Attention Athletic Directors!!

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On The Canal

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Warm Ups: Improving Running Economy and Efficiency

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There are three physiological variables that effect performance. These are:
1) Maximal Oxygen consumption – VO2Max
2) High Lactate threshold level – Anaerobic threshold
3) High efficiency and economy of motion – swimming, running, cycling

Running **economy** is measured as movement velocity for a given energy consumption/expenditure. It is the oxygen cost of running at a particular speed. Running efficiency is mechanical power output (work) for a given energy consumption/expenditure. Economical runners have the ability to increase speed at a given effort with less oxygen demand at a given speed. Improving efficiency can improve economy.

Running efficiency therefore is the percentage of energy expended by the body that is converted to the mechanical work of locomotion (running).

Work Efficiency = Mechanical Work / Chemical Energy Expended
Minimizing energy lost or expended during running can improve efficiency and therefore improve running economy. Sources of energy loss in running are:

1. *Chemical energy conversion losses.*

Food energy is chemically converted into ATP used for muscle contraction. All is not transferred to ATP. Approximately 60% is lost as heat energy. Optimizing oxygen delivery to muscles and minimizing the production of lactic acid helps to better utilize energy conversion to ATP. This source of inefficiency is the same in all individuals and can be affected by the runner's environment.
2. *Fiber type differences in converting ATP energy to contraction force.*

Energy losses occur in the step in which chemical energy is trapped within ATP and is converted to mechanical energy via muscle contraction. Fiber composition of the muscle influences the efficiency of muscle contraction. Slow twitch muscle fibers are more efficient than fast twitch muscle fibers.
3. *Energy costs of moving limbs.*

It costs energy to just move the limbs, support the body and hold balance. This is the unloaded cost of movement. Movement frequency impacts total efficiency. A higher cadence costs more energy. Heavier limbs are less efficient to move. Trained athletes tend to zero in on an optimal cadence and stride length for their body type and anatomy. An individual can increase the energy expended when they are out of range of their optimal stride cadence and stride length. The key is to find a balance to achieve optimal power and velocity with each stride.

There exist many factors that effect running economy. Training to improve running efficiency can optimize energy utilization into the energy costs to run at a certain speed and therefore improve running economy. Other factors that effect running economy are:

1. Stride length
2. Stride frequency (cadence)
3. Shoe weight and body weight
4. Leg length and body size
5. Leg strength
6. Flexibility

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7. Running posture and form
8. Foot biomechanics
9. Air resistance
10. Air Temperature and Body Hydration
11. Age
12. Training

Studies have shown that most experienced runners naturally chose an optimal stride length. In most cases, efforts to change a runner's stride length tend to be less efficient and increase energy costs and reduce optimal running speed. Achieving a stride frequency in the optimal range can improve a runner's efficiency and economy. There is an optimal range whereas too low a cadence limits maximal obtainable speed whereas too high a cadence limits leg length and increases energy expended at that speed.

Training has been shown to improve efficiency. Beginning runners make the greatest gains in efficiency, although experienced runners can make small improvements in efficiency that can give them a slight edge over their competitor. Running more will increase a beginning runner's efficiency tremendously. Stride length and frequency will naturally adjust to a more efficient pattern. Body weight will decrease to the demands of running. Neuromuscular coordination and movement biomechanics will improve. Lastly, the body will become more efficient metabolically in regards to oxygen delivery, glycogen utilization and the ability to cool itself.

Experienced runners can yield small changes through specific training. Studies have shown that training at anaerobic threshold or race pace can improve efficiency by developing neuromuscular facilitation at a specific pace. Tempo runs at 1/4 to 1/2 of the race distance can optimize stride length, stride frequency, oxygen utilization and neuromuscular facilitation at race pace and distance. The mind and body can experience and learn what race pace feels like and can deal with the sensations of what the race will be like.

Factors that effect stride length and cadence are running posture, foot biomechanics, cadence, flexibility, leg power and leg length (obviously a runner cannot change his leg length but this is an important factor to consider when working with a young runner who naturally will increase leg length as growth occurs). By improving these factors a runner may improve their running economy and be able to maintain an optimal stride cadence. This often leads to a natural change in their stride length.

Neuromuscular facilitation and muscular endurance also play an important role in maximizing running economy. A runner will be more economical if he becomes specifically skilled with the running movement. A runner needs to be able to train the neuromuscular system to be able to achieve an economical running form and the muscular endurance to maintain that form over a distance.

Body weight differences can effect running efficiency. Body elements that reflect linear dimension of the body such as leg length, pelvic width, foot length and leg to torso ratio effect running efficiency. These are constant body type variables that most runners are unable to change. Body mass or weight can effect running efficiency and can be modified and make a difference. Experience has shown that overweight runners can improve efficiency by losing weight, but being too lean can also negatively effect efficiency. The key is to find the weight at which you are able to perform well and stay healthy. Over time, adequately fueled and hydrated runners tend to pick a healthy weight and body composition naturally.

Weight has more of an effect on efficiency when it is added to the extremities. The addition of 100 grams of weight increases the energy costs by about 1%. Light weight, well cushioned shoes will help improve efficiency and performance. It may be more beneficial to train in well cushioned shoes even if they are heavier and only use light weight trainers or racing flats during track sessions or races. The gains in less weight must be weighed against the increased risk of injury.

Body temperature and hydration status can effect running performance and efficiency. As the ambient temperature rises it becomes more difficult to maintain running pace. We lose efficiency in the heat because of the increased energy demands to cool the body. The body attempts to control heat by cooling the body through sweating. Sweat rate is dependent upon acclimatization, conditioning, air temperature, humidity and wind. Water loss leads to dehydration and increased body temperature. Weight loss with exercise is a good indication of the amount of water lost. One pound of weight loss equals 450 ml of water loss. Dehydration significantly effects performance. Every liter of water loss causes:

1. An increase in heart rate by 8 beats per minute
2. A decrease in cardiac output by 1 liter per minute
3. An increase in core body temperature by 0.3 degrees Celsius

A 2-3% loss of body water can lead to a 3-7% decrease in performance.

Running economy may be difficult to measure. One needs to measure oxygen uptake per unit body weight at a given pace. In a laboratory setting, VO2 Max or LT is plotted against running speed to determine changes or comparisons of running economy within or between individuals. A field test that can also be utilized to assess improvements in running economy is a submax test run at a certain heart rate or pace. With an improvement in economy, one should see either a decrease in heart rate for a given pace or an increase in pace for a given heart rate. Listed below are ways to improve running economy:

1. Train at a higher pace (race pace or greater) – Tempo runs
- Tempo runs improve fitness, increase the time to onset of fatigue and develop neuromuscular facilitation.
- Tempo runs can be either longer efforts of 15 – 30 minutes or intervals of 3-12 minute repeats with active rest intervals.
- The intensity of these efforts are at or around lactate threshold

2. Train at Race pace
- Training runs of 1/4 to 1/2 of race distance at race pace gives the body the experience of the race and the ability of the mind and body to adapt to race pace.

3. Leg Strength Training
- Strength training with weights or uphill running can improve overall leg strength and power.
- Uphill running repeats are performed weekly
- Key Strength training exercises are explosive exercises that focus on the hamstring, hip flexors and glutes.
- Samples of these are: high bench step-ups, single leg squats, one leg hops up an incline and heel raises.

4. Cadence Drills – drills to increase stride rate and neuromuscular facilitation
- Turnovers – count stride rate per 60 s. Perform repeats of 60s intervals with stride cadence > 90.
- Pool running
- Quick feet foot strike drills and barefoot running

5. Breathing rhythm drills
- Efficient breathing improves oxygen delivery and utilization and optimizes aerobic energy production.
- Practice a breathing rhythm of 2-2 (breathe in for 2 strides and breathe out for 2 strides)
- Efficient runners may use a 3-3 or 2-1 rhythm

6. Downhill running
- Perform intervals of downhill striders on a 1-2% down grade
- 200 – 400 meter repeats and progress to 800-1200 meter repeats
- A soft surface is better (grass)
- Focuses on leg speed and turnover
- Improves neuromuscular endurance

7. Practice good running posture and form
- Run tall with head up and chest forward
- Run lightly
- Run with elbows at side and elbows at 90 deg.
- Run relaxed
- Run with legs underneath hips
- Accelerate with hips not upper body

8. Improve Flexibility
- Improve hamstring and glutes flexibility – antagonist to forward thigh drive and can result in an early forward leg strike
- Improve hip flexor flexibility – tightness affects pelvic position and running posture. Pelvic tilt reduces leg power output.

9. Reduce body weight and weight of clothing and footwear

10. Maintain proper hydration status, acclimate to hot environments and consume a healthy diet. ■

Sports Hernia

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Mechanism of Injury
- Disruption of the pivot apparatus and a redistribution of forces to other musculo-tendinous attachments during extremes of exercise.
- Hyperextension/hyper abduction of the thigh with injury to the rectus abdominus attachment site to the pubic bone. The pivot point is the anterior pelvis or the pubic symphysis.
- Secondary inflammation = osteitis, tendonitis, bursitis (acute on-chronic)
- No occult hernia found
- Most patients have a single inciting event in history

Epidemiology
- Usually occurs and recurs in high load sports - soccer, hockey, football, track and field, baseball, basketball, racquet sports
- Male>female (90%)
- Professional soccer/hockey survey - 9% pubalgia, 12% chronic discomfort, 18% had "groin pull"
- Professional hockey - 4% retired (highest cause of injury-related retirement)
- Ten percent (10%) presentation of non-athletes

Clinical Presentation
- Athletes often unable to continue in sport may face an end to their career with groin pain
- Disabling pain at extremes of exercise
- Most athletes remember distinct injury (not all)
- Abdominal pain at inguinal canal near insertion of rectus at pubic bone
- Usual unilateral - may become bilateral with time
- Pain is minimal at rest
- Diagnosis is needed by ruling out other causes
- Pain secondary to unstable pelvis
- Most athletes can be pain free if they become sedentary, however, this would involve a significant lifestyle change. For many athletes and active people, this is not usually in their best interest ■

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