Biomechanical Considerations for Cross Country Running

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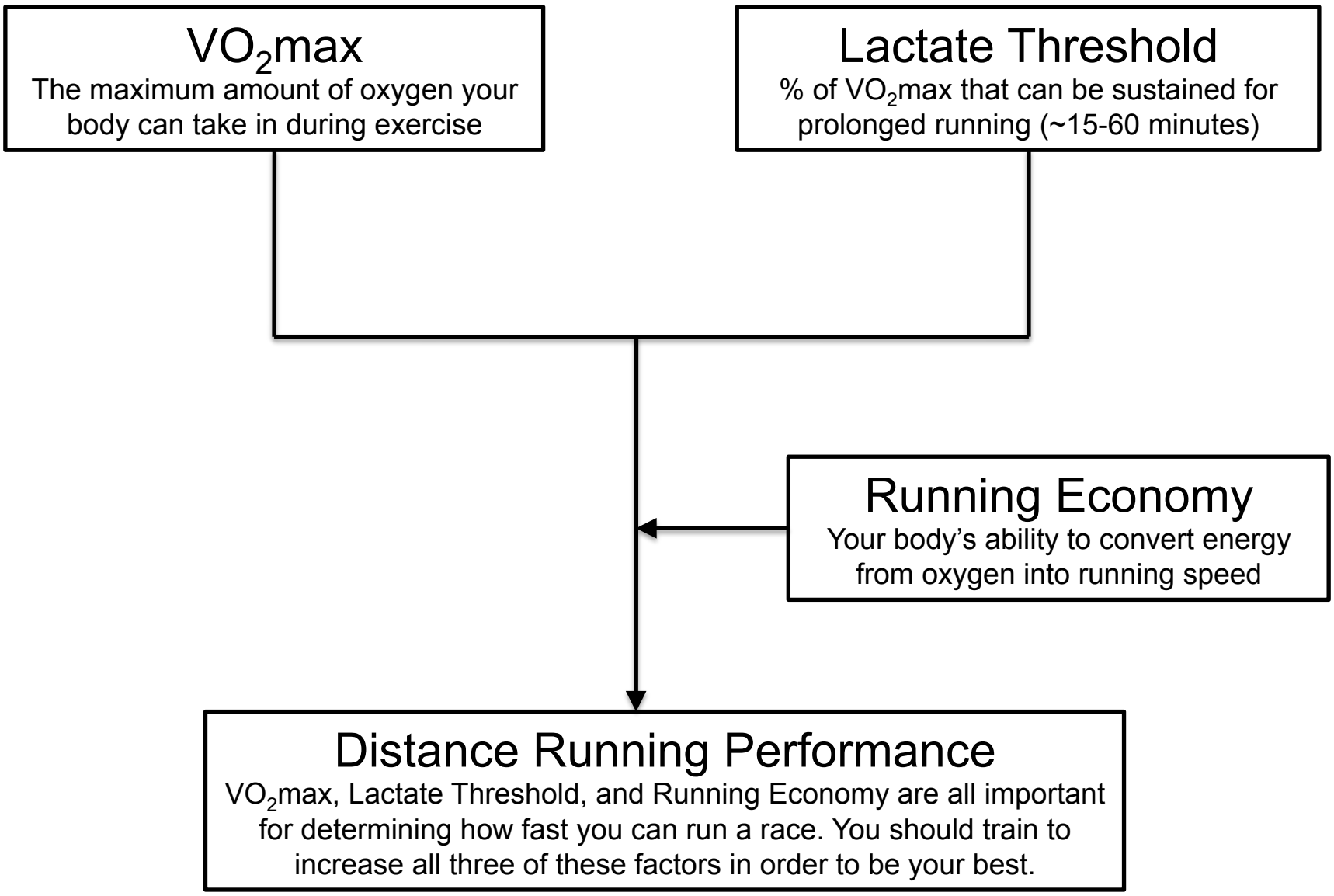
Predicting Distance Running Performance

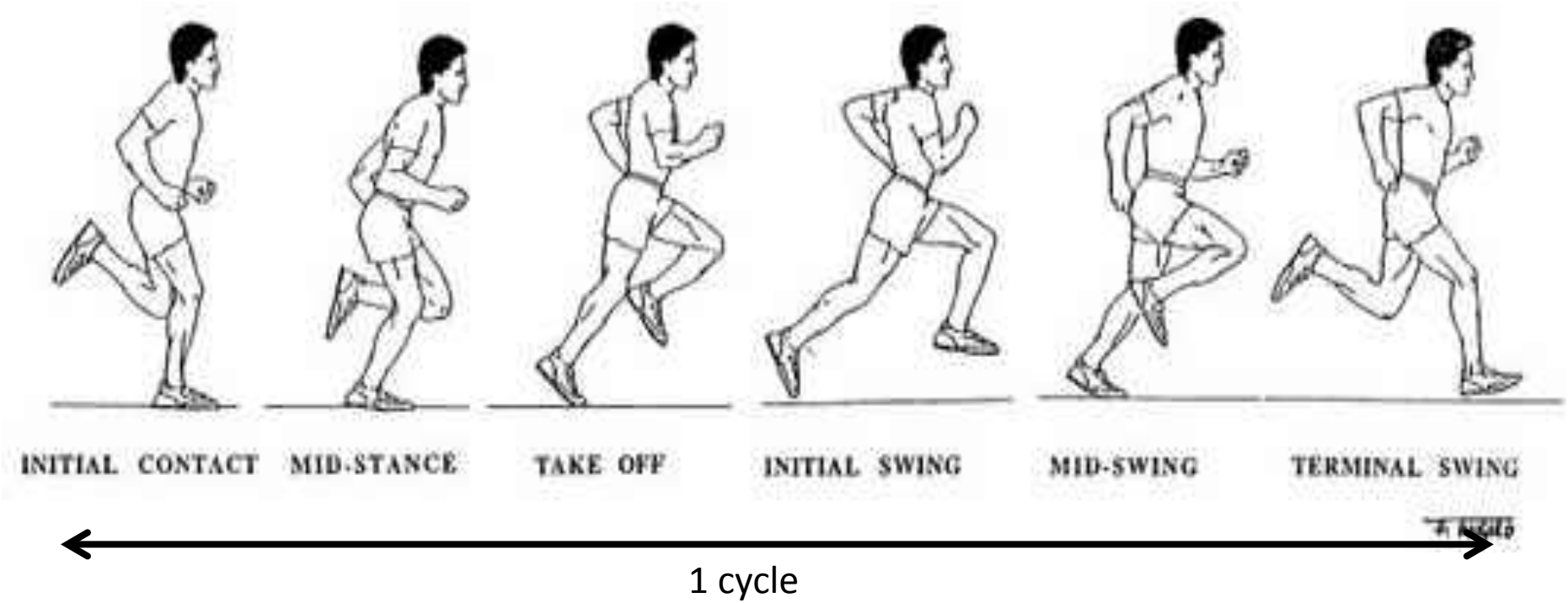


Running Economy

- Proper technique is more economical
- But, changes in running mechanics can actually *cost* the athlete more energy, which decreases efficiency (Lake & Cavanagh, 1996)
- As a new technique is learned, metabolic cost to using new muscles goes down = increased efficiency
- Changes can reduce injury → train more → improve performance

Some Basics: The Gait Cycle

- The gait cycle is the basic unit of measurement in gait analysis
  - Stance (~40% of cycle) and swing (~60% of cycle)



Why does running gait change with cross-country running?

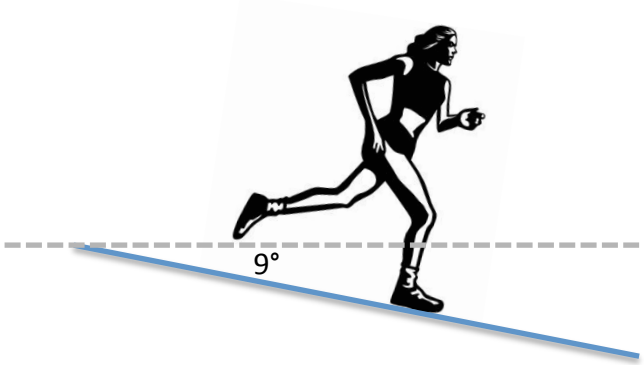
- Cross-country running is different from road and track running
  - Terrain and hills
  - Cold, wet, and windy conditions

vs.

(Courtesy of Athletics New Brunswick)

Hills

- Level running – maximizes use of stretch-shortening cycle (SSC) for forward motion
- Elastic energy storage in hill running does not change (Snyder et al., 2012)
  - Increased mechanical energy needed to run uphill
  - Less mechanical energy when running downhill



metabolically optimal running grade

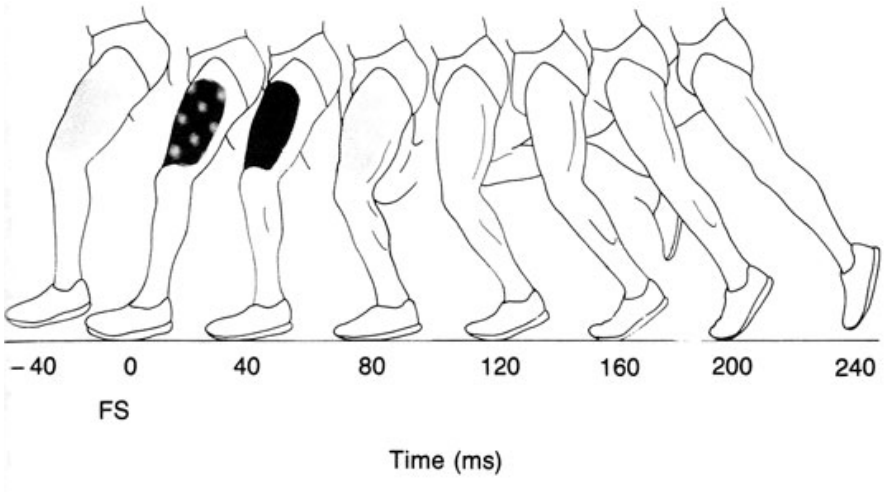
Grade (degrees)	Energy stored per step (J)	Mechanical energy spent per step (J)
-9	37.2	37.8
-6	36.0	50.6
-3	35.5	65.6
0	36.2	84.9
+3	35.3	100.8
+6	34.8	113.6
+9	31.4	132.3

Uphill

- Physiologically
  - Lighter runner has advantage going up hills
- Biomechanically
  - Running uphill, stride length decreases → hamstrings contract through smaller ROM → fatigue more quickly
  - Runner must raise their leg higher in front of them before placing their foot back on the ground, working hip flexors and stretching glutes more
  - Push-off phase of their stride also requires more force since they are going up as well as forward
  - The runner with the stronger glutes, hamstrings, and calves has advantage going up hills

Downhill

- During downhill running, stride length increases and mechanical energy must be dissipated through eccentric contractions, which can cause injuries
- The runner with the stronger quadriceps will certainly be able to withstand more impact in the stance phase



Arms

- Uphill running forces the runner to drive their arms harder than they would do when running on flat ground, again requiring greater strength demands

Terrain

- Softer ground in cross-country running due to grass and dirt course

Pros

- Less jarring
- Stimulus to strengthen stabilizing muscles

Cons

- Increase in metabolic demand due to increased muscular work to keep lower leg and hip joints stable
- Decreased GRF → less energy return for forward motion
- Hips cannot extend as fully against softer surface, reducing the knee drive that contributes to increased stride length

Terrain Compensations

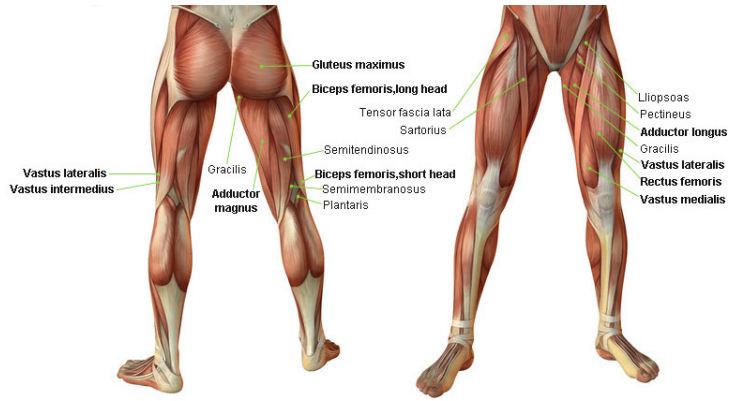
- Softer ground = shorter stride → must increase stride rate to maintain running speed and to maintain leg stiffness (Kerdock et al., 2002)

running speed = stride rate x stride length

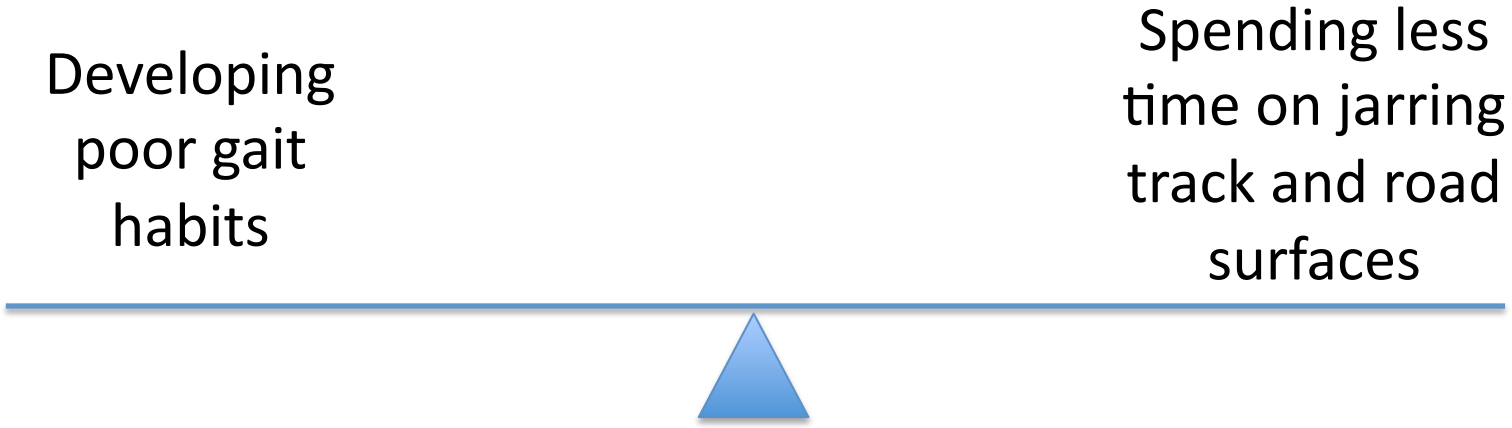
- This consequently increases physiological cost, especially for the runners who have to change their gait pattern the most
- Track runner with a long stride is most affected

Leg Stiffness

- Increased leg stiffness is beneficial to maximize SSC during the loading portion of the stance phase (Latash & Zatsiorsky, 1993), leading to greater economy of running (Kerdock et al., 2002)
  - Too much stiffness has been linked to bony injury
  - Too little stiffness has been linked to soft tissue injury
- Lower extremity adapts to surface stiffness to maintain an optimal leg-surface stiffness during the stance phase of gait
  (Ferris et al., 1998; Butler et al., 2003)



Analysis


Developing poor gait habits
Spending less time on jarring track and road surfaces

So why do athletes spend time training for cross-country running?

- Physical training
- Psychological edge
  - Unpredictable training and racing environments
  - Stimulation to an otherwise monotonous track program

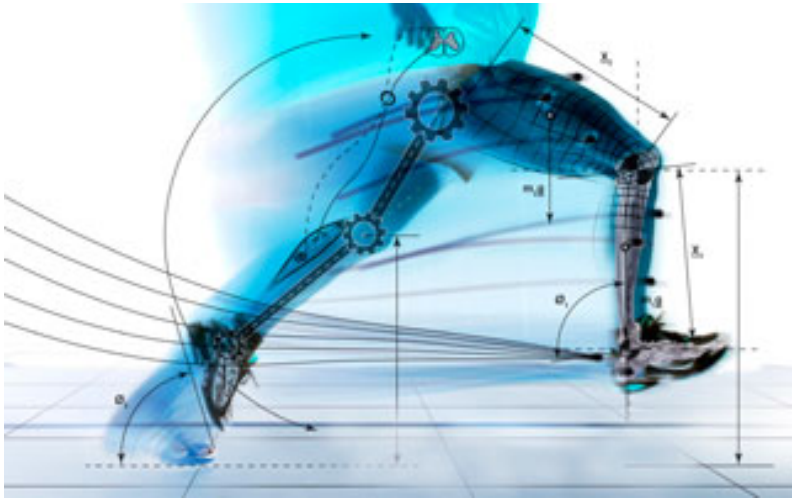
"I run cross-country because it is fun, it is both physically and mentally challenging, there is a sense of camaraderie, and it has an ever-changing, unpredictable environment."
– Jessica Smith (800 m; Olympian 2012)

"XC has always been part of my fall training and racing schedule because it makes me tougher and stronger. The crucial endurance base phase that comes with training for XC helps me get through the long track season. And the proprioceptive nature of XC is a nice break from the monotony and overuse niggles that come with being on the track the rest of the year."
– Hilary Stellingwerff (1500 m; Olympian 2004, 2012)

"Besides building the endurance and strength needed to run well in cross-country, I think it is just a lot of fun to do various challenging and unique courses and terrain. I have always found that a strong cross-country season carries over into track, and so I don't want to give that up."
– Cam Levins (5000 m/10,000 m; Olympian 2012)
(From Christoper Kelsall's November 11 interview in Athletics Illustrated)

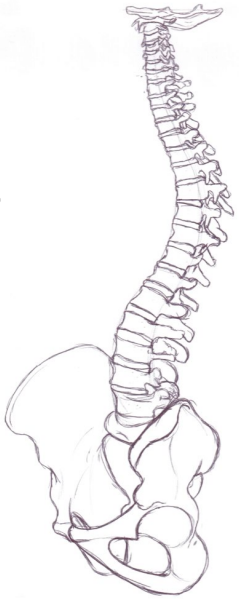
What can coaches can look for to help correct their athletes' mechanics?

- Goal for coaches = maximize performance while minimizing injury
- As much an art as science
  - When to make changes: In season? In career?
  - How much to push an athlete to do so: Physically? Psychologically?

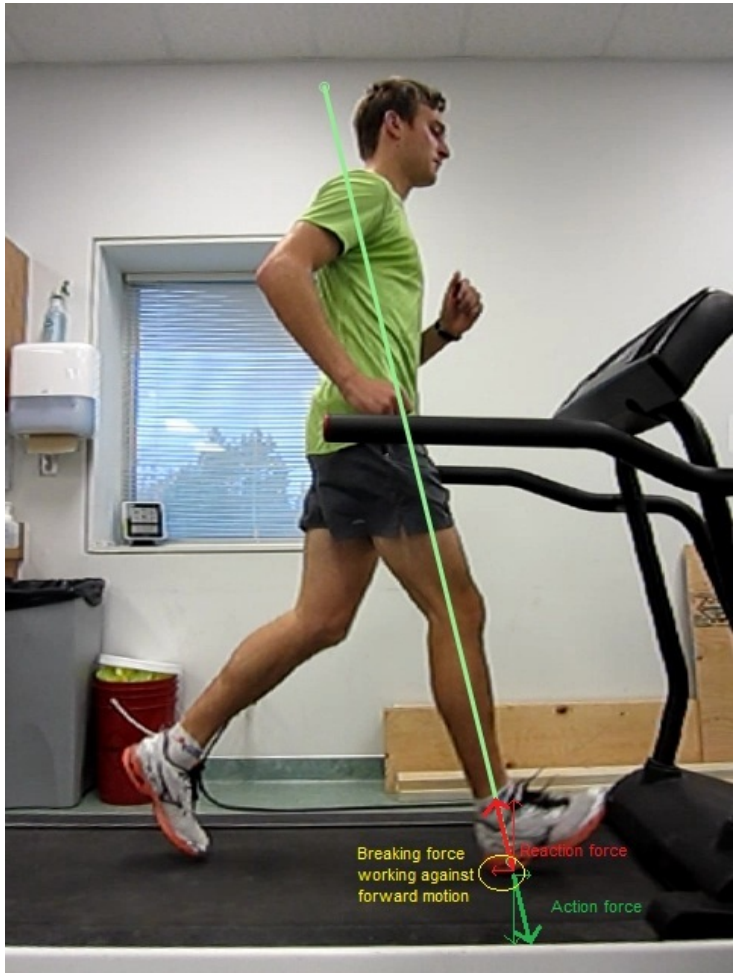


Core Stability

- Beware, athletes with unstable hips
- When we run, some parts of our body need to move (i.e. our legs and arms), while other parts need to stay still (i.e. our spine and pelvis).
- Ex: Hamstrings
  - Phasic muscles, need to turn 'on and off' as part of gait cycle
  - If being used to stabilize the pelvis and are 'on' all the time, this leads to tissue fatigue and decreased effectiveness for propulsion



Stride Characteristics



- A heel-striker is probably at the greatest disadvantage on soft, wet terrain.
  - Braking forces
  - Skidding, as the body's center of gravity is not balanced over the foot's contact point with the ground
- Ideally, runners will adopt a mid foot strike so that they have a decreased tendency to skid.

Stride Characteristics

- Additionally, runners with a long, loping stride
  - Rely heavily on the energy return of a strong push off
  - Require greater compensation for the softer ground

How can coaches look closely at their athletes?

- Video slows down the movement so that gait can be investigated frame-by-frame
- Doesn't need to be complicated or expensive
  - Video camera
  - Point-and-shoot
  - iPhone
    - Analysis applications: Dartfish Express, Coach's Eye, etc.

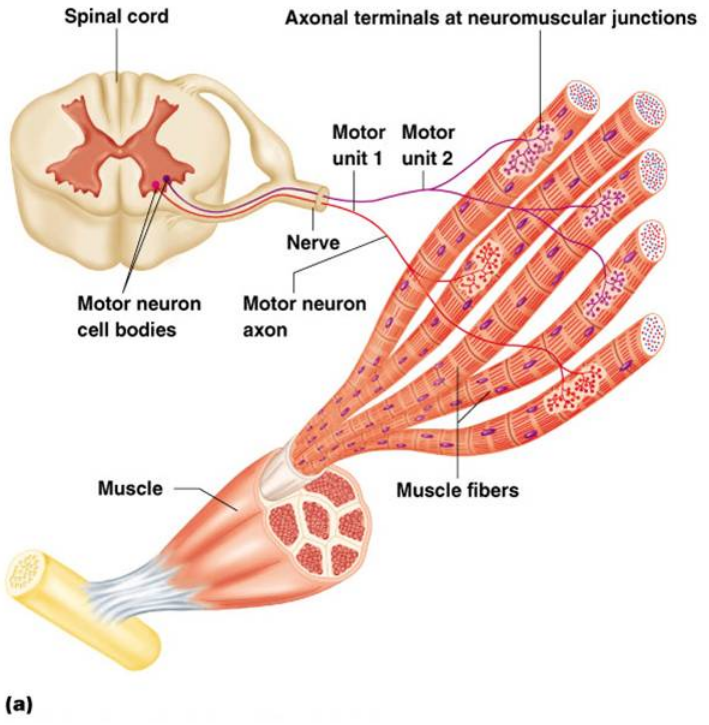
120 fps; Canon 100 HS; $120

Opportunity!

- Coaches Video Workshop
  - Presented by Ron Parker
  - Saturday, December 1; 1-3 pm
  - Vancouver Airport Hilton
- A workshop for coaches with a practical demonstration of how to use video to coach athletes in track and field.

Recommendations to improve XC gait

- Motor unit recruitment
- Specificity of training



Recruitment

- Strengthening exercises can lead to improvements in performance and reduction in injury
- BUT must be specific to the skill of running
  - First, must recruit muscle fibers
  - Second, must be able to use muscles for running
- Recruit more stabilizing muscles by activating prior to run
  - Ex: lunges to encourage glute firing

Practice running on uneven ground

- XC requires ability to change from flat to hilly terrain
- One study has shown that orienteers have a greater ability to run on hilly terrain, as indicated by greater economy of running for athletes with similar VO2 (Jensen et al., 1999)
- Athletes must practice the skill of running on softer ground

More to learn from East African dominance

- XC running has been dominated by Kenya and Ethiopia for the last 20 years
- Kenyans rarely run on pavement, and spend most of their time away from the track, running on undulating, loose dirt surfaces that promotes adaptation to unstable surfaces

Summary

- Some runners more successful in cross-country running than others
  - Biomechanical variables
  - Psychological variables
- Running is a skill
  - Must be learned and practiced
  - Skill of cross-country running seems to benefit skill of track and road running

Thank You!

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