, et al
Regulation Of Skeletal Muscle Glycogen Phosphorylase And PDH During Maximal Intermittent Exercise
American Journal Of Physiology....Volume 277....1999.....page E890 – E900

"The latter hypothesis, often called the "mass action effect". Suggests that the rate of lactate production is determined by the balance between pyr production and oxidation. When pyruvate production exceeds the rate at which it can be converted to acetyl-CoA via pyruvate dehydrogenase [PDH], it b to accumulate.....it is converted to lactate".

"These data concur with the findings of Timmons et al., suggesting that the provision of oxidative substrate is one factor limiting oxidative metabolism ea exercise, and that increasing the availability of substrate early in exercise allows for increased oxidative metabolism...."

R.A.Howlett, et al.
Effects of Dichloroacetate Infusion On Human Skeletal Muscle Metabolism At The Onset Of Exercise
American Journal Of Physiology....Volume 277....1999.....page E18 – E25

"This high velocity training elicits high levels of force and brief contact time."

"Regular training at velocities above v-marathon [marathon velocity] seems to characterize top class marathoners."

V.L.Billat, et.al.....Physical Training And Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise....Volume 33 #12...2001....page 2089 - 2097

"High intensity training decreased rates of whole body carbohydrate oxidation and increased rates of fat oxidation during steady state [90 minutes] ride."

"Activation of AMPK....increased Glut-4.....and also increases mitochondrial density and muscle glycogen content."

S.A. Clark
Intensified Exercise Training Does Not Alter AMPK Signaling In Human Skeletal Muscle
American Journal of Physiology, Endocrinology, & Metabolism.....Volume 286.....2004.....page E737 - E743

".....there have been relatively few investigations of the effects of sprint training on mitochondrial enzymes or aerobic power in humans....."

"The significant increases in Vo2max.....were somewhat unexpected.....Changes of this magnitude are usually associated with training programs involving several hours per week at sub-maximal intensity."

Muscle Performance And Enzymatic Adaptations To Sprint Interval Training
Journal Of Applied Physiology.....Volume 84 #6.....June 1998.....page 2141

Denis et.al (1992) have reported that the ability to sustain supra-maximal work lasting 30 - 45 seconds was related more to muscle oxidative [aerobic] capacity than to glycolytic [anerobic] capacity."

Changes In Performance, Muscle Metabolites, Enzymes, And Fiber Types After Short Sprint Training
European Journal Of Applied Physiology & Occupational Therapy.....Volume 78.....1998.....page 167

"Current developments in the training of 400m sprinters showed that aerobic training had a positive effect on competition performance."

D.Wallner....et al.
Interdependence Of Aerobic And Anaerobic Performance And Its Consequences For Training In Sprinters And Endurance-Trained Runners
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---------- Beyond The Basics ----------

Faster Times For Everything from 100 meters to the Marathon
Running velocity is determined by how much force the runner can apply to the ground, during the limited amount of time the foot/leg is pushing the runner forward during the running stride. These forces applied to the ground can be increased by making more muscle fibers contract at the same time, and by making more muscle fibers contract more quickly.

The brain of the runner can be trained to increase both of these, by increasing the number of muscle fibers it stimulates, and sending signals more rapidly, and more frequently. The brain does this by increasing its electrical output to the muscles. The brain sends electrical signals to the muscles, along electrical wires called axons. The brain can increase the muscle power output that leads to greater running velocity, which leads to a higher performance level.

High Velocity Training accomplishes this task by;
---- by stimulating the production of new connections [synapses] between brain cells that control muscle function. This allows those brain cells to better coordinate a more efficient sequencing of contraction of different muscle fibers within the same muscle group, thus allowing greater force output, while the runner's foot is on the ground. The more connections between brains cells, the more mitochondria one needs to provide the energy [ATP] that will be used for their function.

---- by stimulating the production of an increased number of tunnels [ion channels] along the electrical wires [axons] that carry electrical signals from the brain cells to the muscles of the runner. This allows the electrical signals to travel faster from brain to muscle, thus allowing the brain to make the muscles produce force more quickly. Since the amount of time the foot is on the ground decreases as the runner runs faster, it becomes more important to be able to produce force, in a shorter period of time, if one hopes to continue to increase running velocity. The more tunnels one has, the more mitochondria one needs to provide the energy [ATP] that will be used for their function.

---- by stimulating the production of an increased number of pumps [sodium/potassium pumps] along the electrical wires [axons] that carry electrical signals from the brain cells to the muscles of the runner. This allows the electrical signals to be sent more frequently from brain to

muscle, thus allowing the brain to make the muscles produce more force, more quickly, which increases the running velocity the runner can produce. These pumps [sodium/potassium pumps] have several different forms, some of which work faster than others. Each has its own genes. Thus, the principle of "specificity of training", directs which genes are activated by the workout the runner does and therefore determines how much improvement the runner will see. The more pumps one has, the more mitochondria one needs to provide the energy [ATP] that will be used for their function.

The Tunnels
The tunnels [ion channels] have several different forms, some of which work faster than others. Each has its own genes. Thus, the principle of "specificity of training", directs which genes are activated by the workouts the runner does and therefore determines how much improvement the runner will see. Since the increase in the number of tunnels [ion channels] in general [regardless of type of tunnel] leads to increases in velocity, the runner will see a continuum of training induced adaptations, in number, in type of tunnel, and in the subsequent growth in size of the electrical wire [axon], which therefore, create a situation where the genes for these tunnels, have no way of placing limits to the increases in velocity induced by training.

The Pumps
These pumps are enzymes. Though these enzymes do not function at the speed of light, they do tend to move at enormous velocities, thus the velocity of the slowest of the slow pumps, is not the limiting factor to running at, any current world record pace, at any race distance between 100 meters and the marathon. Thus, running velocity in the context of breaking world records by ---large amounts---, is not limited by the genes for these pumps [sodium/potassium pumps].

The brain and nervous system control the muscles, therefore, it is the brain and nervous system which control performance level and the genes for the various parts of the brain and nervous system that control performance....do not limit improvement in running velocity, but rather....empower the runner to improve running velocity. The runner's body contains cells and genes....neither of which function like slabs of cement, but rather, function in a manner that allows the runner to adapt to a "survival of the fittest" environment, when the survival of our species was determined by the level of skill and fitness in the roles of both predator and prey.

Large Scale Improvement
In road running and track running events, if the rate and volume of ATP production needed in the nerve is insufficient to maintain the required frequency of nerve impulses. a lower level of performance will result. This concept can be applied to races of all distances. Achievement of large scale improvement in performance must be preceded by a large scale improvement in energy production. Large scale improvement in energy production, can only be achieved by large scale increases in the number of energy producers.

anecdotal information.....

"I ran 3:52.02 in the mile running an average of just over 40 miles a week [almost all of it high quality). I believed that if I ran 80 miles a week I would nm 3:42.

Wrong, I upped my mileage, lowered the quality, and never ran faster."

Craig Masback.....CEO of USA Track & Field
Track & Field Coaches Review.....Decernber 1999.....page II

"I usually do no more than 60 miles a week.....when I am building up my base....."
"I know there are many more runners that run many more miles....."
"I have not had any injury worries for several years and so I've found a formula that works, although the sessions I do are often quite intense. I'm a firm believer in speed related to endurance and not doing what Americans often call 'junk' miles."

Benard Lagat [3:26 1500m.....second fastest all time]
By Phil Munshill For the IAAF
Track & Field Writers Of America Newsletter.....Sept/October 2002

"I definitely only ran like 75 to 85 a week. I incorporate tempo runs, long runs, track work, and easy days."

Heather Hanscom [ran her second marathon at the U.S. Olympic Trials April 3, 2004.....2:31.....6th place.....PR by 7 minutes]
November 2003.....Interview with Pat MacAdie www.fast-women.com
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Runner's World Daily: "Are you doing more mileage now than ever before? "
Jen Rhines: "No, I'm not running quite as much as I did when I trained for Chicago last year. I've tried to bring the average pace I do on my easy runs and on my long runs down a little bit. That works a little better for me. I've tried to focus on all quality and no junk miles. My highest week last year was like 117. Now I'm more like 95 to 100. It's better to keep a little snap in my legs rather than overdo it. "

Jen Rhines by Peter Gambaccini
http://runnersworld.com/home/0,1300,1-0-0-5593-1-0-,00.html
[Jen Rhines set a PR by 11 minutes to qualify for the 2004 U.S. Olympic team.....2:29:57]

"Being over 40 and from Illinois boosted Spangler's earnings to $11,500 for her 2 hours 32 mintes, 29 seconds of work. "

".....she gave birth 21 months ago and only got back into training in January 2003. "

"After years of injury, why is the older Spangler running so well and on fewer miles (60 - 70 compared to about 100 per week.....)."

[Jenny Spangler set American best masters time with 2:32 at Chicago marathon last October]

Speedplay - Good Luck, Good Bucks For Spangler
[By Mike Prizy.....Chicago Athlete.....Nov/Dec 2003]

"Runnersworld: "How specifically did the training change?"

Ian Syster:..... "Less mileage, more quality. We run our long runs very hard. Someone is always pushing the pace. That's the key to the marathon, because you can hang in there in practice when the pace is being pushed, you get to the point where that feels comfortable during the race. "

Ian Syster [2:07:06 Marathoner in 2002]
A Brief Chat With.....Ian Syster by Dave Kuehls Runnersworld.com.....June 24, 2002

"The athletes I talk to who are running the fast marathons, from 2:07 down to 2:05, aren't putting in the high mileage, but a lot of high intensity stuff, at 5:C pace and lower. I tend to think that's what separates a lot of people in the marathon, just the level of comfort they have with the long runs. "

Eric Mack...[2: 12:42 marathon in 2000,]
Reported by Peler Gambaccini.....A Brief Chat With Runner's World Daily News.....October I I, 2002....runnersworld.com
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"My fastest steeplechase time was 9:2S. During that season, I dropped to the second fastest American in history in the Montreal Olympics, where I ran 8:23. and missed the American record by less than a second,"

".....I went from a quantity runner to a quality runner, less distance, and (became) more of a toe runner than a heel runner."

Henry Marsh [Four-time Olympian, ranked first... in the world in the steeplechase in 1981, 1982, and 1985)

reported by Peter Gambaccini.....A Brief Cbat With
Runner's World Daily News.....Novernber 29, 200l.....Runnersworld.com
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"For base work, he does 5O to 60 miles a week. Speed is essential but so is recovery. Too much intensity is not good. We do 8 or 10 x 400 very fast with sho rest, rather than 20 x 400,"

Coach of Alan Webb 2000/2001 school year.....high school 3:53 miler
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"In summer I run about 5O kilometers (30 miles) a week, with Monday and Wednesday speed work sessions. We'll do eight 3OO's with 2 minutes rest o Monday, and ten 200's with 75 to 90 seconds rest on the Wednesday. That's pretty low-key compared to other people at the same level,"

Nick Willis, 17 year old
From New Zealand 4:01 miler

"In the fifties, Franz Slamfl who trained Roger Bannister, the first sub-4 minute miler, employed interval training in varying forms 5 days per week almost a year round."

Aerobic Interval Training and Performance
Sports Medicine...Volume 31 #1...200l...page 16

"Runners can be a hit wacky about mileage. Weekly mileage is simultaneously an illuminating and useless statistic. High weekly mileage bas becom shorthand for the level of seriousness and dedication of a runner, but it says nothing about the quality of the miles, nor does it accurately predict anyone's lev of performance. In college. we carne up with the term "Olympic Training Log Champion" for athletes who seemed more interested in having an impressiv looking number at the end of the week rather than any particular training benefit."

excerpt from.....Steve Holman....."High Mileage Syndrome" Runner's World Daily News....January 31, 2002.....runnersworld.com

Most Fit At Velocities Trained On Most

Your highest level of fitness will be at the paces upon which you do the most training. If you're following a mileage [volume] oriented training program, add up your "easy days", "recovery days", "morning runs", and long runs.

If most of your training is at 9:00 - 10:00 per mile pace, that is where you will be the most fit.

If most of your training is at 8:00 - 9:00 per mile pace, that is where you will be the most fit.

If most of your training is at 7:00 - 8:00 per mile pace, that is where you will be the most fit.

If most of your training is at 6:00 - 7:00 per mile pace, that is where you will be the most fit.

If most of your training is at 5:00 - 6:00 per mile pace, that is where you will be the most fit.

If most of your training is at 4:20 - 5:00 per mile pace, that is where you will be the most fit.
Your highest level of fitness will be at the paces upon which you do the most training.

If most of your training is at 6:00 - 7:00 per mile pace, that is where you will be the most fit.

If most of your training is at 5:00 - 6:00 per mile pace, that is where you will be the most fit.

If most of your training is at 4:30 - 5:00 per mile pace, that is where you will be the most fit.

If most of your training is at 4:10 - 4:30 per mile pace, that is where you will be the most fit.

If most of your training is at 3:50 - 4:10 per mile pace, that is where you will be the most fit.

If most of your training is at 3:30 - 4:00 per mile pace, that is where you will be the most fit.

The Reality As Long As You Live In This World ------ If you abandon the mileage [volume] oriented training program, by deleting the workouts that produce most of the mileage, your "easy days", "recovery days", "morning runs", and long runs.....you can more easily train on faster paces without over-training.

Your highest level of fitness will be at those faster paces, because your highest level of fitness will be at the paces upon which you do the most training.

In a velocity oriented training program you can do this intentionally, on purpose. In a mileage oriented training program, this is often achieved by accident because.....

1. the runner trained faster on their "easy days", "recovery days", "morning runs", and long runs than he/she was supposed to, particularly runners who train in groups, and somebody "feels good" that day and takes off.

2. the runner trained in a group where the majority were much faster runners than he/she was [similar to what happens when one goes from middle school to high school, or from high school to college].

When The Training Gets Faster The Runner Gets Faster------ When the training gets faster, either intentionally--on purpose or by accident, the runner gets faster.

The easiest way to do it intentionally, on purpose, is via a velocity oriented training program.

The Reality ------ A training program that allows you to stay in an anabolic state [avoids the over-trained state] and train on paces that are fast relative to the performance levels in your segment of the sport [ie. high school, college, or age group] or in the sport as a whole.....is a training program that will get you fit at those paces, because your highest level of fitness will be at the paces upon which you do the most training.

This is where the sport is headed!!!

"It may well be that an important component of sustained, intense training is to directly alter muscle contractility. It is possible that high intensity interval trai enhances athletic performance
by stimulation of the appropriate muscle fibers needed to be recruited at, or close to, race pace."

Journal Of Sport Sciences.....Volume 15 #3 June 1997

".....it has been shown that training intensity, rather than frequency or distance, was the most important factor to improve Vo2max."

L.V.Billat.....2001
Interval Training For Performance: A Scientific And Empirical Practice
Sports Medicine.....Volume 31 #2.....2001....page 79

"This high velocity training elicits high levels of force and brief contact time."

"Regular training at velocities well above v-Marathon seems to characterize top-class marathoners."

V.L.Billat, et.al.....2001
Physical And Training Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise.....Volume 33 #12....2001....page 2089 - 2097

"Significant adaptations and performance improvements, which are not represented by the Vo2max, can occur in well-trained subjects after specific endur training program."

A.P.Demarle, et.al.....March 2001
Decrease of O2 Deficit Is A Potential Factor In Increased Time To Exhaustion After Specific Endurance Training
Journal Of Applied Physiology.....Volume 90 #3.....March 2001....page 947 - 953

"These data indicate that endurance can vary greatly among individuals with a equal Vo2max."

E.F.Coyle, et.al.....1988
Determinants Of Endurance In Well Trained Cyclists
Journal Of Applied Physiology.....Volume 64 #6....June 1988.....pages 2622 - 2630

".....differences in Vo2max were small or nonexistent between world class Kenyans and slower Scandinavians, but.....energy metabolism at high intens were different....."

V.L.Billat, et.al.....2001
Physical And Training Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise.....Volume 33 #12....2001....page 2089 - 2097

".....stroke volume in the elite athletes does not plateau but increases continuously, with increasing intensity of exercise...."

B.Zhou, et.al.....2001
Stroke Volume Does Not Plateau During Graded Exercise In Elite Male Distance Runners
Medicine & Science In Sports & Exercise.....Volume 33 #11....2001....page 1849 - 1854

"....the purpose of this study was to compare the energetic and training factors that contribute to the marathon performance time of top-class...versus high-l marathon runners."

"The high energy output seems to be the discriminating factor for top-class male marathon runners who trained at higher relative intensities."

V.L.Billat, et.al.....2001
Physical And Training Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise.....Volume 33 #12....2001....page 2089 - 2097

"We have previously shown that the superior endurance performance of African distance runners, compared with white runners, was due to their ability to sustain a higher percentage of Vo2max with increasing running distance."

"Of particular interest is that these superior performances may be due to a training-induced adaptation."

".....the white runners spent as little as (13%) of their total training volume performing high-intensity (>80% Vo2max) running.....which in all cases was significantly less than the African athletes
(36%)."

June 1997.....J.A. Hawley, et al
Training Techniques To Improve Fatigue Resistance And Enhance Endurance Performance
Journal Of Sport Sciences.....Volume 15 #3.....June 1997....page 328 - 329

"Little data exist that specifically and accurately evaluate energy system contributions.....Considerable information can be found that attempts to do so, but this has generally been based on data originating in the 1970's that inappropriately used oxygen debt to quantify anaerobic energy release."

"The crossover to predominately aerobic energy system supply occurred between 15 and 30 seconds for the 400, 800, and 1500 meter events."

"These results suggest that the relative contribution of the aerobic energy system during track running events is considerable and greater than traditionally thought."

Energy System Contribution During 200 to 1500 meter Running In Highly Trained Athletes
Medicine & Science In Sports & Exercise.....Volume 33 #1.....January 2001.....page 157

"Current developments in the training of 400m sprinters showed that aerobic training had a positive effect on competition performance."

D.Wallner.....et al.
Interdependence Of Aerobic And Anaerobic Performance And Its Consequences For Training In Sprinters And Endurance-Trained Runners
Journal Of Sport Sciences.....Supplement.....page 551

"Denis et al. (1992) have reported that the ability to sustain supramaximal work lasting 30 – 45 seconds was related more to muscle oxidative [aerobic] capacity that to glycolytic [anaerobic]
capacity."

Changes In Performance, Muscle Metabolites, Enzymes And Fiber Types After Short Sprint Training
European Journal Of Applied Physiology & Occupational Therapy.....Volume 78.....1998.....page 167

".....there have been relatively few investigations of the effects of sprint training on mitochondrial enzymes or aerobic power in humans....."

"The significant increases in VO2max.....were somewhat unexpected.....Changes of this magnitude are usually associated with training programs involving several hours per week at submaximal exercise intensity."

Muscle Performance And Enzymatic Adaptations To Sprint Interval Training
Journal Of Applied Physiology.....Volume 84 #6.....page 2141.....June 1998

"Runners can be a bit wacky about mileage. Weekly mileage is simultaneously an illuminating and useless statistic. High weekly mileage has become shorthand for the level of seriousness and dedication of a runner, but it says nothing about the quality of the miles, nor does it accurately predict anyone's level of performance. In college, we came up with the term "Olympic Training Log Champion" for athletes who seemed more interested in having an impressive looking number at the end of the week rather than any particular training benefit."

excerpt from.....Steve Holman....."High Mileage Syndrome"
Runner's World Daily News....January 31, 2002.....runnersworld.com

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"I believe that in order to run your best marathon, you have to, in the recent past, have run close to your best at five and 10,000 meters. Not necessarily within a couple of seconds, but if you've run 27:30 for 10,000 meters before, you better be able to run at least 27:45 or 27:50 prior to that marathon.

You're going to need that sort of speed. I think the problem that we have had in recent years is that we've had some guys who've gone into the marathon with sub-28:00 times, but it was a year or two years before, and then they went into what they called 'marathon training' and lost that sort of speed. I think that's affected their ability to run a marathon. You have to periodically go back to the shorter distances to make sure you're keeping the speed."

Alberto Salazar
reported by Peter Gambaccini.....A Brief Chat With
Runner's World Daily News.....November 15 2001.....Runnersworld.com

"I usually do no more than 60 miles a week.....when I am building up my base....."

"I know there are many more runners that run many more miles...."
"I have not had any injury worries for several years and so I've found a formula that works, although the sessions I do are often quite intense. I'm a firm believer in speed related to endurance and not doing what Americans often call 'junk' miles."

Benard Lagat [3:26 1500m.....second fastest all time]
By Phil Munshill For the IAAF
Track & Field Writers Of America Newsletter.....Sept/October 2002

"Runnersworld: "How specifically did the training change?"

Ian Syster:....."Less mileage, more quality. We run our long runs very hard. Someone is always pushing the pace. That's the key to the marathon, because if you can hang in there in practice when the pace is being pushed, you get to the point where that feels comfortable during the race."

Ian Syster [2:07:06 Marathoner in 2002]
A Brief Chat With.....Ian Syster by Dave Kuehls
Runnersworld.com.....June 24, 2002

"The athletes I talk to who are running the fast marathons, from 2:07 down to 2:05, aren't putting in the high mileage, but a lot of high intensity stuff, at 5:00 pace and lower. I tend to think that's what separates a lot of people in the marathon, just the level of comfort they have with the long runs."

Eric Mack...[2:12:42 marathon in 2000,]
Reported by Peter Gambaccini?..A Brief Chat With
Runner's World Daily News.....October 11, 2002....runnersworld.com

"I ran 3:52.02 in the mile running an average of just over 40 miles a week [almost all of it high quality]. I believed that if I ran 80 miles a week I would run 3:42 Wrong, I upped my mileage, lowered the quality, and never ran faster."

Craig Masback.....CEO of USA Track & Field
Track & Field Coaches Review.....December 1999.....page 11

"My fastest steeplechase time was 9:25. During that season, I dropped to the second fastest American in history in the Montreal Olympics, where I ran 8:23.9 anc missed the American record by less
than a second."

".....I went from a quantity runner to a quality runner, less distance, and (became) more of a toe runner than a heel runner."

Henry Marsh [Four-time Olympian, ranked first in the world in the steeplechase in 1981, 1982, and 1985]
reported by Peter Gambaccini.....A Brief Chat With
Runner's World Daily News.....November 29, 2001.....Runnersworld.com

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"For base work, he does 50 to 60 miles a week. Speed is essential but so is recovery. Too much intensity is not good. We do 8 or 10 x 400 very fast with short rest rather than 20 x 400."

Coach of Alan Webb.....high school 3:53 miler

"In summer I run about 50 kilometers (30 miles) a week, with Monday and Wednesday speedwork sessions. We'll do eight 300's with 2 minutes rest on Monday and ten 200's with 75 to 90 seconds rest
on the Wednesday. That's pretty low-key compared to other people at the same level."

Nick Willis, 17 year old from New Zealand 4:01 miler

"In the fifties, Franz Slamfl who trained Roger Bannister, the first sub-4 minute miler, employed interval training in varying forms 5 days per week almost all yeai round."

Aerobic Interval Training and Performance
Sports Medicine...Volume 31 #1...2001...page 16

"Igloi trained his runners with rigorous interval workouts....."

Runners World Online Feb,15 1996
www.runnersworld.com/dailynew/archives/1996/February/960215.html

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"We ran 10 to 15 miles a day, usually in intervals."
Jim Ryun.....In Quest For Gold: The Jim Ryun Story

"increased training duration seems to place a greater demand on the body than increased training intensity."

M.Bagger et.al.
Increased Training Duration Versus Increased Training Intensity In the Development Of Overtraining
Journal Of Sport Sciences.....Volume 19 #8.....page 626

".....it has been shown that training intensity, rather than frequency or distance, was the most important factor to improve Vo2max."

L.V.Billat.....2001
Interval Training For Performance: A Scientific And Empirical Practice
Sports Medicine.....Volume 31 #2.....2001....page 79

"From the viewpoint of immune function, the optimal training regimen is of low volume."

Immune Responses To Training: How Critical Is Training Volume?
Journal Of Sport Medicine & Physical Fitness.....Volume 39 #1.....March 1999

".....muscle fibers are not inalterable but are highly versatile entities capable of changing their phenotype from fast to slow or slow to fast. "
".....muscle fibers adjust their phenotype to meet the altered functional demands."

D.Pette
Historical Perspectives: Plasticity Of Mammalian Skeletal Muscle
Journal Of Applied Physiology.....Volume 90 #3.....March 2001.....page 1119 - 1124

"Maximum running speed depends upon the ability of the runner to generate force quickly, that is, in about 100ms, almost the length of time that the foot is on the ground.....Thus, unless strength training trains the ability of the legs to generate forces in a very short time, that is, with maximum explosive force, slower training would not assist in the development of running speed. Strength training for sprinters should emphasize the most rapid development of leg forces."

W.Young , B.Mclean. J.Ardanga.....1995
Relationship Between Strength Qualities And Sprinting Performance
Journal Of Sports Medicine And Physical Fitness.....Volume 35.....1995

"We conclude that human runners reach faster top speeds not by repositioning their limbs more rapidly in the air, but by applying greater support forces to the ground."

Faster Top Running Speeds Are Achieved With Greater Ground Forces Not More Rapid Leg Movements
Journal Of Applied Physiology.....Volume 89.....2000.....page 1991-1999

"The results from the present study support the hypothesis that lactate production is due in part to metabolic inertia and cannot solely be explained by an oxygen limitation, even under conditions of acute hypoxia."

American Journal Of Physiology: Endocrinology, Metabolism
Volume 279.....2000.....pg E752 – E761

".....voltage sensor activation of Ca release is inhibited to only a comparatively small extent (<10%), even at 30mM lactate. This indicates that lactate accumulation is probably not a major factor in muscle fatigue, even in fast-twitch fibers."

Effect of Lactate on depolarization-induced Ca release in mechanically skinned skeletal muscle fibers
American Journal Of Applied Physiology.....Volume 278.....2000.....pg C517 – C525

"These results indicate that lactate has only a relatively small inhibitory effect on normal excitation-contraction coupling [muscle force output], indicating that lactate accumulation per se is not a major factor in muscle fatigue."

Effect of Lactate on depolarization-induced Ca release in mechanically skinned skeletal muscle fibers
American Journal Of Applied Physiology.....Volume 278.....2000.....pg C517 – C525

"Central fatigue as documented by TMS occurs before complete exhaustion....."

Central Fatigue In Sports & Daily Exercise
International Journal Of Sports Medicine.....Volume 18.....pg 614 – 617 1997

"We conclude that endurance training enhances the capacity of human skeletal muscle to accumulate glycogen after glycogen-depleting exercise."

Effects Of Endurance Exercise Training On Muscle Glycogen Accumulation In Humans
Journal Of Applied Physiology.....Volume 87 #1.....pg 222.....1999

Controllability: Training Program Design

The ability to move one's fitness level forward on purpose, is the definition of controllability. A training program should develop running performance, and do so on purpose. To accomplish that task, one should;

1 --- identify what the underlying mechanisms of running performance are.
2 --- identify the required aspects of a workout necessary to address the identified mechanisms of running performance
3 --- apply that information to design a training program that develops running performance [on purpose]

Major Mechanisms Of Performance in Distance Running Events -------
One has to be able run at the pace necessary to run a goal time for a race distance. To do so, one must be able to create the required level of force or power output during the drive phase of the running stride. To accomplish that, one's brain and nervous system must be able to do the following.....

----- Recruitment
Be able to recruit many muscle fibers as to share the work in producing the necessary power output to run a goal time

----- Recruitment Rate
Be able to quickly recruit many muscle fibers while the foot is on the ground during the running stride as to share the work in producing the necessary power output to run a goal time

----- Recruitment Duration
Be able to maintain the required level of recruitment and recruitment rate in producing the necessary power output for the duration of the race

Since the mechanisms of performance revolve around creating and maintaining a given power output, this should be clearly reflected in the training program one designs to address the identified mechanisms.

The next step in reasoning one's way through designing a training program that develops running performance [on purpose].....

Physiological Premise 1 -----
Improvements in recruitment, recruitment rate, and recruitment duration are the result of causing/inducing the process of gene transcription of specific genes in the brain, nervous system, and muscles that are responsible for recruitment, recruitment rate, and recruitment duration.
Therefore.....the workouts in the training program should be designed to cause/induce the process of gene transcription of specific genes in the brain, nervous system, and muscles that are responsible for recruitment, recruitment rate, and recruitment duration.

Physiological Premise 2 -----
The only level of gene transcription one must induce is that which is specific to the level of power output necessary to run a goal time. Since recruitment, recruitment rate, and recruitment duration are about power output during the drive phase of the running stride, which in turn is largely about training velocity, it follows that inducing the level of gene transcription necessary to run a goal time is best done by training at or faster than the pace necessary to run the goal time.
Therefore....the workouts in the training program should revolve around the concept of training at goal paces. In other words, the training program should be velocity oriented.

Physiological Premise 3 -----
The process of gene transcription in human cells responds well to repeated, ---standardized--- workloads. And at some point, to continue improving, one will eventually have to increase the standardized workload. Therefore, it is wise to focus one's efforts on designing a standardized training program consisting of standardized workouts, delivered on a standardized schedule, with standardized recovery periods, with standardized progressions in workload over time.

The next step in reasoning one's way through designing a training program that develops running performance [on purpose]……

Standardized Workload-------
In a standardized, velocity oriented training program, the bottom-line objective is to create a standardized workload, delivered through specific workouts in the training program.

Hence the focus is simply on;
--- using as workout durations….standardized race distances [ie. 1500m, 10k, marathon, etc],
--- using as training paces…..standardized power outputs [ie. goal pace].

The way to create a relatively high degree of controllability in moving one's fitness level from point A to point Z, is to consistently deliver a standardized workload to the human body.

This allows you to create a controllable, step-wise progression in the manner in which you increase the standardized workload over a period of time, with this as the underlying mechanism in the process by which you move your fitness level from point A -to-point Z.

The human body adapts well to….
--- standardized training stimuli

--- standardized progressions in the durations of the standardized training stimuli

--- standardized recovery periods

Standardize -Everything- Including The Recovery Periods-------
Design standardized recovery periods based on a "time course of recovery" from the standardized workouts in your training program. The standardized recovery period can be increased in duration if occasional situations require [but never reduced].

Having recovery time periods programmed into the training schedule facilitates figuring out temporary anomalies in recovery and reduces the guess work involved with trying to decide whether or not to train on a given day.

A Training program consistent with the physiological information available to us in this century lives around –3-- structural principles;

1. Velocity
[goal pace]

2. Durations
[Duration of each repetition (ie. intervals)]

3. Progressions
[progress over time to where the entire race distance can be covered using only [1] repetition]

--- Workouts are run in a manner where the race distance is covered in a cumulative total of shorter repetitions [ie. intervals], with each repetition run in selected Durations. The ultimate objective is to make Progressions over time, to where the entire race distance can be covered [in a workout or race] using only [1] repetition.

--- This type of progression oriented process is consistent with how the process of stimulating gene transcription works inside the cells of the human body. It provides one with a common sense, relatively controllable manner of following a stepwise progression of standardized increments of escalating the workload until one reaches the goal time for the race distance.

The next step in reasoning one's way through designing a training program that develops running performance [on purpose].....

The Individual Workouts -----

Chose a "main event". Your main race distance that you have a goal time for.
--- Design a goal pace workout for that race distance, and make it the first workout in the training schedule.

--- For the other workouts in the training schedule, choose other race distances common to the sport. Include ones that are at each of 2 extremes [long and short] in duration, and therefore in training velocity. This provides a comprehensive group of training stimuli. Limit the number of workouts to that necessary to run your main event, and 2 – 3 other distances.

--- This process of creating workouts insures that all of the workouts in one's training program are relevant to the sport, and that all paces run during the workouts are relevant to goal times. This in turn, insures that the workouts in the training program are designed to cause/induce the process of gene transcription of specific genes in the brain, nervous system, and muscles that are responsible for recruitment, recruitment rate, and recruitment duration at a level that will be significant and necessary in order to eventually achieve one's goal time.

In Track & Field, the common race distances are [100m, 200m, 400m, 800m. 1500m, 5000m, 10,000m, marathon].

If your event is 1500 meters, you should have a 1500m goal pace workout for your "main event". To fill in the rest of the your training cycle, there should be at least one workout at a race distance that requires extremely high velocities [ie. 100m goal pace workout]. There should be at least one workout at a race distance that is set at the long end of the race distances that are common in the sport [ie. marathon goal pace workout]. Any other workouts should be some variation on these 2 themes.

Physiologically, for laying the ground work for a facilated level of improvement in recruitment ability over the long term of your life and running career, it is wise to include a stimulus for maximum recruitment, and a stimulus for maximum recruitment rate. They should be intervals that are extremely short in number and duration.

The Physiological Reality of Gene Transcription Oriented Progressions -------

It doesn't matter where your fitness is relative to your goal. This training program is designed to allow you to start where-ever you happen to be at the time, and progress from there. Even with short duration repetitions, your fitness will move. If you've grown up in this sport from an early age, you've been indoctrinated into looking at short durations as "anaerobic". Physiologically, it would be wise to unlearn that. With training, whatever you believe is anaerobic today, will be less so tomorrow as mitochondria are added as an adaptation to training. Your fitness will move with short durations and will begin moving faster as you progress to longer durations.

Accept no limitations. What you don't know about the human body can limit....
--- your thinking
--- your reasoning
--- and the design of your training program

Training produces adaptations to training;
--- among nerve and muscle fibers that are active during the training
--- among nerve and muscle fibers that experience large increases in activity during the training

Note the use of the phrase "are active". An increase in activity of specific nerve and muscle fibers regardless of fiber type is the mechanism of something important to this subject. In thinking through how to implement this point of view, it may help to work through some of the more obvious rhetorical questions;

----- how many nerve and muscle fibers do you need to have active in order to run the times you want to run in your races
----- does running at your goal paces recruit the nerve and muscle fiber types that you will need to have active in order to run the times you want to run in your races
----- if the answer is yes, shouldn't this be a consistent training stimulus embedded in your training program

Continue to the logical conclusion.....
----- do you need to train at nerve and muscle fiber recruitment levels that you'll –never- be using during your races

----- if the answer is no, shouldn't you train at goal paces so that you'll always be activating the number of nerve and muscle fibers that you'll be using during your races [meaning....shouldn't you avoid training at slower velocities]

----- given the answers to these questions, does it seem logical to believe that one must do slow paced traditional "base building" at velocities you'll ---never--- run during a race. If the answer is no, then why do it

The next step in reasoning one's way through designing a training program that develops running performance [on purpose].....

In designing specific workouts in an all-goal pace all the time type of training program, which is by definition an all intensity all the time type of training program.....avoid the temptation to play mind games with rest periods in between one interval run and the next, or between one training day and the next.

If you've grown up in this sport from an early age, you have likely been indoctrinated into the requirement to take no days off, and to take short rest periods during interval workouts.

Unlearn both of these practices. Neither is physiologically wise, sound, or necessary in this type of training program.

"Perhaps the study of Baldwin et al. finally establishes that muscle glycogen depletion does not cause fatigue within the muscle by reducing the available energy below a critical amount."

"...if the rate of ATP production falls below the rate of ATP use, then there must be a progressive reduction in muscle ATP concentrations leading to skeletal muscle rigor if no other safety mechanism exists."

"The essential contribution of Baldwin et al. is to show that some other control mechanism must be present.....as shown by a number of other studies...."

".....if performance during prolonged exercise is ultimately regulated centrally by the brain.....then RPE [rating of perceived exertion] may play some role in that....process. For example, the rate of increase in RPE may reflect the rate at which crucial fuel reserves are being depleted."

"The pivotal importance of the study by Baldwin et al.is that it allows us finally to close the chapter on the concept that a state of absolute energy depletion is ever reached during prolonged exercise, just as it also does not occur during any other form of voluntary exercise."

Dr. Tim Noakes
Letter To The Editor
Journal Of Applied Physiology.....Volume 96 #4....April 2004.....page1571 - 1572

".....failure of the Central Nervous System in providing an optimal neural drive to the contracting skeletal muscles may contribute to the development of fatigue during prolonged exercise. Oxidation of glucose from the bloodstream is under normal circumstances the only energy source for the Central Nervous System, and a continuous systemic supply is essential, as glucose storage in neuronal tissue is limited."

".....the idea that carbohydrate availability for the brain is important in maintaining an adequate neural drive to the muscles is supported by the finding that glucose infusion directly in the carotid artery can delay fatigue...."

".....hypoglycemia (low glucose levels) impairs the ability to sustain a high neural drive to the muscles...."

".....exercise is associated with an activation of large regions of the brain including the motor cortex areas as well as regions involved in cardio-respiratory regulation, and endothelial glucose transport may become rate limiting for the cerebral metabolic rate of glucose when the arterial glucose concentration falls below a critical point...."

"A continuous supply of blood glucose to the brain is essential....."

"....central fatigue during strenuous exercise could relate to depletion of brain glycogen stores."

".....exercise-induced hypoglycemia in endurance trained subjects lowers the average force production.....and the reduced force development is associated with a diminished activation drive from the Central Nervous System."
L.Nybo.....April 2003
CNS Fatigue And Prolonged Exercise: Effect Of Glucose Supplementation
Medicine & Science In Sports & Exercise.....Volume 35 #4.....April 2003.....page589 - 594

"Adaptive changes can occur in the nervous system in response to training."

".....increased efferent neuronal outflow with training, including increases in maximal firing frequency...."

"....increases in maximal contraction force and power as well as maximal rate of force development will occur.....as a result of changes in the nervous system."

"Importantly, the rate of force development plays an important role in the ability to perform rapid and forceful movements, both in highly trained athletes as well as elderly individuals....."

"....the rate of force development is enhanced with an increase in efferent neural drive....."

"An increased central descending motor drive results in an increased motor neuron recruitment and firing rate, which increases outflow of efferent motor impulses in the axons."
P.Aagaard.....April 2003.....Training-Induced Changes In Neural Function
Exercise & Sport Sciences Reviews.....Volume 31 #2.....April 2003.....page 61 - 67

"..... at exhaustion exercise is ended without limb locomotor muscle fatigue and with sub-maximal cardiac output. A simple fact provides a basis for an explanation. Voluntary exercise starts and ends in the brain. "

"It starts with spatial and temporal recruitment of motor units and ends with their de-recruitment. "

"An alternative model explaining the limitation of exercise endurance thus proposes that the central nervous system integrates input from various sources all related to the exercise and limits the intensity and duration of recruitment of limb skeletal muscle to prevent jeopardizing the integrity of the organism."

"This model acknowledges the cardio-respiratory and muscle metabolic capacities as prime actors on the performance scene, while crediting the central nervous system for its pivotal role as the ultimate site where exercise starts and ends."
B.Kayser .....Exercise Starts And Ends In The Brain
European Journal of Applied Physiology..... Volume 90, Numbers 3-4..... October 2003.....page411 - 419

"Based on the EMG and force data, one may conclude that the decrease in force is a result of reduced Central Nervous System drive to muscle....."

".....recent findings indicate that some force loss may result from.....nervous system fatigue."

Z.Jing, et al.
Nonlinear Cortical Modulation Of Muscle Fatigue: A Functional MRI Study
Brain Research.....Volume 957 #2.....December 13, 2002.....page 320-329

".....it seems very likely that a decrease in motor cortex excitability is at least in part involved in the mechanisms leading to a loss of force."

"Thus, reduction of ICF indicates decreased motor cortex excitability upstream from the motor cortex output neurons."

"...reduced Intra-cortical Facilitation by double-pulse TMS reflects central fatigue specifically for the part of the motor cortex involved in the task."

"...it was discussed that the mechanisms representing fatigue mainly originate upstream from the spinal level."

Frithjof Tergau, et al.
Motor Cortex Fatigue In Sports Measured By Transcranial Magnetic Double Stimulation
Medicine & Science In Sports & Exercise.....Volume 32 #11.....2000.....page 1942 - 1948

"Running was associated with a relative increase of glucose uptake in the.....pre-motor cortex and the cerebellar vermis."

"Activitiy of the primary sensori-motor cortex was higher in the...[leg motor area], than the...[thorax and arm]."

M.Tashiro, et al.
F-FDG PET Mapping Of Regional Brain Activity In Runners
Journal Of Sports Medicine & Physical Fitness.....Volume 41 #1.....2001

"The causes of fatigue during muscular exercise include factors that reside in the brain (central mechanisms)....."

J.M.Davis
Central And Peripheral Factors In Fatigue
Journal of Sports Sciences.....Summer 1995.....page S49 - 53

"....the training induced gains in contractile Rate Of Force Development and impulse, were attributed to an enhanced neural drive....."

P.Aagaard, et.al.....2002
Increased Rate Of Force Development and Neural Drive Of Human Skeletal Muscle Following Resistance Training
Journal Of Applied Physiology.....Volume 93.....2002.....page 1318 - 1326

"Research suggests athletes are unable to maintain maximal firing frequencies for the full duration of, for example, a 100m sprint. Fatigue after a single training session may also have a neural manifestation with some athletes unable to voluntarily fully activate muscle....."

A.Ross, M. Leveritt, S.Riek
Neural Influences On Sprint Running: Training Adaptations And Acute Responses
Sports Medicine.....Volume 31 #6.....2001.....page 409 - 425

"Central fatigue, as documented by TMS occurs before complete exhaustion....."

J.Hollge, et al.
Central Fatigue In Sports And Daily Exercises: A Magnetic Stimulation Study
International Journal Of Sports Medicine.....Volume 18.....1997.....page 614 - 617

".....an increased 'neural drive' to the muscle fibers contributes to the training induced increase in maximal contractile force, even in the absence of increases in muscle size."

P.Aagaard, et. al.
"Neural Adaptation To Resistance Training: Changes In Evoked V-wave And H-reflex Responses
Journal Of Applied Physiology.....Volume 92.....June 2002.....page 2309

"explosive-strength training, may lead to specific neural adaptations, such as the increased rate of activation of motor units...."
L.Paavolainen...
Explosive-Strength Training Improves 5-km Running Time By Improving Running Economy And Muscle Power
Journal Of Applied Physiology.....Volume 86 #5.....1999.....page 527

The 100 meter World Record was broken last weekend.

some comments.....

We're seeing a positive trend in sprinting. A gradually more consistent move toward the necessary long, high velocity training of the long sprinter being applied toward running the 100 meter dash event.

Physiologically, the 100m dash is an in fact, an --endurance-- event. Even the fastest sprinters in the world fail to hold their maximum velocity for more than 10 - 20 meters of the race. The person who slows down the least after reaching his/her maximum velocity is the person who has the highest level of performance. Being aerobically fit at --very-- high velocities is the underlying mechanism of performance for this event and the pathway to further world records. In years past, we've seen members of the Santa Monica track club [ie. Carl Lewis, Leroy Burrell, Mike Marsh] and others [ie. Tyson Gay, Allyson Felix, etc.] have some of their best years when having done well in an abundance of relatively long, high velocity workouts [200 - 600m], and now we've seen the lengthening line of long sprinters who have moved down and experienced high level success at the 200 and 100 meters [ie. FloJo, Michael Johnson, Usain Bolt].

In our sport, we can expect to see the continued move forward of the 100m World Record, perhaps on a more frequent basis, as sprint coaches begin to effectively piece together this aspect of the underlying mechanism of performance for this event, and successfully develop a standardized protocol that addresses it. As some in the sport get this done, we'll see more sprinters, male and female, running major times on a more frequent and more consistent basis as their training programs empower them to have a greater level of controllability over their performance level.

These are great times to be alive and on this planet in our sport. We're going to see a 9.6 run for 100 meters. We're likely to see a 9.5 run for 100 meters. We're going to see a woman run under 10.4 for 100 meters. The limits of human performance are well outside of the ballpark in which many people in our sport believe them to be.

Around the end of last week, Tyson Gay ran a wind aided 9.68 for 100 meters.
Thats faster than Thompson ran at altitude [El Paso] with a 5 meter per second aiding wind.
So now we have a world record thats just above 9.6 and another guy running 9.6 at sea level with an aiding wind.
Predictably, more to come.....

Usain Bolt 9.69!!!!
I surely didn't expect to see a wind-legal 9.6 this year.
But, repeating what I posted earlier.....
These are great times to be alive and on this planet in our sport. We're going to see a 9.6 run for 100 meters.
We're likely to see a 9.5 run for 100 meters. We're going to see a woman run under 10.4 for 100 meters. The limits of human performance are well outside of the ballpark in which many people in our sport believe them to be.

Last weekend.....
100m final [World Championships]
--- Usain Bolt 9.58 [World Record]
--- Tyson Gay 9.71 [American Record]
--- Asafa Powell 9.84
--- Daniel Bailey 9.93
--- Richard Thompson 9.93

At this point everybody should be open to the concept of re-thinking what they think they know about the limits of human performance. Its the 21rst century. Its early yet. More is coming, especially in distance running.
The application of sport sciences has only just begun.

Carmelita Jeter's performance of 10.64 approaches that which should be considered the World Record, the 10.61 run by FloJo at the Olympic Trials in 1988.

---- FloJo's 10.49 was likely wind aided. I was at FloJo's Oly trials races. The wind reading in the infield display kept saying 0.0 m/sec for a few of the heats. That was odd. It was odd that so many people in her heat set PR's. It was odd that other heats were wind aided. It was odd that Carl Lewis [9.78] time was wind aided. But supposedly not the 10.49, with a wind at 0.0 meters per second. It was a pretty windy day.

---- Marion Jones, prior to her use of "the clear", ran 10.71. Thus the all-time list should probably look like this.....

10.61 -- FloJo
10.64 -- Carmelita Jeter
10.71 -- Marion Jones

As stated previously, these are great times to be alive and on this planet in our sport. **We're going to see a woman run under 10.4 for 100 meters. The limits of human performance are well outside of the ballpark in which many people in our sport believe them to be.**

Yesterday in Florida, Tyson Gay ran 400m in 44.89.
A personal best. Started last year with 45.57.

Repeating from the initial post on this thread, also an excerpt from the June 2, 2008 ETG Press Communication prior to the 9.6 and 9.5 performances of Tyson Gay and Usain Bolt.....
http://www.theetgtrackclub.com/index.cfm?fuseaction=press_media

We're seeing a positive trend in sprinting. A gradually more consistent move toward the necessary long, high velocity training of the long sprinter being applied toward running the 100 meter dash event.

Being aerobically fit at --very-- high velocities is the underlying mechanism of performance for this event and the pathway to further world records. In years past, we've seen members of the Santa Monica track club [ie. Carl Lewis, Leroy Burrell, Mike Marsh] and others [ie. Tyson Gay, Allyson Felix, etc.] have some of their best years when having done well in an abundance of relatively long, high velocity workouts [200 - 600m], and now we've seen the lengthening line of long sprinters who have moved down and experienced high level success at the 200 and 100 meters [ie. FloJo, Michael Johnson, Usain Bolt].

In our sport, we can expect to see the continued move forward of the 100m World Record, perhaps on a more frequent basis, as sprint coaches begin to effectively piece together this aspect of the underlying mechanism of performance for this event, and successfully develop a standardized protocol that addresses it. As some in the sport get this done, we'll see more sprinters, male and female, running major times on a more frequent and more consistent basis as their training programs empower them to have a greater level of controllability over their performance level.
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Physiologically, the 100m dash is an in fact, an --endurance-- event

Physiologically, the 100m dash is an in fact, an --endurance-- event. Even the fastest sprinters in the world fail to hold their maximum velocity for more than 10 - 20 meters of the race. The person who slows down the least after reaching his/her maximum velocity is the person who has the highest level of performance. Being aerobically fit at --very-- high velocities is the underlying mechanism of performance for this event and the pathway to further world records.
A positive trend in sprinting is the gradually more consistent move toward the necessary long, high velocity training of the long sprinter being applied toward running the 100 meter dash event.
Tyson Gay and Usain Bolt have run the fastest 100m times in the world so far this year. These performances, like last year, were preceded by relatively fast times run at 400m, demonstrating a relatively high aerobic fitness level at high velocities.

Usain Bolt 400m in Feb 2007 = 45.28
2009 = 45.54
2010 = 45.87
Tyson Gay 400m in 2009 = 45.57
2010 = 44.89
Tyson Gay, after defeating Usain Bolt head to head, last week ran 9.78 into a head wind.
His personal best is the American Record at 9.69. Had his 9.78 performance been with an aiding wind of 1 - 2 meters per second, it may have put him in the same ballpark of Usain Bolt's world record at 9.58.

"Current developments in the training of 400m sprinters showed that aerobic training had a positive effect on competition performance."
D. Wallner, et al
Interdependence Of Aerobic And Anaerobic Performance And Its Consequences For Training In Sprinters And Endurance-Trained Runners
Journal of Sports Sciences.....Volume 17 #7....1999....page 551

".....there have been relatively few investigations of the effects of sprint training on mitochondrial enzymes or aerobic power in humans...."

"The significant increases in Vo2max.....were somewhat unexpected....Changes of this magnitude are usually assciated with training programs involving several hours per week at sub-maximal intensity."
J.D. MacDougall,et al
Muscle Performance And Enzymatic Adapations To Sprint Interval Training
Journal Of Applied Physiology.....Volume 84 #6....June 1998...page 2141

"Denis et al [1992] have reported the ability to sustain supra-maximal work lasting 30 - 45 seconds was related more to muscle oxidative [aerobic] capacity than to glycolytic [anerobic] capacity."
B. Dawson, et al
Changes In Perfomrance Muscle Metabolites, Enzymes, And Fiber Types After Short Sprint Training
European Journal Of Applied Physiology & Occupational Therapy....Volume 78...1998...page 167

"Little data exist that specifically and accurately evaluate energy system contributions....Considerable information can be found that attempts to do so, but this data has generally been based on data in the 1970's that inappropriately used oxygen debt to quantify anaerobic energy release."

"The crossover to predominately aerobic energy system supply occured between 15 and 30 seconds for the 400, 800, and 1500 meter events."
"These results suggest that the relative contribution of the aerobic energy system during track running events is considerable and greater than traditionally thought."
M.R. Spencer, et al
Energy System Contribution During 200 To 1500 Meter Running In Highly Trained Athletes
Medicine & Science In Sports & Exercise....Volume 33 #1....January 2001....page 157

Sprint event lane assignment affects reaction time.....

"Loud sounds can decrease reaction time and increase force generated during voluntary contractions."

"Reaction time for the 100/110 m athletics events at the 2004 Olympics were obtained from International Association of Athletics Federations archives and binned by lane. Additionally, 12 untrained participants and four trained sprinters performed sprint starts from starting blocks modified to measure horizontal force."

"Runners closest to the starter at the Olympics had significantly lower reaction time than those further away. Mean reaction time for lane 1 (160 ms) was significantly lower than for lanes 2-8 (175 ± 5 ms), and reaction time for lane 2 was significantly lower than that for lane 7."

".....increasing "go" signal intensity from 80-100-120 decibel significantly decreased reaction time from 138 ± 30 to 128 ± 25 to 120 ± 20 ms, respectively."

"Peak force was not influenced by sound intensity.

"We suggest that procedures presently used to start the Olympic sprint events afford runners closer to the starter the advantage of hearing the "go" signal louder; consequently, they react sooner but not more strongly than their competitors."

"....it was surprising to find that at the 1996 Olympic Games, there appeared to be a relationship between lane assignment and reaction time, such that reaction time progressively increased from lanes 1 to 8..."

"According to OMEGA, the official time keepers of the Olympic Games, the "go" signal has been delivered through the speakers behind each runner since 1984 to avoid problems related to sound propagation. However, Lennart Julin and Dapena suggested that the discrepancies in reaction time in the 1996 data are consistent with delays related to the time required for sound to propagate from the starting pistol beside lanes 1 to 8, suggesting that the use of the loud gun remains problematic."

A.M. Brown, et al
"Go" Signal Intensity Influences the Sprint Start.
Medicine and Science in Sports and Exercise.....Volume 40 #6....June 2008.....page 1142-1148

The Mechanisms Of Fatigue
In The Human Brain & Nerve Fibers

---------- One
Has to do with the electrical activity of the brain cells and nerve fibers.

The pumps for sodium and potassium along the nerve fibers and brain cell membranes must be in high number, and require many mitochondria to supply energy for their function. Failure to have a high number of pumps, or enough mitochondria to supply energy, will result in a reduction of the ability of the brain cell, or nerve fiber, to conduct signals to muscle. Since you lose ever growing amounts of sodium and potassium as you proceed during a race, the in-ability [by a lack of pumps or pump activity] to recover them in large amounts eventually reduces the intensity of the activation signals to muscle, which results in reductions in force output by muscle, which in turn, causes the runner to slow.

---------- Two
Has to do with the incredibly basic reality that brain cells and nerve fibers function primarily on glucose and glycogen, as opposed to fat.

Though we have a few miles of nerve fibers and a relatively large brain, we can start to get low on brain/nerve glycogen stores during a race. This is why we have a liver, that basically functions as a gas tank for the brain. It stores glycogen, and when needed, releases that glycogen into the blood stream as glucose, where it travels to brain, nerve, and muscle [the liver can also convert fat to glucose, and release into the blood stream.....a process called gluco-neo-genesis].

As this blood glucose starts going lower, your perceived exertion will rise, which in other words, is the brain beginning the initial steps in the process of slowing you down.

---------- Three
Has to do with the substances brain cells use to communicate with one another [neuro-transmitters, neuro-modulators]. The reduction of dopamine, with elevated levels of serotonin.

Intensely focused, directed, cognitions [thoughts] result in reduction of the perception of fatigue. They accomplish this in part by affecting release of the brain neurotransmitter [chemical brain cells use to communicate] called glutamate, a neuro-modulator called dopamine, as well as a substance called mono-amine oxidase-A, which collectively result in reduction of the perception of fatigue.

Intensely focused, directed, cognitions are generally glutamate type neuro-transmission. Glutamate increases release of dopamine. Dopamine reduces fatigue perception.

When the race/workout begins, the increase in adrenalin (epinephrine) leads to an increase in brain serotonin. Serotonin can reduce glutamate and cause the B form of mono-amine oxidase to break down dopamine.....before it can have it's fatigue reducing effects. Thus it is important to enhance one's ability to maintain Attentional Focus because these cognitions can increase mono-amine oxidase A induced breakdown of serotonin, and maintain elevated dopamine levels. It also helps prevent focusing on fatigue which would consist of cognitions that produce higher levels of serotonin and mono-amine oxidase-B thus contributing to reduced drive/motivation, lethargy, and fatigue.

Inside The Brain During A Race

[Brain Cells, Attentional Focus, & Fatigue Tolerance]

You can run humans or animals to exhaustion, provide an electrical stimulus to dopamine releasing areas of the brain, and the human/animal will continue running as if there was never a fatigued state.

"Central fatigue, as documented by TMS occurs before complete exhaustion....."

J.Hollge, et al.
Central Fatigue In Sports And Daily Exercises: A Magnetic Stimulation Study
International Journal Of Sports Medicine.....Volume 18.....1997.....page 614 - 617

Attentional Focus & Running Performance -----
Attentional Focus is.....that which you choose to focus your attention on. The brain can only attend to a few things at one time. Thus the brain will attend to what you choose to focus it's attention on. To focus one's attention on the task of "pushing yourself" in running is to have intensely focused, directed, cognitions [thoughts]. Intensely focused, directed, cognitions [thoughts] "are" the production of brain substances that reduce the perception of fatigue. Purposely and controllably placing and maintaining Attentional Focus is a trainable skill. To establish controllability of performance and achieve self-mastery, one must master this skill.

"Attentional focus rather than anxiety per se seems to influence pain."

A.Arntz, P.de Jong
Anxiety, Attention And Pain
Journal of Psychosomatic Research.....Volume 37 #4.....May 1993.....page 423 - 431

"Attentional focus, which was manipulated within electrical stimulation, seemed to have a much stronger influence on pain responses than pharmacological manipulation, independent of epinephrine. It may be speculated that, although evidence was found for effects of epinephrine on pain, they may be overruled by effects of attention.

S.A.Janssen, A.Arntz, S.Bouts
Anxiety And Pain: Epinephrine-Induced Hyperalgesia And Attentional Influences
Pain.....Volume 76 #3.....June 1998.....page 309 - 316

Things Affecting Cognitive Control Of Fatigue ------
-- perceived control = perception of how much control over fatigue one may have
-- perceived self-efficacy = how effective, prepared, and skilled one is at handling fatigue
-- level of confidence in ability to tolerate anticipated levels of fatigue
-- negative/positive self statements that focus one's attention on or away from the task, and on or away from fatigue
-- past experience with fatigue and programming (psychological conditioning) about how one is suppose to respond
-- past levels of ego oriented competitive drive impacts "win at all costs" attitudes, thus fatigue tolerance behavior
-- cognitions of competitive anger have opposing effects on fatigue tolerance as do cognitions of self-preservation ["slow down"]

Brain Cells & Thoughts [cognitions] -----
Intensely focused, directed, cognitions [thoughts] result in reduction of the perception of fatigue. They accomplish this in part by affecting release of the brain neurotransmitter [chemical brain cells use to communicate] called glutamate, a neuro-modulator called dopamine, as well as a substance called mono-amine oxidase-A, which collectively result in reduction of the perception of fatigue.

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The basic brain physiology of Attentional Focus,...
--- **Good**.....focus one's attention on the race plan.....have positive, directed cognitions.....Glutamate increases dopamine.....mono-amine oxidase A breaks-down serotonin.....have high fatigue tolerance

--- **Bad**.....lose one's attention, mind focuses on negative aspects of race and/or race performance outcome.....have negative, wandering cognitions.....Serotonin reduces glutamate..... mono-amine oxidase B breaks down dopamine.....have low fatigue tolerance, reduced drive/motivation, lethargy, and fatigue

Brain Cell Impact On Running Velocity -----
Maintaining or increasing muscle force output during a race is dependent upon muscle fiber recruitment by the brain, which is something that is also affected by Attentional Focus. The number of muscle fibers one can recruit determines muscle power output, which determines running velocity. Attentionally focused Relaxation is the manner by which one can neurologically increase, as well as insure the dis-inhibition of muscle fiber recruitment, and enhance muscle power production.

"Research suggests athletes are unable to maintain maximal firing frequencies for the full duration of, for example, a 100m sprint. Fatigue after a single training session may also have a neural manifestation with some athletes unable to voluntarily fully activate muscle or experiencing stretch reflex inhibition after heavy training. This may occur in conjunction with muscle damage."
A.Ross, M. Leveritt, S.Riek
Neural Influences On Sprint Running: Training Adaptations And Acute Responses
Sports Medicine.....Volume 31 #6.....2001.....page 409 - 425

Training The Brain: Cerebral Training Of Attentional Focus ------

1. during fast training sessions, focus on "feeling" the pace as comfortable to maintain

2. follow a scripted cognitive race plan focusing on task related/associative cognitions and task oriented process goals

3. stress inoculate yourself by use of visualizations, focusing on feeling levels of fatigue you expect during the race/workout

---

"Positive affect (positive thoughts/emotions) systematically influences performance on many cognitive tasks. A new neuropsychological theory is proposed that accounts for many of these effects by assuming that positive affect is associated with increased brain dopamine levels."

F.G.Ashby, A.M.Isen, A.U.Turken
A Neuropsychological Theory Of Positive Affect And Its Influence On Cognition
Psychological Review.....Volume 106 #3.....July 1999.....page 529 - 550

"The causes of fatigue during muscular exercise include factors that reside in the brain (central mechanisms)....."
"Central fatigue is largely unexplored, but there is increasing evidence that increased brain serotonin (5-HT) can lead to central (mental) fatigue, thereby causing a deterioration in sport and exercise performance."

J.M.Davis
Central And Peripheral Factors In Fatigue
Journal of Sports Sciences.....Summer 1995.....page S49 - 53

"There is an increasing interest in the mechanisms behind central fatigue..."
"When the 5-HT [serotonin] level was elevated in this way the performance was impaired in both rats and human subjects, and in accordance with this a decrease in the 5-HT level caused an improvement in running performance...."

E. Blomstrand
Amino Acids And Central Fatigue
Amino Acids.....Volume 20 #1....2001....page 25 - 34

"These results suggest a relation between cerebral changes in neurotransmitters and excitatory amino acids, such as glutamate and GABA, and central fatigue."
C.Y..Guezennec, et al.
Effects Of Prolonged Exercise On Brain Ammonia And Amino Acids
International Journal of Sports Medicine...Volume 19 #5.....July 1998....page 323 - 327

".....it seems very likely that a decrease in motor cortex excitability is at least in part involved in the mechanisms leading to a loss of force."
".....glutamatergic agents as well as dopaminergic ....are also believed to affect motor cortex neurons...."
"Thus, reduction of ICF indicates decreased motor cortex excitability upstream from the motor cortex output neurons."
"...reduced Intra-cortical Facilitation by double-pulse TMS reflects central fatigue specifically for the part of the motor cortex involved in the task."
"...it was discussed that the mechanisms representing fatigue mainly originate upstream from the spinal level."

Frithjof Tergau, et al.
Motor Cortex Fatigue In Sports Measured By Transcranial Magnetic Double Stimulation
Medicine & Science In Sports & Exercise.....Volume 32 #11.....2000.....page 1942 – 1948

"Substantial evidence supports an important role for the excitatory neurotransmitter L-glutamate as a modulator of dopamine release in the central nervous system. All of the established glutamate receptor subtypes identified to date have been implicated in the regulation of dopamine release. It appears that glutamate can exert both facilitatory and inhibitory control over dopamine release and that this may be both phasic and tonic in nature."

P.S. Whitton
Glutamatergic Control Over Brain Dopamine Release In Vivo And In Vitro
Neuroscience & Biobehavioral Reviews.....Volume 21 #4.....July 1997.....page 481 -488

"Specifically, whereas stress-induced dopamine release in the neostriatum is mediated by an action of glutamate on the dopamine cell body, stress-induced dopamine synthesis in the neostriatum is mediated by an action of glutamate on the dopamine nerve terminal."

JM.Finlay, MJ Zigmond
The Effects Of Stress On Central Dopaminergic Neurons: Possible Clinical Implications.
Neurochemical Research.....Volume 22 #11.....November 1997.....page 1387 – 1394

"Changes in brain monoamine metabolism may be involved in the mechanisms underlying the clinically observed psychological effects of physical exercise."

M.Elam, TH.Svensson, P. Thoren
Brain Monoamine Metabolism Is Altered In Rats Following Spontaneous, Long-Distance Running
Acta Physiologica Scandinavica.....Volume130 #2.....June 1987.....page 313 - 316

"Interactions between excitatory amino acid (EAA) and dopamine (DA) pathways in the basal ganglia have been known for some time to contribute importantly to the generation of motor behaviors. In particular, the role played by ionotropic glutamate receptors (iGluRs) in such interactions and in the production of locomotion has received considerable attention, particularly in brain areas such as the ventral tegmental area (VTA) where EAA afferants are known to modulate the activity of DA neurons and the nucleus accumbens (NAcc) where descending EAA projections and ascending DA mesencephalic projections come in close apposition to each other and co-innervate intrinsic neurons projecting to motor output regions."

P. Vezina, JH. Kim
Metabotropic Glutamate Receptors And The Generation Of Locomotor Activity: Interactions With Midbrain Dopamine
Neuroscience & Biobehavioral Reviews.....Volume 23 #4.....March 1999.....page 577 - 89

"Running was associated with a relative increase of glucose uptake in the.....pre-motor cortex and the cerebellar vermis."
"Activitiy of the primary sensori-motor cortex was higher in the...[leg motor area], than the...[thorax and arm]."

M.Tashiro, et al.
F-FDG PET Mapping Of Regional Brain Activity In Runners
Journal Of Sports Medicine & Physical Fitness.....Volume 41 #1.....2001

"Recent in vivo (13)C nuclear magnetic resonance (NMR) neurochemical studies have established a quantitative coupling between the rates of glucose oxidation and glutamate neurotransmitter flux in rats and humans..."
"...70%-80% of brain energy consumption is devoted to the same glutamate/glutamine neurotransmitter signaling as are the small percentages stimulated by tasks."

R.G. Shulman
Functional Imaging Studies: Linking Mind And Basic Neuroscience
American Journal of Psychiatry.....Volume 158 #1.....January 2001.....page 11 – 20

"These results suggest that locomotor activity increases....the excitatory influence of the corticostriatal glutamatergic system"

I.Liste, et,al.
Locomotor-Activity-Induced Changes In Striatal Levels Of Preprotachykinin And Preproenkephalin mRNA. Regulation By The Dopaminergic And Glutamatergic Systems
Brain Research Molecular Brain Research....Volume 70 #1.....June 1999.....page 74 - 83

".....studies have proposed that motor neurons innervating more active muscle fibers have higher oxidative enzyme activity.....than those innervating less active muscle fibers."

Brain Research Bulletin.....Volume 43 #2 1997

"Formation and survival of new neurons.....can be substantially increased by the provision of an enriched environment or by increased locomotor activity".
"Direct stimulation of patients' own neural stem cells through.....behavioral manipulation might offer scope for greater repair...."

R.J.E. Armstrong, R.A.Baker.....October 2001
The Lancet....Volume 358.....October 6, 2001.....page1174 - 1176

Major Mechanisms Of Optimal Strength & Power

Strength

-- brain & nervous system **recruitment** of muscle fibers
-- increase ability of brain & nervous system to make muscle produce large amount of force

Power

-- brain & nervous system **recruitment rate** of muscle fibers
-- increase ability of brain & nervous system to make muscle produce large amount of force….quickly

Mechanisms Of Developing Strength & Power

Muscles don't move without being told to do so.
To be told to do so, they have to be sent an electrical signal.
This signal tells them how much force to produce and how quickly to produce it.
The brain sends these signals down its transmission lines [ie. nerves] out to the muscles.

The mechanisms of performance in our sport are conceptually contained in the following questions;
1. **How much** force can you produce [Strength]
2. **How quickly** can you produce a high level of force [Power]
3. **How long** can you keep that going [Endurance]

Strength…..
How much force can you produce.

The more force you can produce while your foot is on the ground during the running stride, the faster you can run.
Stimulus = use heavy weight, very few reps, very few sets
[definition of "heavy weight" = weight you can't lift more than 2 to 3 reps consecutively]

Power……
How quickly can you produce a high level of force.
During the running stride, the foot is on the ground for only a short period of time. You need to be able to produce a high level of force during the short period of time that the foot is on the ground. The rate of force production is kind of important in our sport. The rate of force production increases with the rate of electrical signals from the brain, down the transmission lines [nerves], and to the muscles.

Stimulus = use lite weight, high velocity lifting [during the "up" motion], very few reps, very few sets
[definition "lite weight" = about 30% of what you can lift no more than 2 to 3 reps consecutively]

Real strength training….
very high weight, very low reps and sets, stimulus forces high recruitment of muscle fibers by the brain and nervous system. Real strength is about the brain and nervous system, -not- muscle mass. That's the mechanism by which a guy at the 1996 Olympic Games set a world record in the clean and jerk…..nicknamed "pocket Hercules" due to weighing only 140 pounds he lifted 412 pounds off the floor and brought it to his chest, then pressed it over his head.
Real strength is about the brain and nervous system, -not- muscle mass. Several sprinters on the planet, weighing the 140 - 150 pounds, about the same as middle distance runners but running 9.7 - 9.9 for 100 meters. Power output is about the brain and nervous system, not muscle mass. One could turn on "Good Morning America" or the "Today Show" a few years ago when Shaolin monks from China were touring the U.S.. One of them weighing 160 - 180 pounds did a hand stand using only his index fingers, not only supporting his body weight but maintaining his balance with no help as well. Strength and power are about the brain and nervous system, not muscle mass.

Strength via the brain and nervous system.
If you train it you will have it.
If you don't, you won't.
Focus on brain and nerve -not- muscle mass.
Biggest is not always strongest.

The major proteins that your training program needs to cause production of, to a very high level for high level performance.....
1 --- Proteins involved in synaptogenesis [production of connections between brain cells to aide in synchronization of signals to muscle for muscle fiber force output and rate of force production]

2 --- faster rather than slower forms of sodium/potassium/chloride/calcium pumps and channels along brain cell, nerve fiber, and muscle fiber membranes.

Most of these proteins have multiple iso-forms specific to a given velocity of function.
Thus your training program needs to be designed in a manner that.....
1 --- causes production of the right proteins, the ones specific to the velocity related to your goal performance level
2 --- avoids inducing production of high levels of perhaps slower functioning proteins

This is what applied Sport Sciences looks like.

All events in track and field/road running have something to do with how much force you can produce, and how quickly you can produce it. This program addresses the mechanisms of improving both the amount of force one can produce, and how quickly one can produce it.

".....an increased 'neural drive' to the muscle fibers contributes to the training induced increase in maximal contractile force, even in the absence of increases in muscle size."

P.Aagaard, et. al.
"Neural Adaptation To Resistance Training: Changes In Evoked V-wave And H-reflex Responses
Journal Of Applied Physiology.....Volume 92.....June 2002.....page 2309

The Training Stimulus: Recruitment -----
To increase recruitment, the main focus is to work with heavy weight.

Moving heavy weight requires large amounts of force to be produced. The greater the requirement for force production, the greater the stimulus for the nervous system to improve its ability to recruit large numbers of muscle fibers. Extremely few repetitions are needed to provide a potent training stimulus (ie. a cumulative total of 3 repetitions per exercise, for the entire training session).

The Training Stimulus: Recruitment Rate -----
To increase recruitment rate, the main focus is to work with 30% of max weight, at maximal velocity. Moving at maximal velocity requires large amounts of force to be produced at a high rate. The greater the requirement for the rate of force production, the greater the stimulus for the nervous system to improve its ability to recruit large numbers of muscle fibers quickly.

Extremely few repetitions are needed to provide a potent training stimulus (ie. a total of 3 repetitions per exercise, for the entire training session).

Making Progressions -----
If the training stimulus remains the same over a long period of time, no further adaptations to training will occur, and one's improvement in strength will level off and plateau. One must have, built into the training program, a protocol for making progressions onto higher training stimuli [higher weight].

".....explosive-strength training, may lead to specific neural adaptations, such as the increased rate of activation of motor units....."
L.Paavolainen.....1999
Explosive-Strength Training Improves 5-km Running Time By Improving Running Economy And Muscle Power
Journal Of Applied Physiology.....Volume 86 #5.....1999.....page 1527

"A variable considered when designing programs to optimize athletic performance is training velocity."

"It may be that irrespective of load and limb velocity, the repeated intent to move a.....load as rapidly as possible might be an important stimulus for functional high velocity adaptation. "

"Furthermore combination training that incorporates same session sport specific training with either a heavy load or a mixed training load approach might provide an optimal strategy for promoting intramuscular and intermuscular co-ordination and improving functional performance."

JB.Cronin, et.al.
Is Velocity-Specific Strength Training Important In Improving Functional Performance?.
Journal of Sports Medicine & Physical Fitness.....Volume 42 #3.....September 2002....page 267 - 273

"There is a prevalent belief that at least 3 sets of each exercise are required to elicit optimal increases in strength and hypertrophy."

"there is little scientific evidence, and no theoretical physiological basis, to suggest that a greater volume of exercise elicits greater increases in strength or hypertrophy. This information may represent an important practical application of time-efficient, low-volume exercise."
RN.Carpinelli, RM Otto
Strength Training: Single Versus Multiple Sets
Sports MedIcine.....June 1999.....Volume 27 #6....page 409 - 416
Sports Medicine....August 1998...Volume 26 #2.....page 73 - 84

"High-load activities, such as resistance training, appear to provide the best stimulus for enhancing bone mineral;....."
RD. Lewis, CM. Modlesky
Nutrition, Physical Activity, And Bone Health In Women
International Journal of Sport Nutrition.....Volume 8 #3.....September 1998.....page 250 - 284

It was concluded that improvement in strength may be accounted for by neural factors during the course of very intensive strength training.

K. Hakkinen, M. Alen, P.V.Komi
Changes In Isometric Force- And Relaxation-Time, Electromyographic And Muscle Fibre Characteristics Of Human Skeletal Muscle During Strength Training And Detraining.
Acta Physiologica Scandinavica.....Volume125 #4.....December 1985.....page 573 - 585

"Since not only maximal strength but the ability of the leg extensor muscles to develop force rapidly are both important performance characteristics contribu several tasks of daily life such as climbing stairs, walking, or even prevention of falls and/or tips, this should taken into consideration when constructing s training programs for both middle-aged and older men and women."

"In order to induce increases in explosive strength and power capacities, heavy resistance training also in older people should be combined with power type of s training performed with lower-load exercises but emphasizing higher movement velocities of the exercises performed."

K.Hakkinen, et.al.
Effects Of Heavy Resistance/Power Training On Maximal Strength, Muscle Morphology, And Hormonal Response Patterns In 60-75-Year-Old Men & Women
Canadian Journal Of Applied Physiology
Volume 27 #3.....June 2002.....page 213

"...much of the decline in functional capacity with advancing age in physically-inactive people is due to progressive disuse atrophy rather than the aging process pe
Sport Science Exchange
Roundtable, Winter 1992
Gatorade Sport Science Institute

"When old adults participate in a strength-training program with heavy loads, they experience an increase in muscle strength and an improvement in the steadi submaximal isometric contractions."

"The increase in maximal voluntary contraction strength was greater for the heavy-load group ....."

DH. Laidlaw, et al.
Strength Training Improves The Steadiness Of Slow Lengthening Contractions Performed By Old Adults
Journal of Applied Physiology.....Volume 87 #5.....November 1999.....page1786 - 1795

"Dynamic and high-magnitude loading, which elicits a high strain rate in bones, is known to be effective for anabolic loading."

".....high-impact exercise is considered to be very beneficial for bones."

Y.Umemura, N.Sogo, A.Honda
Effects Of Intervals Between Jumps Or Bouts On Osteogenic Response To Loading
Journal Of Applied Physiology.....Volume 93.....2002.....page 1345

".....increasing intensity of aerobic exercise.....and adding weight training to the exercise program aer among the most effective strategies to reduce the risk of cc heart disease....."

M.Tamasescu, et.al.
Exercise Type And Intensity In Relation To Coronary Heart Disease In Men
Journal Of American Medical Association.....October 23/30, 2002.....Volume 286 #16.....page 2000

"Formation and survival of new neurons.....can be substantially increased by the provision of an enriched environment or by increased locomotor activity (exercis
"Direct stimulation of patient's own neural stem cells through.....behavioral manipulation might offer scope for greater repair....."

R.J.E.Armstrong, R.A.Baker.....October 2001
The Lancet.....Volume 358.....October 6, 2001.....page 1174 - 1176

"We conclude that human runners reach faster top speeds not by repositioning their limbs more rapidly in the air, but by applying greater support forces to the grou

Faster Top Running Speeds Are Achieved With Greater Ground Forces Not More Rapid Leg Movements
Journal Of Applied Physiology
Volume 89.....2000 pg. 1991-1999

"Maximum running speed depends upon the ability of the runner to generate force quickly, that is, in about 100ms, almost the length of time that the foot is ground.....Thus, unless strength training trains the ability of the legs to generate forces in a very short time, that is, with maximum explosive force, slower t would not assist in the development of
running speed. Strength training for sprinters should emphasize the most rapid development of leg forces."

W.Young , B.Mclean. J.Ardanga.....1995
Relationship Between Strength Qualities And Sprinting Performance
Journal Of Sports Medicine And Physical Fitness.....Volume 35.....1995

"We conclude that human runners reach faster top speeds not by repositioning their limbs more rapidly in the air, but by applying greater support forces to the grou
Faster Top Running Speeds Are Achieved With Greater Ground Forces Not More Rapid Leg Movements
Journal Of Applied Physiology
Volume 89.....2000 pg. 1991-1999

Stay Anabolic

Your body's cells must stay in an anabolic state in order to optimize progress

Physics	Physics Of Fitness Improvement
A body, Set in motion Will stay in motion Unless acted upon by a force	A fitness level That starts improving Will keep improving Unless acted upon by something that stops it

Almost any type of training should result in fitness improvement unless.....

1 --- You fail to make periodic increases in velocity of your intervals/road runs

Or.....

2 --- You fail to make periodic increases in duration of your intervals

Or.....

3 --- You fail to stay anabolic

In the ETG training program, if fitness stops improving, or is very slow in improving, the first place to look is at the intensity...."how hard you are running". Due to the high frequency of relatively high velocity running, you should be running at velocities that are "comfortable", and require only a moderate effort to maintain. The 10m sprints should be the only running that should be anything approaching even a near maximum effort.

The ETG training program has high intensity built into it, so avoid adding more....by "pushing yourself" hard in the workouts.

The easiest way to slow or stall your progress in this training program is to "push hard" in any given workout. Your body's cells must stay in an anabolic state if progress is to be optimized. This cannot be accomplished by either "pushing hard".....or.....by anabolic steroid/drug use.....both of which cause immune system suppression, as well as suppression of your body's own anabolic hormones.

Velocity is built into the program, since everything is run at Goal Pace or faster instead of doing slower mile repeats, etc.....so you should never allow yourself to feel like you're not "pushing hard". You should never feel exhausted or wiped out after these workouts.

ETG Training Program Principles

"Exercise bouts that maximize anabolic hormonal response and/or minimize the catabolic hormonal response promote greater long-term adaptations....."

"Similarly, exercise bouts that limit the anabolic hormonal response and/or exacerbate the catabolic hormonal response suppress adaptations....."

D.A.Judelson, et al
Effect of hydration state on resistance exercise-induced endocrine markers of anabolism, catabolism, and metabolism
Journal Of Applied Physiology.....Volume 105 #3....September 2008....page 815 - 824

"Although there is obviously a training stimulus beyond which any additional load or stimulus does not induce further desired adaptation, the control mechanisms for the adaptive process require regular periods of overload....."

"However, an imbalance between training frequency and subsequent recovery may give rise to an accumulation of training stress that results in a suboptimal adaptation response in skeletal muscle, termed overtraining. Therefore, the frequency of overload is important in defining the training stimulus, with adequate recovery required to ensure optimal muscle adaptation."

V.Coffey, et al
Effect of High-Frequency Resistance Exercise on Adaptive Responses in Skeletal Muscle
Medicine & Science in Sports & Exercise.....Volume 39 #12.....December 2007.....page 2135-2144
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ETG Training Program Principles

There are --2-- separate consequences of "Over-training"
1. The one where you incur a running injury

2. The one where your body enters into the physiological state where your anabolic system [a.k.a tissue building] is suppressed to some significant degree and thus your ability to acquire training adaptations and move forward in fitness level is suppressed. This can be referred to generally as **"Physiological Over-training",** or being in an "over-trained state".

Physiological over-training, or being in an "over-trained state" is something one can measure. It often comes in the form of cortisol [stress hormone} production, which suppresses anabolic [tissue building] hormones and other hormone production [ie. testosterone, estrogen, growth hormone, thyroid hormone, and overall adrenal gland function], and competes with anabolic hormones for binding sites on tissues such as muscle. It reduces protein production, such as muscle protein, blood proteins [ie. Red Blood Cells, Immune system cells, etc]. This is a state where even though you are -not- injured, and even though you are training fully, your fitness level does -not- move forward, and may even reverse.

Again, this is a measurable state. You can measure cortisol levels. You can measure red blood cell and EPO production ability. You can measure muscle protein synthesis. You can measure immune system activity. You can measure adrenal gland function. You can measure certain aspects of brain activity.

Regardless of what type of training program you believe in and follow [mileage oriented, or velocity oriented], its helpful if one's body can stay in an anabolic state such that it can adapt to one's training, thus moving forward in fitness, leading to increases in performance level.

That’s major challenge and the major objective when designing any training program.

If your body can't adapt, you can't move forward in fitness level. If your body can't move forward in fitness level, it can't move forward in performance level.

Much of sport is about moving forward in performance.

Pulling Up The Plant
To See How The Roots Are Doing

[by Marshall Burt]

Something I hear on occasion is that....."I tried velocity oriented training and I got faster at the shorter distances, but had trouble running my longer distances, so I went back to training slower and longer".

You get the most fit at the paces you train on most.

But you also get the most fit at the distances you train on most.

If the furthest you've progressed in your half-marathon goal pace workout is 7 miles run successfully at goal pace, then you'll have a pretty good fitness level for the 7 miles - 7.5 mile distance. If after running 7 miles at your goal pace, you decide to jump into a half-marathon race and attempt to run at goal pace for the entire race, you may be disappointed. Instead of jumping into a race, if you suddenly decide to go for a 12 - 15 mile run at a relatively fast pace for you, you may be disappointed with that also. In short, if you pull up the plant to see how the roots are doing, you may be setting yourself up for disappointment.

You're the most fit at 7 miles because that's where your training has been. Your training has not been at the half-marathon distance, or at a 12 - 15 mile run.

If the furthest you've progressed in your 5k goal pace workout is 1.5 miles, then you'll have a pretty good fitness level for the 1.5 miles - 1.75 mile distance. If after running 1.5 mile repetitions at your goal pace, you decide to jump into a 5k race and attempt to run at goal pace for the entire race, you may be disappointed. You're the most fit at 1.5 miles because that's where your training has been. Your training has not been at the 5k distance.

A velocity oriented training program comes at your race distance from below it, working upward. Therefore, you won't be very fit at distances above where you've been in your training. Why? Because you haven't done that training yet. Once you make the training progressions to that level you'll have that fitness. You won't have that fitness <u>before</u> you've done the training.

A traditional mileage oriented training program comes at your race distance from above the race distance and progresses downward to the race distance by increasing the training velocity. Relatively little training is done at goal pace and thus, you'll have little fitness at goal pace. You'll have lots of fitness at slower paces for longer distances. Why? Because that's where your training happens to be.

Patience must rule the day in a velocity oriented training program.

Arguably, in the context of "jumping into races" or trying out long runs well before you've made the progressions to being in the ballpark of your race distance, a velocity oriented training program is not for those who fit the stereotype of the overly-competitive American who must race as often as possible, or for the curious who get excited after making quick progress and want to experiment to see what they can do with their new found fitness.

One cannot pull up the plant to see how the roots are doing.

Replace Altitude Training

By Marshall Burt

Still a lot of American distance runners doing the Altitude Training thing. I'm hoping it is entering its final years of popularity.

I have never been a believer, fan, or advocate of altitude training. Whether that term means traditional altitude training or the "live high train low" method. None the less, one day back in the early to mid-1990's I was sitting in a lecture room at the University Of Texas. In the room full of exercise physiologists were some of the top human performance researchers in the world [they were working at Univ of Texas Kinesiology dept]. They had invited a researcher in the Dallas area to give a lecture about his work on altitude training. He had just begun work on what he called "live high, train low".

He presented his data which included conclusions attributing a large chunk of the improvement in fitness and performance to the expansion of red blood cells. A couple of the Univ of Texas researchers challenged that assertion. They challenged it since in years past, they had done studies where they infused red blood cells into people and measured the amount of improvement in related areas of fitness and performance. So they knew to what extent either infusion or altitude related increases in red blood cells affected those things. They asserted that much of the improvement in fitness and performance measures that researcher from Dallas had attributed to the expansion of red blood cells could not be accounted for by the expansion of red blood cells.

That inherently meant that something else was the cause.

I set the subject aside in my mind for many years since altitude training never seemed like a physiologically logical training method to me anyway.

In the years that followed I came across research identifying mechanisms by which a number of training stimuli at sea level lead to EPO production and red blood cell expansion. This along with studies that suggested that the cardiovascular system is not the main limiting factor on distance running performance.

Wasn't until some time in 2011 that I returned to the subject of there being a cause other than red blood cell expansion for improvements in various aspects of fitness and performance with altitude training. It occurred to me that whether runners are doing traditional altitude training or "live high train low", in being in or near mountains, they all have in common, road runs of varying lengths that are all done on courses that inherently have a relatively high frequency of long hills of relatively significant grades. Something they don't normally, intentionally train on with the same or similar frequency during their normal lives at sea level.

Thus one has this confounding variable in any altitude training study even for people doing the "live high train low" method since being in or near mountains inherently alters the nature of the courses one will regularly train on. Physiologically the main area of difference isn't the altitude, its the size, length, and frequency of the hills.

In the late 1980's, while coaching at the high school level I had designed a 4 and 8 mile course that wound and looped through a "up-scale" neighborhood near the high school because the hills there were quite lengthy [400 - 800m], steep, and frequent. The athletes and the major aspects of the training being the same, weekly or more frequent runs [fartleks] on these courses was the only significant difference. This allowed me to pick up on substantial increases in fitness from this type of training. This reinforced an experience my freshman year in college running a weekly 9 mile fartlek workout on a course that included a very hilly neighborhood near the college.

I believe we live in an era where we understand enough about the physiological aspects of altitude training that we can, with some degree of confidence, abandon the concept.

One can argue that every training program in our sport should include a base building workout done all-year-around, on a frequency of at least twice per month. That workout consisting of a road run, perhaps in fartlek form where the surges in pace are lengthy [ie. 400 - 800m or longer] on a course where the hills are long, steep, and frequent. If necessary it may be necessary to design a loop course where the loop will be repeated over and over if the number of lengthy hills in one's area are few or far between.

One can train at a higher velocity at sea level compared to altitude, even in the "live high train low" method [since "low" often doesn't mean sea level]. Thus, combining that benefit with intentionally seeking out and designing a road course around the superior types of hills one gets when running on or near a mountain at altitude, on can move away from and far beyond the Altitude Training era in our sport.

Like the subject of so-called "Performance Enhancing Drugs" [a.k.a. performance retarding drugs] Altitude Training is a subject matter that has long outlasted its physiological worthiness, efficacy, and usefulness in distance events performance.

"In spite of accumulating evidence that altitude training affords no advantage over sea level training, many coaches and athletes believe that it can enhance sea level performance for any athlete, whether endurance or power is the focus in their particular sport."

"The issue of whether altitude training enhances sea level performance remains a controversial subject."

L.A. Wolski, et al
Altitude Training For Improvements In Sea Level Performance
Sports Medicine.....Volume 22 #4....October 1996...page 251

Its not about red blood cells.....

“Scientifically speaking, altitude training has no effect,”

“Neither the ability to cycle far or the ability to sprint is improved on average.”

[Dr. Nikolai Nordsborg, University of Copenhagen]

".....based off of a study using elite cyclists to assess Live High Train Low at a training center in the Jura mountains of France."

"Unlike the vast majority of researchers who had investigated Live High Train Low , this team used a double-blind design, which is the gold standard for scientific research. It had been difficult to use a double-blind design in studies using natural altitude: athletes knew whether they were living in the mountains or at sea level, and so did researchers."

"Only the lead researcher knew which athletes were assigned where; even the on-the-ground staff did not know, eliminating bias at another level."

"The cyclists lived in the treatments for four weeks, during which time they were told to train normally, outside, at the natural 1,135 meters of elevation."

".....athletes living the Live High Train Low lifestyle did not increase their red blood cell mass or the erythropoietin levels....and that group did not see greater improvement in the tests and time trials.....than their control group counterparts."

[Dr. Christoph Siebenmann, Carsten Lundby of the University of Zurich]
[Dr. Nikolai Nordsborg of the University of Copenhagen]

".....human erythropoietin administration...."

".....paradoxically, its effects are opposite of those of endurance training, namely a change in red cell mass without an increase in the total blood volume. Thus use of.....erythropoietin as a performance enhancing agent is dangerous, particularly in the less fit athlete, and probably of little benefit in the highly conditioned one."

J.L.Spivak
Erythropoietin Use And Abuse: When Physiology And Pharmacology Collide
Advances In Experimental Medicine & Biology....Volume 502....2001....page 207 - 224

"It has been shown that, in elite athletes, hematocrit does not correlate with performance."

A.Legaz, J.J. Gonzales, et al
Hematocrit > 50%: An Accurate Index For Prevention and Control Of Doping In Athletes?
University Of Zaragoza
Spanish Olympic Committee

Its not about red blood cells.....

[effects of EPO/blood doping in the Tour de France].....

"Evidently, the inconclusive research findings as well as our own observations oppose popular beliefs as well as opinions of the anti-doping agencies about the ergogenic effects of Hb doping aids for cyclists. This disparity made us insecure. What if aforementioned arguments and observations are valid and those of the anti–doping authorities are not?"

"We summarized the main statistical findings of our study....The analyses offered no support for the outlier hypothesis, since none of the victors in the 1990 – 2008 periods demonstrated abnormal peaks in their time performances compared to the performances of their counterparts in foregoing periods."
H.Lodewijkx, B.Brouwer
Epo Epidemic in Professional Cycling
Research Quarterly for Excercise and Sport.....Volume 82 #4.....2011....page 740 - 754

".....asked questions about the reliability of urine testing for recombinant human Epo (rHuEpo).
"The Epo test that has been adopted in World Anti-Doping Agency (WADA)-accredited laboratories is based on isoelectric focusing."

"Several problems were already identified in a WADA-commissioned report in 2003."

"Epo test results are clearly not always interpreted identically. The use of the software processing has been criticized."

"The American WADA-accredited laboratory has performed the direct Epo test on more than 2,600 samples, only nine of them were found to be positive. The low numbers of athletes caught by the test are somewhat contradictory to the overall increase of mean hematocrit values since rHuEpo became available."

"....the high number of false-negative results imply a risk that athletes doping with Epo will avoid detection....."
J.R. Delanghe1, M.J. Joyner
Testing for recombinant human erythropoietin
Journal Of Applied Physiology....Volume 105 #2.....August 2008.....page 395 - 396

"In their recent editorial on the disappointing disagreement between two World Anti-Doping Agency (WADA)-accredited laboratories evaluating samples for detecting recombinant human erythropoietin (Epo) in urine, Delanghe and Joyner concluded that blood-based indirect Epo tests offer an interesting alternative."

"This is ideally true, considering that the urine test is proven unreliable. However, indirect testing.....is a hard task to accomplish."

"Under ideal conditions laboratory tests are still intrinsically biased by a certain degree of preanalytical and analytical variability."

"In the athletic field, such biases are enormously amplified and hardly governable. Strenuous physical exercise, temperature, and humidity all have substantial influences on several hematological parameters."

"When left uncontrolled and unstandardized, all these variables would dramatically affect the reliability of indirect hematological testing to detect cheating."

Venke Skibeli…..
"Delanghe and Joyner claim that an improved regimen in anti-doping testing would be to introduce indirect testing of blood parameters known to be affected by EPO, and to establish blood profiles related to personalized acceptance limits. Indirect testing has previously been struggling with great inherent variations and has not proved more efficient in detecting EPO abuse than the direct analysis."
G. Lippi
Comments on Delanghe and Joyner's Editorial "Testing for recombinant human erythropoietin"
Letters to the editor Journal Of Applied Physiology

[one of several reasons why "weekly long runs" are --not-- superior to high intensity short stuff for building blood vessels in distance runners. And this is among the reasons why there are no "weekly long runs" in TheETG training program]

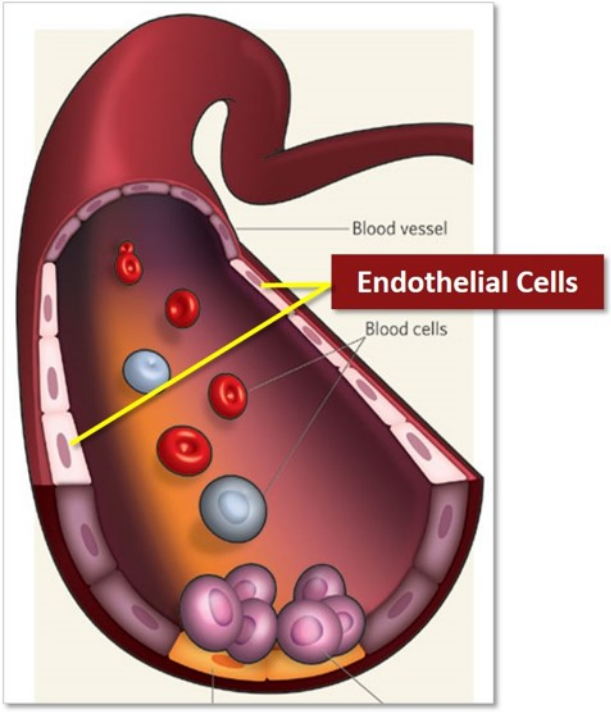
".....endothelial progenitor cells contribute to vascular repair process by differentiating into endothelial cells. This study investigates how high-intensity interval and moderate-intensity continuous exercise training affect circulating endothelial progenitor cell levels and endothelial progenitor cells functionality....."

"60 healthy sedentary males were randomized to engage in either HIT (3-minute intervals at 40 and 80 % VO2max for five repetitions) or MCT (sustained 60% VO2max) for 30 min/day, 5 days/week for 6 weeks, or to a control group that did not received exercise intervention."

"High intensity interval training is superior...."

"Moreover, high intensity interval training effectively enhances endothelial progenitor cell functionality and suppresses endothelial injury....."

Hsing-Hua Tsai, et al
High-intensity Interval training enhances mobilization/functionality of endothelial progenitor cells and depressed shedding of vascular endothelial cells undergoing hypoxia
European Journal of Applied Physiology -- Volume 116 #11 --December 2016 -- page 2375



Marathon Training In The 21rst Century

Go into your marathon race;
-- fit enough to run your fastest 10k
-- able to supply fluids early and throughout the race at a rate that matches sweat rate
-- and able to supply carbohydrate early and throughout the race at a rate that approaches carbohydrate [blood glucose] utilization

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"The athletes I talk to who are running the fast marathons, from 2:07 down to 2:05, aren't putting in the high mileage, but a lot of high intensity stuff, at 5:00 pace and lower. I tend to think that's what separates a lot of people in the marathon, just the level of comfort they have with the long runs."

Eric Mack...[2:12:42 marathon in 2000,]
Reported by Peter Gambaccini?..A Brief Chat With
Runner's World Daily News.....October 11, 2002....runnersworld.com

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"Runnersworld: "How specifically did the training change?"

Ian Syster:....."Less mileage, more quality. We run our long runs very hard. Someone is always pushing the pace. That's the key to the marathon, because if you can hang in there in practice when the pace is being pushed, you get to the point where that feels comfortable during the race."

Ian Syster [2:07:06 Marathoner in 2002]
A Brief Chat With.....Ian Syster by Dave Kuehls
Runnersworld.com.....June 24, 2002

"I believe that in order to run your best marathon, you have to, in the recent past, have run close to your best at five and 10,000 meters. Not necessarily within a couple of seconds, but if you've run 27:30 for 10,000 meters before, you better be able to run at least 27:45 or 27:50 prior to that marathon."

"You're going to need that sort of speed. I think the problem that we have had in recent years is that we've had some guys who've gone into the marathon with sub 28:00 times, but it was a year or two years before, and then they went into what they called 'marathon training' and lost that sort of speed. I think that's affected their ability to run a marathon. You have to periodically go back to the shorter distances to make sure you're keeping the speed."

Alberto Salazar [former World Record holder for the marathon]
reported by Peter Gambaccini.....A Brief Chat With
Runner's World Daily News.....November 15 2001.....Runnersworld.com

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Major Mechanisms of Marathon Performance;
--- Aerobic Energy Production
--- Glycogen Storage
--- Supplying fluids a at rate that matches sweat rate
--- Supply carbohydrate [glucose] at a rate that approaches carbohydrate [blood glucose] utilization

Aerobic Energy Production -----
Workouts should require relatively High Velocity Training for muscle fiber recruitment. You only see adaptations around active nerve/muscle fibers. The faster you run, the more will be the number of active fibers [The faster you run, the more force your nerve/muscles are required to produce. The more force that is required, the greater will be the number of active nerve/muscle fibers].

Endurance athletes need a high frequency and number of workouts that increase mitochondria [mitochondria produce energy [ATP] aerobically].

The more mitondria you have, the more energy [ATP] you can produce and the faster you can run]. Use intervals/fartleks to facilitate higher velocity work.....ATP demand can be kept high with high velocity runs or surges of 800 meters - 10,000 meters in duration.

"the purpose of this study was to compare the energetic and training factors that contribute to the marathon performance time of top-class .....versus high-level marathon runners."

"The high energy output seems to be the discriminating factor for top-class male marathon runners who trained at higher relative intensities."

V.L.Billat, et.al.....2001
Physical And Training Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise.....Volume 33 #12.....2001.....page 2089 - 2097

"differences in Vo2max were small or nonexistent between world class Kenyans and slower Scandinavians, but.....energy metabolism at high intensities were diffffent"

V.L.Billat, et.al.....2001
Physical And Training Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise.....Volume 33 #12.....2001.....page 2089 - 2097

"We have previously shown that the superior endurance performance of African distance runners, compared with white runners, was due to their ability to sustain a higher percentage of Vo2max with increasing running distance."

"Of particular interest is that these superior performances may be due to a training-induced adaptation."

".....the white runners spent as little as (13%) of their total training volume performing high-intensity (>80% Vo2max) running which in all cases was significantly less than the African athletes (36%)."

June 1997.....J.A. Hawley, et al
Training Techniques To Improve Fatigue Resistance And Enhance Endurance Performance
Journal Of Sport Sciences.....Volume 15 #3....June 1997.....page 328 - 329

Background Information About ATP -----
The letters, "ATP", stand for Adenosine Tri-Phosphate. This consists of an Adenosine, linked by a chain (bonds) to 3 phosphates (hence the term... "Tri"-phoshate). Generally speaking, the energy that the nerve and muscle uses is contained in the chain (high energy bonds). Breaking the chain (high energy bonds) results in a microscopic explosion (release of energy). An enzyme called ATPase, breaks the bond which causes the explosion. The energy from the explosion is used to push something in nerves and muscles.

What Is ATP For.....In Nerves -----
Nerves conduct electrical signals from brain, to muscle, which causes the muscle to produce force. The nerves conduct these electrical signals by causing sodium and potassium to move into and out of the nerve fiber. At a microscopic level, along the covering (membrane) of nerves, there are small tunnels (called channels) that allow sodium and other particles to move into and out of the nerve fiber. Following each electrical signal that travels down the nerve fiber, the sodium and other particles must be moved back to their original positions, so that another signal can be sent. There are some pumps (called sodium/ potassium pumps) that are responsible for this process. The pumps are located in the membrane (covering) of the nerve. They grab the sodium.....turn .....and dump it outside the nerve. It does the opposite with potassium, dumping it inside the nerve.

Energy (ATP) is needed to cause the pumps turn. The frequency of which signals are able to travel down a nerve fiber determines the amount and velocity of force production by the muscle. This (power) is fairly important in track and field and road running events. The athlete's ability to provide high levels of ATP for the pumps, allows the pumps to function at high levels, resulting in maintaining high muscle force outputs.

Fatigue in the nerve precedes the fatigue in muscle.

Generally speaking, the muscle will produce force, if the nerve tells it to. Thus the nervous system reduces it's activation of muscle, prior to the muscle reaching a state of fatigue.

What Is ATP For.....In Muscle -----
At a microscopic level inside muscles, small arms (myosin) attach and pull on a set of pillars (actin), to produce muscular force. After pulling on the pillar, the arm must detach to reset itself, so it can attach and pull again. This cycling process occurs several times per arm, per muscle contraction. And there are several hundred arms per muscle fiber. Energy (ATP) is needed to push the arms back into the reset position, in between pulls on the pillar. As the runner gets low on ATP (state of fatigue), the number of arms that can attach and pull is reduced, thus muscle force output is reduced.

"Runners can be a bit wacky about mileage. Weekly mileage is simultaneously an illuminating and useless statistic. High weekly mileage has become shorthand for the level of seriousness and dedication of a runner, but it says nothing about the quality of the miles, nor does it accurately predict anyone's level of performance. In college, we came up with the term "Olympic Training Log Champion" for athletes who seemed more interested in having an impressive looking number at the end of the week rather than any particular training benefit."

excerpt from.....Steve Holman...."High Mileage Syndrome"
Runner's World Daily News.....January 31, 2002.....runnersworld.com
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"I usually do no more than 60 miles a week.....when I am building up my base....."

"I know there are many more runners that run many more miles....."

"I have not had any injury worries for several years and so I've found a formula that works, although the sessions I do are often quite intense. I'm a firm believer in speed related to endurance and not doing what Americans often call 'junk' miles."

Benard Lagat [3:26 1500m.....second fastest all time]
By Phil Munshill For the IAAF
Track & Field Writers Of America Newsletter.....Sept/October 2002

"Mileage", Glycogen Storage, & Glucose Transporters -----
Glycogen is a bunch of glucose molecules placed together by the enzyme glycogen synthase. Glucose Transporters are proteins located in the nerve/muscle fiber membranes that transport the glucose coming to the nerve/muscle from the blood stream, and transports it through the membrane to the inner part of the nerve/muscle.

"Before the marathon, I didn't break 100 (miles a week) training for it. I had the flu for a couple of weeks or so, and then before that I had tendinitis in the knee. It was the quads and the lower extremities that were tight and causing the knee pain...

In the marathon, I didn't want to push it early because I didn't have a 20-mile run in me yet. It's 26 miles. It's not rocket science. I just tried to be smart on the day."

Meb Keflezighi
["Keflezighi, headed to the Athens Olympics after finishing second to Alan Culpepper at the 2004 U.S. Men's Marathon Trials in 2:11:47"]

March 26, 2004
runnersworld.com
http://www.runnersworld.com/home/0,1300,1-0-0-ZNEWS,FF.html

"I definitely only ran like 75 to 85 a week. I incorporate tempo runs, long runs, track work, and easy days."

Heather Hanscom [ran her second marathon at the U.S. Olympic Trials April 3, 2004.....2:31.....6th place.....PR by 7 minutes]

November 2003.....Interview with Pat MacAdie www.fast-women.com

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Runner's World Daily: "Are you doing more mileage now than ever before? "

Jen Rhines: "No, I'm not running quite as much as I did when I trained for Chicago last year. I've tried to bring the average pace I do on my easy runs and on my long runs down a little bit. That works a little better for me. I've tried to focus on all quality and no junk miles. My highest week last year was like 117. Now I'm more like 95 to 100. It's better to keep a little snap in my legs rather than overdo it. "

Jen Rhines by Peter Gambaccini
http://runnersworld.com/home/0,1300,1-0-0-5593-1-0-,00.html
[Jen Rhines set a PR by 11 minutes to qualify for the 2004 U.S. Olympic team.....2:29:57]

"Being over 40 and from Illinois boosted Spangler's earnings to $11,500 for her 2 hours 32 mintes, 29 seconds of work. "

".....she gave birth 21 months ago and only got back into training in January 2003. "

"After years of injury, why is the older Spangler running so well and on fewer miles (60 - 70 compared to about 100 per week.....)."

[Jenny Spangler set American best masters time with 2:32 at Chicago marathon last October]

Speedplay - Good Luck, Good Bucks For Spangler
[By Mike Prizy.....Chicago Athlete.....Nov/Dec 2003]

"It can be observed that he [El Guerrouj] does not work large volumes, but there is a predominant high level of quality."

'They run by time, 20, 30, 40 minutes., but Salah Hissou never runs more than one hour of continuous running....."

[Hicham El Guerrouj = world record holder for the mile & 1500m]

[Salah Hissou = #5 all-time at 10,000 meters, 26:39]

The Training Of The Moroccan World Class Athletes
[Article on the British Track & Field governing body's website]
[slightly different version can be found at.....http://www.mariusbakken.com/tr_marroccan.htm]

The liver is responsible for supplying glucose [puts it into the blood stream, which in turn, goes to....] to the nervous system, and it can serve that function in two ways. It will breakdown the glycogen stored their and send it into the blood as glucose, where it can travel to the nervous system. It can also create Glucose from protein and/or fat through a process called gluco-neo-genesis. It has been established that the number of Glucose Transporters one has, determines the amount of glycogen that will be stored following a meal. And it is also well established that the amount of Glycogen one has stored, has a significant impact on performance. Generally, prolonged training runs or repeated high velocity intervals.....that deplete glycogen stores to some threshold level, are effective stimuli for increasing-maintaining Glucose Transporter levels.

This protein has a very high turnover rate. It takes only 3 to 4 days of going without a training stimulus [that increases or maintains Glucose Transporters] to begin to see detraining of this aspect of fitness [decrease of Glucose Transporters].

Thus the training stimulus must be applied every 3 - 4 days. This is why many runners generally feel that high mileage training programs are necessary for high level performance. Runners who engage in high mileage will automatically be engaging in extremely frequent workouts that substantially deplete glycogen levels.

Runners who engage in high mileage will have a decrease in their Glucose Transporters only when they decrease their mileage to a large degree, effectively decreasing the rate of training stimuli that increase or maintain Glucose Transporters. These runners may have tried a low mileage training program that had an insufficient --- "number or rate" --- of workouts that increase or maintain Glucose Transporter levels. Thus they erroneously conclude that it's the "mileage", rather than the specific insufficient --- "number or rate" --- of individual workouts, that "work best for them".

Prolonged training runs ---- or ---- repeated high velocity intervals.....that deplete glycogen stores to some threshold level.....are effective stimuli for increasing--maintaining Glucose Transporter levels.....not "mileage" per se.

"Some.....stimuli that induce an increase in mitochondria also result in an increase in GLUT 4....."

E.O.Ojuka, et.al.
Regulation of GLUT4 Biogenesis In Muscle: Evidence For Involvement Of AMPK and Ca
American Journal Of Physiology, Endocrinology, And Metabolism.....Volume 232.....May 2002.....page E1008

Supplying Fluids at a Rate that Matches Sweat Rate -----
Fluid loss during a workout or marathon race cannot be prevented by pre-workout/race fluid ingestion. The kidney will simply excrete the excess as urine into the bladder. You must be well hydrated before the race begins, and drink during the race to maintain hydration status.

You need to drink at a rate and amount sufficient to match sweat rate. If sweat rate exceeds the rate of fluid intake, dehydration will take place, your perception of the effort of your run will increase, in spite of the fact that the pace may be the same or slower.

Sweat rate may generally be around 8oz or 250ml per 10 - 15 minutes. Fluids must be ingested during the marathon race, at that rate, [preferably with a pinch of salt put in each cup to increase absorption]. Intake of moderate amounts of plain water may suppress thirst drive before adequate amounts of fluids have been ingested. Significantly more fluid is absorbed from carbo/electrolyte (sodium) beverages (-90-95%) than plain water (-50-60%).

Intake of fluids containing 15 - 20 grams of carbohydrate per 250ml (8oz) may be best during a workout/race. Carbohydrates in fluid stimulates sodium and water absorption. Sodium is essential for glucose transport from the small intestine into the blood stream. Fluids containing protein stimulates water and sodium absorption independently of glucose.

--- What you ingest, moves from the stomach, to the intestines, to the blood stream.
--- Maximal stomach emptying rate of fluid into the small intestine = 33 - 38ml (about 1/7 of a cup) per minute.
--- Fluid absorption rate from the small intestine into the blood stream = 25ml(1/10 cup) per minute.

Elevation in core body temperature tells the brain to turn on sweating. An increase in osmality (ratio of solids to fluids due to loss of fluids by sweating) of blood turns on thirst drive. Once there is a significant decrease (20%) in plasma volume (the part of the blood that is mainly water -- - you sweat it out), drinking will have no effect (reduction) on body temperature.

Supply Carbohydrate [glucose] at a Rate that Approaches Carbohydrate [blood glucose] Utilization -----
-- glycogen is a bunch of glucose molecules hooked together [glucose is the digested form of sugar]
-- glycogen is the stored form of carbohydrate
-- glycogen is stored in the liver which serves as a fuel tank to provide glucose to the brain and nervous system by way of the blood stream, during the marathon race.
-- glycogen is stored in the brain and nervous system

Muscles can use fat as a fuel source, however the brain and nervous system generally, can only use glucose. If you start to run low on this fuel supply, your perception of how hard you're working will increase (perceived effort increases), even though your pace remains the same or slower. You must supply glucose, at a rate that is at least in the ball park of the rate you are burning it. Otherwise, it is inevitable that you will "bonk" or "hit the wall".

People usually take in carbohydrates at a rate that causes them to reach low levels by the 18 - 22 mile markers, which is where many people begin to "bonk", or "hit the wall".

You may need to consume 200 - 300 grams of carbohydrate during the race. If you started taking this in around the 15 mile marker, it is unlikely that his amount would get into the blood stream before you reached the 18 - 22 mile markers. There does exist a given "rate" at which you're able to get glucose into your blood stream, and on to your brain/nervous system. Since the glucose coming to muscle, nerve, and liver is moving to those locations by way of the blood stream, the rate of blood flow is one determining factor of the rate of glycogen repletion. You can get glucose in as fast as you can deliver it through your blood stream, coming from your digestive tract. Thus the main limitation is the amount ingested, the amount absorbed out of the small intestine into the blood stream, and the rate of blood flow from the small intestine to the brain/nervous system/muscles. Since you have a set amount of time....[that you cannot change].....that exists between the time you ingest the carbohydrate and the time you can use it, you will want to begin ingesting carbohydrates very early in the race. You've already begun a small but very significant depletion of this fuel source by 30 minutes into your marathon race. You should begin consuming carbohydrates no later than 30 minutes into the marathon race.

Don't Bonk, Hit The Wall, or Get Dehydrated -----
Glycogen depletion is higher during exercise where you fail to drink, than if you do drink. Power output decreases with dehydration (as much as 20% loss of power output) either because of glycogen depletion or an inability to use it.

Red Blood Cells & Distance Runners -----
Red Blood Cells carry oxygen through the blood vessels.....from the lungs.....to nerves and muscles. The oxygen is carried by hemoglobin, which is inside the red blood cells (RBC's). The "heme" portion of Hemo-globin contains iron that is used to bind the oxygen to the hemoglobin so that it can be carried through the blood stream.

When the red blood cells flow into blood vessels serving nerve and muscle fibers, the oxygen is unloaded for use by parts of these tissues called mitochondria. The oxygen is then used by mitochondria in the process of energy [ATP] production for driving sodium pumps located along nerve fibers, and for muscle contraction.

EPO [Erythropoietin] -----
The stimulus for red blood cell production is provided by a now famous hormone called EPO [E-ryth-ro-poi-e-tin], which is produced by the kidneys. From there, EPO travels through the blood....to bone marrow, where it stimulates the production of new red blood cells.

Mechanism Of EPO Production -----
During a workout, when blood flow, and therefore, oxygen delivery.....are decreased in the kidney, a chemical called aden-o-sine accumulates. Adenosine binds to receptors on cells in the kidney that produce EPO, and tells them to increase their EPO production. Prolonged running, high intensity running, being at high altitudes or using altitude "tents" or chambers.....are all very effective stimuli for decreased oxygen deliver in the kidney, thus they are effective stimuli for EPO production.

Importance Of Protein Intake -----
The level of protein intake in the diet is limiting on EPO production. EPO is not stored, it is produced in response to an adequate training stimulus. Small deficiencies of protein intake on the day of the training stimulus [workout], cause decreases in production of EPO. Hemoglobin and red blood cells are comprised of protein. Thus protein intake affects their production as well, even if EPO production has been unaffected.

Importance Of Iron Intake -----
The "heme" portion of Hemoglobin contains iron that is used to bind the oxygen to the hemoglobin so that it can be carried through the blood stream. The level of availability of iron from the runner's diet is what limits the production of new red blood cells [RBC's], since the supply of iron is the rate limiting aspect of hemoglobin production.

Ferritin is the stored form of iron in the body. Ferritin levels decrease following hemoglobin/red blood cell production. Thus it is important to insure that an adequate supply of iron is available to the bone marrow following workouts that induce RBC production, and when traveling/training at high altitudes. These types of stimuli increase the demand for iron, thus one is required to supply it, or face the consequence of reduced adaptation to the stimuli [reduced improvement in fitness].

Red Blood Cell Turnover ----
The major determining factor of the life of a red blood cell [RBC]is how well it can change it's shape (deformability) when moving through small blood cappillaries. RBC's can be damaged when they reach a "bottle neck" type situation when moving from large arteries into small arterioles and cappillaries. RBC's have a limited capacity to repair damage to themselves, thus the ability to deform can dramatically enhance the life of the cells. The fluidity of the membrane of the RBC's enhances deformability. Fluidity is affected by the type of fat [essential fatty acids] that comprise the membrane. Essential Fatty Acids (Omega-3from the oil of fish of cold water origin, increase membrane deformability, thus enhancing the life of RBC's.

When the rate of destruction of RBC's exceeds the rate of production, anemia may result (low red cell count).

The second major mechanism of damage to RBC's is "free radical" attack (oxidant attack) on their membranes. The free radicals are produced by hemoglobin during a process called hemoglobin auto-oxidation. Anti-oxidants are necessary to prevent this irreversable damage to the RBC. Glutathione, Vitamin E, and Vitamin C are the main anti-oxidants that protect RBC's from oxidative damage. Oxidative damage is the primary mechanism of red blood cell aging.

Red Blood Cell Volume Vs. Plasma Volume -----
It is worth noting that an increase in the part of the blood that is mainly water, called plasma, is perhaps as important, if not more important in.....distance running performance.....than increases in red blood cells.

High intensity training increases the volume of plasma that is in the blood. This dilutes the cells to such a degree that a greater volume of blood can be pumped per stroke (per heart beat) of the heart, an increase in "stroke volume". This can actually increase oxygen delivery beyond what an increase in RBC's alone can achieve.

It is well known that.....Altitude Training.....causes a decrease in plasma volume, especially during the first week or two. Generally, as long as one remains at altitude, plasma volume levels fail to return to their pre-altitude levels, until one descends back to sea level.

It was established around 1996 that well trained.....non-detrained.....distance runners see little if any increase in RBC's at moderate (5000-7000 feet) altitude levels. The improvement that runners see following Altitude Training is due to the fact that when they go to Altitude, they never decrease their training paces to an extent that matches the increased difficulty of running at those paces at high altitudes [they attempt to run at the same velocity as they normall run at sea level]. This creates a situation where they are in effect, training at a higher intensity, a higher oxygen demand, than they would normally train at sea level. Increasing the intensity of one's training is something that can be done at sea level by simply choosing to train at higher velocities.

At altitude, they are training at intensities that require them to consume a higher percentage of their maximum oxygen uptake. And it is well known that training at a higher percentage of one's maximum oxygen uptake [training at higher intensities] is the most effective training stimulus for causing the production of mitochondria in nerve and muscle ....leading to higher performance levels.

Problems With Altitude Training Studies -----
Difficulties are existent in the claims of athletes and in past research on altitude training. In the past, many athletes would site benefits in spite of staying at altitude for less than the time known to be required to see increases in red blood cells, thus suggesting that the primary increases in fitness they saw if any, were due to the hidden increases in training intensity that high altitude running creates.

"This high velocity training elicits high levels of force and brief contact time."
"Regular training at velocities above v-marathon [marathon velocity] seems to characterize top class marathoners."
V.L.Billat, et.al.....Physical Training And Characteristics Of Top-Class Marathon Runners
Medicine & Science In Sports & Exercise....Volume 33 #12...2001....page 2089 - 2097

The primary difficulty in research studies that show increases in red blood cells due to altitude training, have been that they used a technique of measuring red blood cells that has been subsequently found to create artificial increases in the estimates of the number of RBC's.

Other problems have been;
--- in the using of runners who had low iron levels and providing them with iron supplements during their stay at altitude.
--- using athletes who were at/near the end of their racing season and thus had tapering periods across several weeks that provided a potential period of detraining [red blood cell reduction] to take place prior to altitude exposure which would obviously reverse that situation
--- the greatest difficulty with altitude related studies has been in attributing 100% of any performance improvement to the increase in oxygen delivery, when the amount of improvement well exceeds the level that is known to be possible in humans by way of increased oxygen delivery [in comparison to red blood cell infusion studies, plasma infusion studies, and studies involving the breathing of air with an elevated oxygen content].

Optimize Vs. Maximize....Red Blood Cell Number -----
Prolonged duration running [ie. long runs], and high velocity running [fartleks, intervals] cause a decrease in oxygen delivery to the kidney, and are thus effective stimuli for increasing EPO production. In knowing the sea level training stimulus that induces the production of RBC's, one can train in such a manner as to....optimize.....rather than....maximize.....RBC levels. Altitude training simply frustrates this process by limiting increases in plasma volume and training velocity, as well as creating a dramatically increased iron and protein demand. The improvements in performance one may see from altitude training, can be equated and/or surpassed by simply choosing to train at higher intensities at sea level.

Regardless of whether the technique used is direct altitude training, or the "live high, train low" method [residing at high altitude, but descending to train at low levels], at some point one must consider the questions of;
--- how many red blood cells do you need
--- how many can you have without compromising your heart's stroke volume [volume of blood pumped per heart beat]
--- the question of questions in human exercise physiology.....whats more important oxygen delivery or oxygen utilization [red blood cells vs. mitochondria]

"In spite of accumulating scientific evidence that altitude training affords no advantage over sea level training, many coaches and athletes believe that it can enhance sea level performance for any athlete, whether endurance or power is the focus in their particular sport."

"The issue of whether altitude training enhances sea level performance remains a controversial topic."

L.A.Wolski, D.C. McKenzie, H.A. Wenger.....October 1996
Altitude Training For Improvements In Sea Level Performance.....Sports Medicine.....Volume 22 #4.....October 1996.....page 251
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compared to normal sport drinks, combining glucose with fructose in a sport drink [2 to 1 ratio] may provide a substantial improvement in performance in cycling and running events of 2 hours or more.....

definitions
--- exogenous carbohydrate = carbos supplied from outside the body
--- carbohydrate oxidation = burning carbos for fuel during exercise, running or cycling

"For some time, it was thought that exogenous carbohydrate oxidation rates would not exceed 1 gram per minute, even at high rates of ingestion (greater than 2 grams per minute). However, recent research from our laboratory has shown that exogenous carbohydrate oxidation can be increased above 1 g·min-1 when multiple transportable carbohydrates are ingested."

"....total exogenous carbohydrate oxidation of the mixture of glucose and fructose was reported to be as high as 1.26 g·min-1.....glucose drinks.....was around 0.80 g·min-1. "

"In subsequent studies, it was observed that when a glucose and fructose beverage in a 1:1 ratio was ingested at very high rates (2.4 g·min-1) during 150 min of exercise....."

"This finding of increased exogenous carbohydrate oxidation has also been reported when the fructose has been replaced by sucrose, the glucose replaced by maltodextrin....."

"As recently reviewed, it was thought that the limitation of the rate of exogenous carbohydrate oxidation to 1 g·min-1 was not in gastric emptying or muscle glucose uptake. Rather, it seemed to be intestinal absorption of carbohydrate that limited exogenous carbohydrate oxidation."

"Glucose is absorbed in the intestine by the sodium-dependent glucose transporter SGLT1. It has been suggested that the SGLT1 transporter becomes saturated at high glucose-ingestion rates. When glucose and fructose are combined, intestinal carbohydrate absorption can be increased, because fructose uses a different transporter whereas fructose is absorbed by the intestinal transporter GLUT 5. This mechanism has been used as a way to explain the robust finding of increased exogenous carbohydrate oxidation with multiple transportable carbohydrates."

"Although it is generally assumed that an increase in exogenous carbohydrate oxidation is beneficial because it reduces the reliance on limited endogenous stores, the ergogenic effects have not yet been demonstrated."

"When glucose and fructose were ingested, ratings of perceived exertion were lower, and self-selected cadence was higher in the later stages of exercise compared with both glucose alone and water. These findings suggest a reduction in fatigue with the ingestion of a glucose and fructose beverage compared with a glucose-only drink."

"The aim of the present study was to investigate the effect of ingesting a glucose plus fructose drink compared with a glucose-only drink [both delivering carbohydrate at a rate of 1.8 g·min-1] and a water placebo on endurance performance."

"Subjects ingested either a water placebo, a glucose-only beverage, or a glucose and fructose beverage in a **2:1 ratio** during 120 min of cycling.....followed by a time trial in which subjects had to complete a set amount of work as quickly as possible."

"Ingestion of glucose plus fructose resulted in an 8% quicker time to completion during the time trial (4022 s) compared with glucose (3641 s) and a 19% improvement compared with W (3367 s). Total carbohydrate oxidation was not different....suggesting that glucose plus fructose led to a sparing of endogenous carbohydrate stores, because glucose plus fructose has been shown to have a greater exogenous carbohydrate oxidation than glucose."

K.Currell, et al
Superior Endurance Performance with Ingestion of Multiple Transportable Carbohydrates
Medicine & Science in Sports & Exercise.....Volume 40 #2.....February 2008.....page 275-281

What To Do After The Race: Recovery From A Marathon

Two of the major aspects of tissue damage that will be occurring following the Marathon race will be;
--- muscle and other tissue damage due to physical tearing from running
--- muscle and other tissue damage due to attack on cell membranes by oxidants [beginning in ernest immediately following the race]

These will manifest themselves in the form of a high degree of post-race soreness--stiffness in the hours and days after the race. The most effective methods of dealing with them consists of a combination of ---all--- of the following;

— Lite weight lifting on the legs.
Tissue healing will take longer if one only uses rest alone. Strength training is a necessary stimulus for accelerated healing. Do minimal number of repetitions [cumulative total of 3 - 5 reps per exercise for the strength training session. Partial [1/4] squat, calf raise, and hamstring curls are sufficient to provide an excellent stimulus to the legs. Begin around 2 - 3 days following the race. Lift at least 2 - 3 times within 1 week of the race.

— Lite massage.
Massage is effective in causing a deep relaxation of the nervous system which aids immune function, and enhances nervous system production of growth factor substances that promote tissue regeneration and healing. Deep massage should be avoided. The body will heal itself when put in the right state. The body will remove the knots in muscles on its own if given the chance. It is unnecessary for the massage therapist to do it for you. Begin within 2 days following the race. Get a massage at least 2 - 3 times within 1 week of the race.

— Jacuzzi, Whirlpool, Hot bath.
These, too, are effective in causing a deep relaxation of the nervous system which aids immune function, and enhances nervous system production of growth factor substances that promote tissue regeneration and healing. They also increase blood flow which encourages tissue healing.
These should consist of no more than a 10 minute session in water.....nothing hotter than 105 - 110 degrees F, nothing cooler than 100 degrees F. Begin 2 - 3 days following the race. Do at least 2 - 3 times within 1 week of the race.

— Protein intake.
Post-race protein turnover will be relatively high. The rate of tissue recovery will be directly impacted by the rate at which you supply protein to those rebuilding tissues. Protein intake may need to be around 1.2 - 1.5 grams of protein for every kilogram of body weight [1 kg = 2.2 pounds] each day, for the first 3 - 4 days after the Marathon, including the day of the race, to be effective in addressing tissue healing.

— Anti-oxidant Intake.
A significant amount of the muscle soreness experienced after a marathon is....not....due to the muscle damage from physical tearing, but from muscle damage induced after the race by oxidants [produced from damaged tissue, as well as by immune system cells that are cleaning up debri]. A short term elevation in Anti-oxidant intake is necessary to match the elevated levels of oxidants. Intake of Vitamin E [2 x 400 1U], Beta Carotene [25,000 1U], Selenium [250mcg], and Vitamin C [2 x 500mg], each day for the first 2-3 days following the Marathon, including the day of the race, are effective in addressing this process.

— pH & Essential Gene Level Nutrients
The body's pH level is a critical aspect of the ability of cells to adapt to the training you do and to recover from workouts and races. Putting your body in an "anabolic" state means the environment inside your body is in state where it can repair itself, build tissue, etc. "Stay anabolic" means to not only ingest protein in your diet and provide yourself with enough rest prior to resuming training, but to also provide the food/nutrients that put and keep your body's pH level in the necessary range, and to consume the essential gene level nutrients [ie. B-vitamins, magnesium, zinc, calcium] that assist the body to recover.

Two - three meals a day for several days post marathon, consume across the course of the day, 2 - 3 salads containing alkalinizing vegetables. Also take in two - three times a day, across the course of the day, essential gene level nutrients....magnesium [~250mg], calcium [~500mg], zinc [~30mg], B-vitamins [b-complex].
If you'd like to test your urine pH, you can buy pH paper for about $10.00 from a lab in Round Rock, Texas.
[Healthline.cc]
[Quantum Labs.....http://www.qnlabs.com]

Keep in mind that you are looking at the pH of urine. How you choose to do that is up to you. You can do the "stream of flow" method of placing a strip of pH paper in a given position. Or you can choose a less potentially messy method by using a dixie cup to collect a small amount, then dipping the pH strip in to cup. Many Americans are reported to be between 5.5 - 5.8. For them the paper won't change color. You'ld like it to turn green to be 6.8 - 7.0 range both in the morning and in the evening. Keep in mind that eventhough you're looking at urine pH, what you're really out to measure is the efficacy of your diet and supplement intake, and thusly, the status of the environment inside your body that your cells operate in to respond to your training.
Creating the best environment is helpful over the long term. The use of the pH paper can help you use trial and error to get your diet to a point where things are approaching the ballpark of being optimal and staying that way for most of the day. Supplements can help make the pH more alkaline [calcium, magnesium, etc]. Generally, most vegetables are alkalizing foods. Choose alkalizing foods that you like.

Example;
a small salad meal eaten by itself, twice across the day.....comprised of [2 baby carrots, 20 spinach leaves, 1/8 inch slices of cucumber [3], 1/2 of small tomatoe [sliced] 1/2 teaspoon of flax seeds.

Example;
a small plate of vegetables, making a meal eaten by itself, twice across the day....comprised of 1/2 cup of peas, 1/2 cup of corn, 1/2 cup of mixed vegetables.
For a list of foods that can help you get some idea of what foods can make your pH more alkaline see a general list;
www.energyselforlife.com/list_of_alkaline_foods.php

So called "performance enhancing drugs" <u>are prescription drugs</u>.

Some examples of the effectiveness of prescription drugs in sport.....

"The drug erythropoietin, often called EPO.....a new systemic review of existing research reveals that **<u>there is no scientific evidence that it does enhance performance</u>**, but there is evidence that using it in sport could place a user's health and life at risk."
EPO [erythropoietin] doping in elite cycling: No evidence of benefit, but risk of harm
Science Daily.....December 5, 2012.

"....**<u>there is no scientific basis from which to conclude that rHuEPO has performance-enhancing properties</u>** in elite cyclists.""The use of rHuEPO in cycling is rife but scientifically unsupported by evidence, and its use in sports is medical malpractice."
J.A.Heuberger, et al
Erythropoietin doping in cycling: lack of evidence for efficacy and a negative risk-benefit.
British Journal Of Clinical Pharmacology.....Volume 75 #6....June 2013...page 1406

"The **<u>over-exaggeration of the effects of growth hormone</u>** in muscle building is effectively promoting its abuse...."
"....there is the question of disinformation on rhGH....Part of this problem may, paradoxically, derive from the anti-doping authorities themselves. By ignoring the evidence the **<u>rhGH does not work</u>** in normal healthy subjects, the athletic establishment could be accused of effectively promoting its use."
"**<u>We must tell athletes the truth: growth hormone does not 'work'</u>** or at least not as they think it does and that its is associatedwith all kinds of immediate and long term hazards-----everything from decreased performance to cancer."
"....none of us scientists, doctors, coaches, or sports bodies should continue to suggest that this dangerous doping practice works."
M.J. Rennie
British Journal Of Sports Medicine.....Volume 37 #2....April 2003....pages 100-103

"**<u>Testosterone prohormones</u>** such as androstenedione, androstenediol, and dehydroepiandrosterone (DHEA) have been heavily marketed as testosterone-enhancing and muscle-building nutritional supplements for the past decade."
"Contrary to marketing claims, research to date indicates that the use of prohormone nutritional supplements (DHEA, androstenedione, androstenediol, and other steroid hormone supplements) **<u>does not produce either anabolic or ergogenic</u>** effects in men. Moreover, the use of prohormone nutritional supplements may raise the risk for negative health consequences."
G.A.Brown, et al
Testosterone Prohormone Supplements.
Medicine & Science in Sports & Exercise.....Volume 38 #8....August 2006.....pg 1367-1537

So called "performance enhancing drugs" <u>are prescription drugs</u>.

Some examples of the effectiveness of prescription drugs in American medicine & health care.....

"Most drugs are only effective **<u>for a small percentage</u>** of people who take them."
Michael Leavitt [U.S. Secretary of Health & Human Services 2005 - 2009]

".....the benefits that US health care currently deliver **<u>may not outweigh the aggregate health harm</u>** it imparts."
Journal Of The American Medical Association...Volume 302 #1..July 1, 2009...page 89 - 91

"It is estimated that more than 700,000 individuals are seen in hospital emergency departments for adverse drug events each year in the United States."
[Centers For Disease Control....2015]

"106,000 deaths/year **<u>from non-error</u>**, adverse effects of medications"
B. Starfield
Is US Health Really the Best in the World
Journal of The American Medical Association.....Volume 284 #4....July 26, 2000....page 483 - 485

".....1.5 million U.S. residents are harmed or killed each year because of medication errors, according to an Institute of Medicine report."
Nature Medicine....Volume 12 #9....September 2006.....pg 984 - 985....News In Brief

Pursue becoming a

Master Of Sport