



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 optimal running form

### 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

**You may copy** any and all contents of this packet, with exception and exclusion of using such copies for purposes of producing revenue, profit, or any direct or indirect compensation.

# Optimal Running Form....Biomechanics

Optimal Distance Running Performance . . . It is not "genetic". It is not out-dated coaching methods based on "years of experience". It is not about altitude, mileage, steroids, or red cells. It is Training, and Knowledge of how to train.

Improvements in running form may not reduce energy expenditure, but will make better use of the runner's energy. The expected benefit is an improvement in performance time by expanding on abilities the runner already possesses. The model or goal template for the running movement focuses on two areas; arm carriage and foot strike.

## Arm Carriage & "Angular Momentum"

As shown in the drawing below, the forward movement of one arm and the backward movement of the other, create a force that rotates the upper body around a vertical axis in a given direction. The legs move in a manner that create a force on the lower body around a vertical axis in the opposite direction of the upper body. These forces are generally referred to as Angular Momentum. Runners who have poor running form may swing their arms in such a manner as to create more upper body angular momentum than the lower body produces. This results in the body rotating and being turned in between each stride. Thus the runner must expend energy, not only to propel her/himself down the road/track, but also to keep facing forward. One of the runner's objectives is to move the arms in such a manner as to produce enough angular momentum in the upper body to cancel out the angular momentum of the lower body, such that the Total Body angular momentum is zero.



Drawing by Tom Sparks

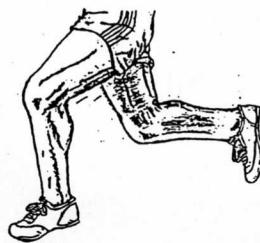
**Upper body angular momentum and Lower body angular momentum, need to cancel each other.**

As you can see in the picture above, the goal movement pattern for arm carriage is to run with the forearms in mid-position (palms facing each other), as opposed to being supinated (palms up), or pronated (palms down). The shoulder (humerus bone) should be slightly internally rotated (turned inward) such that the upper arm moves in toward the nipple of the chest, but never crosses that plane or goes over to the middle of the chest. The elbow joint angle should be kept large (85 - 135 degrees) during elbow flexion/extension (up and down motion). The purpose of this is to maintain a greater moment of inertia (force created simply from the added distance that the center of mass of the forearm is from the shoulder joint axis of rotation). This increases the ability

of the small upper body to balance the forces of angular momentum created by the larger lower body. The large elbow joint angle also improves the amount of vertical lift forces that can be generated during the upward movement of the arms that occurs during the propulsion phase of running.

## Foot Strike

The goal movement pattern of foot strike is to initially strike on the forefoot and allow the heel to strike as the weight is shifted over the foot. The benefit is that braking force (slowing down when the heel strikes first) is lessened because the center of mass of the body is closer to being over the foot at the moment of ground contact rather than being behind. Also, the time spent on the ground may be lessened, and the amount of elastic energy placed in the achilles tendon and calf muscles will be greater, thus leading to a more powerful propulsion off the ground.



Drawing by Tom Sparks  
**Forefoot strikes first**

## Foot: Turned Out Vs. Straight Forward

The direction of foot placement is important to performance as well as injury prevention. The lower leg (tibia/fibula) can rotate independently of the upper leg. The more the foot is abducted (pointed outward), the greater the lower leg is externally rotated (rotated outward...laterally). Foot abduction is associated with greater pronation during the running stride. Pronation increases the side to side movement of the runner's center of mass. This reduces running economy since the point of running is to propel the center of mass forward down the track or road, not side to side. For every centimeter of foot abduction, performance time may suffer approximately 2 seconds per mile. The greater the amount of abduction the greater the velocity and magnitude of pronation. High pronation velocities are linked to injury to the tendons of muscles that work to slow the foot (shin pain, shin "splints"). Strength training the inner hamstrings (semi-tendinosus, semi-membranosis) and stretching the outer hamstring (biceps femoris) should be combined with learning a new motor pattern to rotate the lower leg in to have the foot face more forward.

# ***MAJOR MECHANISMS OF OPTIMAL RUNNING FORM***

The Elite Training Group

## **\* Programming of New Movement Pattern**

- there is a biomechanically optimal sequence of motor unit recruitment that can be learned
- motor template stored in cerebellum
- synaptogenesis creates new motor pathways

## **\* Major Mechanisms of Running Biomechanics**

### **\* Foot Strike**

Forefoot/midfoot initial strike

Foot in neutral (non-abducted) position

Tibia and femur in neutral (non-rotated) position

- midfoot striker compared to heel striker
  - shorter ground contact time
  - higher maximum vertical force (propulsive force)
- foot abduction associated w/greater pronation
- greater pronation = increased mediolateral velocity of CM in medial/lateral directions
- magnitude of pronation associated w/mediolateral forces
- lower running economy associated w/mediolateral forces
- crossover associated w/mediolateral forces

### **\* Arm Carriage**

Elbow joint angle range 85 - 135 degrees during flexion/extension

Forearm in midposition (non-pronated or supinated)

Shoulders slightly internally rotated position during shoulder flexion/extension

No shoulder internal/external rotation motions during shoulder flexion/extension

- upward movement of the arms during propulsion increases propulsive lift
- propulsive lift increases (via arm movement) as running speed increases
- shoulder extension requires greater muscular involvement of posterior deltoids than momentum aided shoulder flexion requires anterior deltoids

# **BIOMECHANICS OF DISTANCE RUNNING**

## **APPLIED RESEARCH**

The Elite Training Group

- motor template stored in cerebellum
- synaptogenesis creates new motor pathways
- there is a biomechanically optimal sequence of motor unit recruitment that can be learned
- fatigue = decrease in stride length, not necessarily stride frequency
- abduction associated w/greater pronation
- greater knee flexion during swing = greater hip flexion
- greater closed chain dorsiflexion during support = less plantar flexion at toe off
- greater pronation = increased mediolateral velocity of CM in medial/lateral directions
- magnitude of pronation associated w/mediolateral forces
- lower running economy associated w/mediolateral forces
- crossover associated w/mediolateral forces
- midfoot striker compared to heel striker
  - shorter ground contact time
  - higher maximum vertical force (propulsive force)
  - often absence of initial force peak (impact force)
- forefoot strike = lower first vertical force peak (impact) & shorter contact time than heel strike
- longer stride lengths associated w/greater hip extension & greater knee extension at toe off
- quadriceps work concentrically during propulsion only for the first 5 degrees of knee extension
- upward movement of the arms during propulsion increases propulsive lift
- propulsive lift increases (via arm movement) as running speed increases
- 30-40% greater angular momentum around the vertical axis is created by the forward swinging arm than the backward swinging arm (moving further from z axis)
- the contact leg possesses greater angular momentum than the swing leg (stance leg is closer to z )
- no increase in total body angular momentum (around z axis) as running speed increases
- left over angular momentum is large during contact phases
- moment of inertia of arms contributes to upper body (arms + upper trunk) moment of inertia and thus upper body angular momentum
- upper body is the main source of the lower body torque
- shoulder extension requires greater muscular involvement of posterior deltoids than momentum aided shoulder flexion requires anterior deltoids

## FOOT STRIKE

Advantages/goals of ball of foot/midfoot strike

- COG placement at ground contact
  - greater ground reaction
  - less braking
  - conservation of momentum
  - allows pawing action of foot
- Greater energy recuperation of triceps surae
  - 75-90% energy storage in achillies
  - greater eccentric than heel strike
  - less time on ground

## ARM CARRIAGE

- Elbow/shoulder, flexion/extension
  - forearm mid-position
  - shoulder slightly abducted, internally rotated
  - elbow joint angle maintained 85-135 degrees
- 
- greater moment of inertia to balance angular momentum produced by legs
  - greater ground reaction than int/ext rotation

# **forefoot first --vs-- heel first**

"The purpose of this study was to examine whether runners using a forefoot strike pattern exhibit a different lower limb loading profile than runners who use rearfoot strike pattern."

"Nineteen female athletes with a natural forefoot strike pattern and pair-matched women with rearfoot strike pattern underwent 3-D running analysis at 4 meters per second."

"Forefoot strike demonstrated lower patellofemoral contact force and stress compared with heel strikers...."

"In addition, knee frontal plane moment was lower in the Forefoot strike compared with heel strikers...."

"Forefoot strike exhibit both lower patellofemoral stress and knee frontal plane moment than Rearfoot strike, which may reduce the risk of running-related knee injuries."

J.P. Kulmala, et al

Forefoot Strikers Exhibit Lower Running-Induced Knee Loading than Rearfoot Strikers  
Medicine & Science in Sports & Exercise.....Volume 45 #12.....December 2013....page 2306

# Forefoot strike –vs-- running injuries

".....study tests if runners who habitually forefoot strike have different rates of injury than runners who habitually rearfoot strike."

"....those who habitually rearfoot strike had approximately twice the rate of repetitive stress injuries than individuals who habitually forefoot strike."

".....runners who habitually rearfoot strike have significantly higher rates of repetitive stress injury than those who mostly forefoot strike."

"One hypothesis, which requires further research, is that the absence of a marked impact peak in the ground reaction force during a forefoot strike compared with a rearfoot strike may contribute to lower rates of injuries in habitual forefoot strikers."

A.I.Daoud, et al  
Foot strike and injury rates in endurance runners: a retrospective study  
Medicine and Science in Sports and Exercise.....Volume 44 #7....July 2012....page 1325 - 1334

"In some subjects the left over total-body [angular momentum around the vertical axis] was fairly large during portions of the contact phases. In others it was very small."

"....the lower body receives most of its torques from the upper body even during the contact phases. This frees the feet to concentrate on pushing downward and backward and not to apply large torques to the ground."

".....the optimum amount of total body [angular momentum around the vertical axis] for a particular person is that which minimizes the free moment exerted by the runner on the ground. This would allow the runner to mainly apply forces to the ground instead of both forces and torques. This might also reduce the tortional stresses on the legs."

R.N.Hinrichs, P.R.Cavanaugh, K.R. Williams  
Upper Extremity Function In Running, II: Center Of Mass And Propulsion Considerations  
International Journal Of Sport Biomechanics?..Volume 3 #3...August 1987?.page 242 - 263

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"Comparing Figure 6 to Figure 1 reveals that this subject swung his right arm less vigorously and closer to the trunk and his left arm more vigorously and farther from the trunk than the average subject."

"These results suggest that one arm has the potential to compensate for the other in terms of generating angular momentum about the vertical axis."

"The compensation demonstrated by Subject 6 did not go without some consequence to other aspects of his motion, however. His arm action produced asymmetrical contributions to lift and drive, contributing slightly more during the right foot contact phase than during the left."

R.N.Hinrichs  
Case Studies Of Asymmetrical Arm Action In Running  
International Journal Of Sport Biomechanics..Volume 8 #2....May 1992....page 111 - 128

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"Through their upward acceleration relative to the trunk, the arms help the legs in propelling the body upward to achieve the airborne phase. The lift provided by the arms increases with running speed."

"The idea of pumping the arms to get a little extra forward speed toward the end of a long run implies some sort of increased propulsion from the arms. However, it is possible that what these runners are feeling is not the drive generated by the arms, but lift. If, with a more vigorous arm action, the arms provide extra lift, the legs have less work to do in propelling the body upward and, in effect, can concentrate on propelling the body forward."

R.N.Hinrichs, P.R.Cavanaugh, K.R. Williams  
Upper Extremity Function In Running, I: Center Of Mass And Propulsion Considerations  
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## \* Total Body Angular Momentum

upper body -- upper torso + arms  
[upper body moment of inertia]  
vs.  
lower body -- lower torso + legs

### Left-Over Angular Momentum [affecting torsional forces required by glutes and hamstring muscles]

- moment of inertia of arms contributes to upper body (arms + upper trunk) moment of inertia and thus upper body angular momentum
- 30-40% greater angular momentum around the vertical axis is created by the forward swinging arm than the backward swinging arm (moving further from z axis)
- the contact leg possesses greater angular momentum than the swing leg (stance leg is closer to z axis)
- no increase in total body angular momentum (around z axis) as running speed increases
- left over angular momentum is large during contact phases
- upper body is the main source of the lower body torque

## \* Stride Length

propulsive force  
[hip extension, ankle plantar flexion, knee extension]

propulsive lift  
[vertical ground reaction]

ground contact time  
[time spent on ground]

braking force  
[position of center of mass at time of foot strike]

magnitude and rate of pronation  
[medial/lateral motions of center of mass]

- fatigue = decrease in stride length, not necessarily stride frequency
- longer stride lengths associated w/greater hip extension & greater knee extension at toe off
- quadriceps work concentrically during propulsion only for the first 5 degrees of knee extension
- midfoot striker compared to heel striker
  - shorter ground contact time
  - higher maximum vertical force (propulsive force)
- upward movement of the arms during propulsion increases propulsive lift
- propulsive lift increases (via arm movement) as running speed increases
- greater closed chain dorsiflexion during support = less plantar flexion at toe off

# **RUNNING FORM PROGRAMMING**

Elite Training Group

## These Drills

- develop a motor nerve impulse template of the goal movements
- store motor nerve impulse template in the cerebellum
- improve proprioception and motor control

### -- Walking A (3 x 50 meters)

walking, shoulders slightly internally rotated,  
elbow flexion/extension between 85-135 degrees,  
forearm in midposition  
forefoot/midfoot intial foot strike area

### -- Barefoot Running (1 x 10-15 minutes)

forefoot/midfoot intial foot strike area

### -- Treadmill Running w/Wall Mirror Real-Time Feedback (3-5 x 1-5 minutes)

treadmill speed set at season goal pace for main race distance  
shoulders slightly internally rotated,  
elbow flexion/extension between 85-135 degrees,  
forearm in midposition  
forefoot/midfoot intial foot strike area

### -- Internal Visualization (1x 5-10 minutes)

running at season goal pace for main race distance  
shoulders slightly internally rotated,  
elbow flexion/extension between 85-135 degrees,  
forearm in midposition  
forefoot/midfoot intial foot strike area

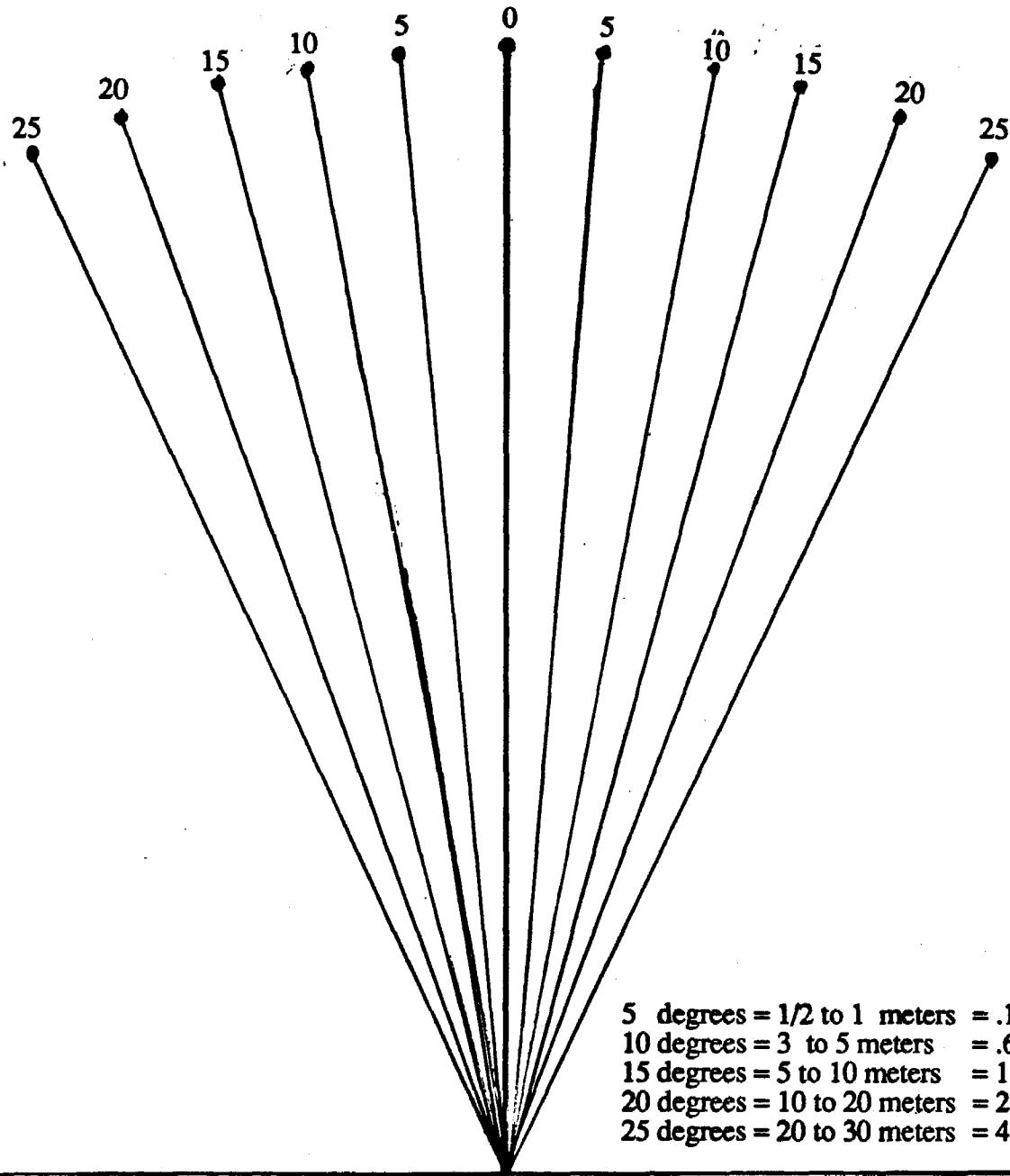
### -- Form Changing Sessions [moderate to fast pace running]

Week 1 = 3-5 sessions - 3-5 minutes  
Week 2 = 3-5 sessions - 5-10 minutes

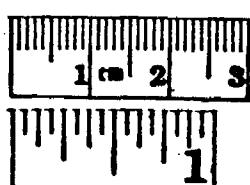
Week 3 = 5-7 sessions - 5-10 minutes  
Week 4 = 2-3 sessions - 15-20 minutes

Week 5 = 2-3 sessions - 25-35 minutes  
Week 6 = 4-6 sessions - 30-40 minutes

# FOOT ABDUCTION ANGLE -- EFFECT ON PERFORMANCE



## Stride Length Improvement:



- 1cm -[just above 1/3 inches]
- 2cm -[just above 2/3 inches]
- 3cm -[just under 1 1/3 inches]
- 4cm -[approx. 1 1/2 inches]
- 5cm -[approx. 2 inches]

## Performance Improvement [seconds per mile]:

- = 2 seconds per mile
- = 4 seconds per mile
- = 6 seconds per mile
- = 8 seconds per mile
- = 10 seconds per mile

# EFFECTS ON PERFORMANCE

<u>Drag Reduction</u>	<u>energy [O2 reduction]</u>	<u>Performance Improvement [per 400m.]</u>
100%	7.5%	4.5 seconds
90%	6.75%	4.0 seconds
80%	6.0%	3.7 seconds
70%	5.25%	3.2 seconds
60%	4.5%	2.8 seconds
50%	3.75%	2.3 seconds
40%	3.0%	1.9 seconds
30%	2.25%	1.4 seconds
20%	1.5%	1.0 second
10%	0.75%	0.5 seconds

Based on Vo2 max of 63 ml/kg/min.

\* Drafting, in still air conditions

2 meters behind = 40% drag reduction

= 3.0% reduction in energy expenditure = 1.9 seconds per 400m. improvement

1 meter behind = 80% drag reduction

= 6.0% reduction in energy expenditure = 3.7 seconds per 400m. improvement

\* 10 mph headwind increases energy expenditure by 11%]

\* 10 mph tailwind decreases energy expenditure by 6%

## Stride Length Improvement



## Performance Improvement [seconds per mile]

1cm -[just above 1/3 inches]	= 2 seconds per mile
2cm -[just above 2/3 inches]	= 4 seconds per mile
3cm -[just under 1 1/3 inches]	= 6 seconds per mile
4cm -[approx. 1 1/2 inches]	= 8 seconds per mile
5cm -[approx. 2 inches]	= 10 seconds per mile

inch

## Shoe Weight Increase

## Energy [O2 increase]

## Performance Decrement

100 grams [3.5 ounces]	= 1%	= 2.5 seconds per mile
200 grams [7 ounces]	= 2%	= 5 seconds per mile
300 grams [10.5 ounces]	= 3%	= 8 seconds per mile

## Foot Abduction Angle

## Ground Loss

## Performance Time Decrement

10 - 15 degrees	= 3 - 9 meters	= 1 - 2 seconds per mile
20 - 25 degrees	= 15 - 30 meters	= 3 - 6 seconds per mile

## Energy Cost Decrease

## Performance Improvement

## Energy Cost Increase

## Performance Decrement

1%	= 2.5 seconds per mile	1%	= 2.5 seconds per mile
2%	= 5 seconds per mile	2%	= 5 seconds per mile
3%	= 7.5 seconds per mile	3%	= 8 seconds per mile
4%	= 9 seconds per mile	4%	= 11 seconds per mile
5%	= 12 seconds per mile	5%	= 13.5 seconds per mile
6%	= 14.5 seconds per mile	6%	= 16 seconds per mile
7%	= 17 seconds per mile	7%	= 19 seconds per mile
8%	= 19.5 seconds per mile	8%	= 22 seconds per mile
9%	= 21.5 seconds per mile	9%	= 25 seconds per mile
10%	= 23.5 seconds per mile	10%	= 28 seconds per mile
20%	= 44.5 seconds per mile	20%	= 62 seconds per mile
30%	= 61.5 seconds per mile	30%	= 103 seconds per mile
40%	= 77 seconds per mile	40%	= 155 seconds per mile
50%	= 90.5 seconds per mile	50%	= 221 seconds per mile



## New Balance XC Seven spikeless

### The story

Racing flats are the first and perhaps the best "minimalist" running shoes ever created.

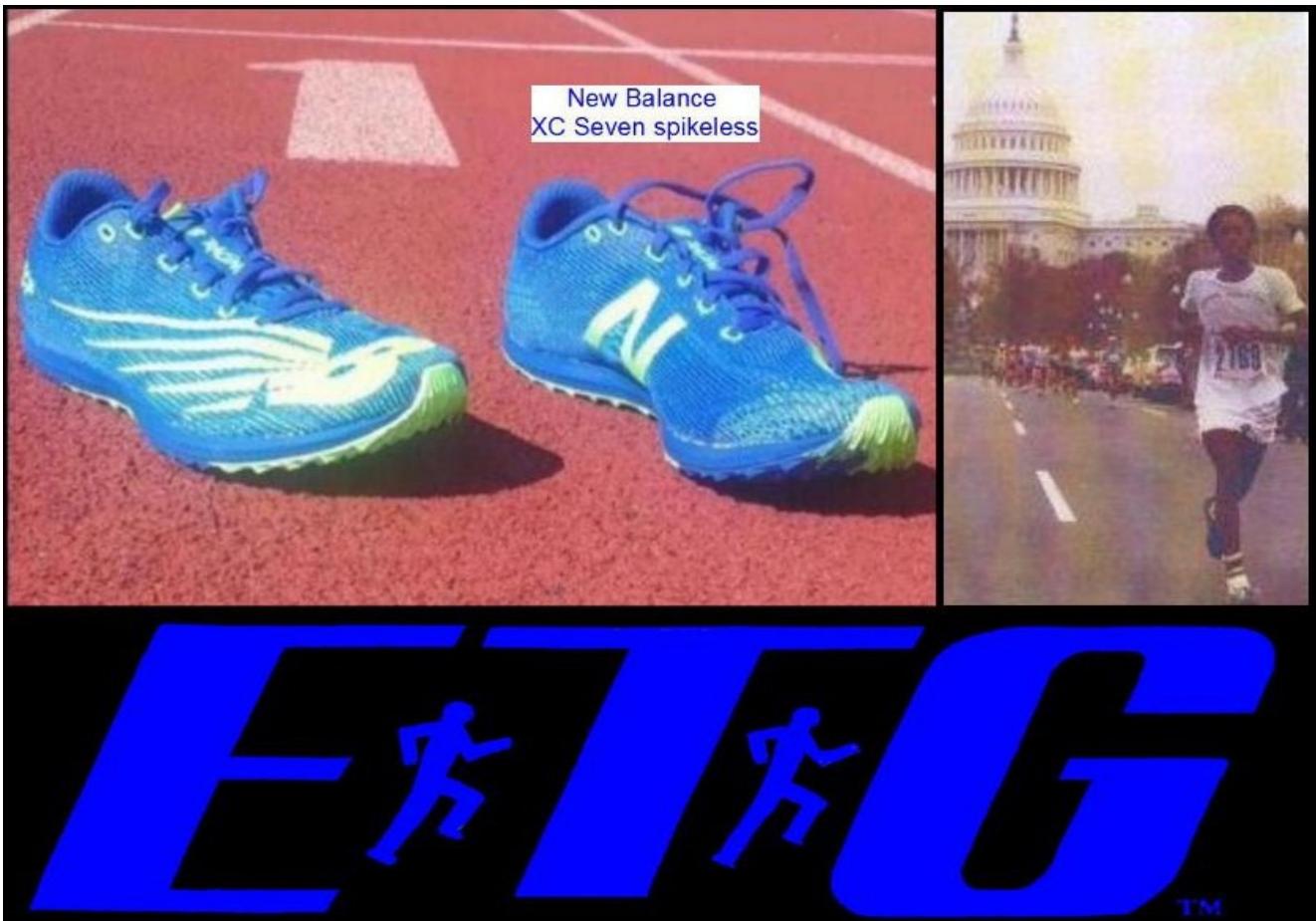
In the early 1990's TheETG club owner Marshall Burt abandoned the training shoe vs racing flats designations, and began using racing flats as the only running shoes. In TheETG we do --all-- run training in racing flats. A bridge that isn't strong enough to hold the cars that cross it, will eventually cause somebody to get wet. Increase the strength of the bridge to where it can endure the loads placed on it. Inadequate tissue strength in the feet and legs will result in issues independent of what shoes you wear or how much they cost, or how biomechanically great or awful your running form happens to be.

Applied running biomechanics 101

The relatively high coefficient of friction created by certain shoe outsole tread patterns vs track spikes....and the resulting potential impact on the energy cost of running, we prefer to go spikeless.

Late 1970's, 8th grade, a year prior to his freshman year in high school, the first training shoes owned by Marshall Burt was the New Balance 320. At the end of the Fall cross-country season of his freshman year he used them to run the 1977 Marine Corps Marathon.

In 2021, 4 decades after running in New Balance 320's and after running in other brands since.....there is the full circle return to New Balance.





Casio 3257 running watch

## The story

Casio motto....."Creativity and Contribution".

In high school during the late 1970's, early 1980's, on recommendation from several teammates, future ETG club owner Marshall Burt bought a Casio 863 running watch, the first running watch he ever owned and perhaps -the- most functional running watch ever made.

As a runner and a coach he stuck with the 863 deep into the 1990's.

Today he runs with the modern day replacement of the Casio 863.....the Casio 3257.

In TheETG's highly standardized "all interval training all the time" training program, one's running watch matters.

The watch during TheETG workouts, its never worn on the wrist.

Always in the hand, always operated via thumb on the hand that holds the watch.

No occupying two hands to take and see the split while running....no elbows raised up and out to see the split. That's not a part of the normal armswing in good running form. Just a simple lifting of the hand during a normal upswing of the arm allows one to see the split.



1980 on left wrist  
casio 863

1993 in right hand  
casio 863



Pursue becoming a

Master Of  
Sport