BIOMECHANICS OF TREADMILL AND ROAD RUNNING

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BIOL 438

Advantages of running on a treadmill

- Control of running conditions
  - Weather/climate
  - Road/terrain
  - Pace
  - Incline

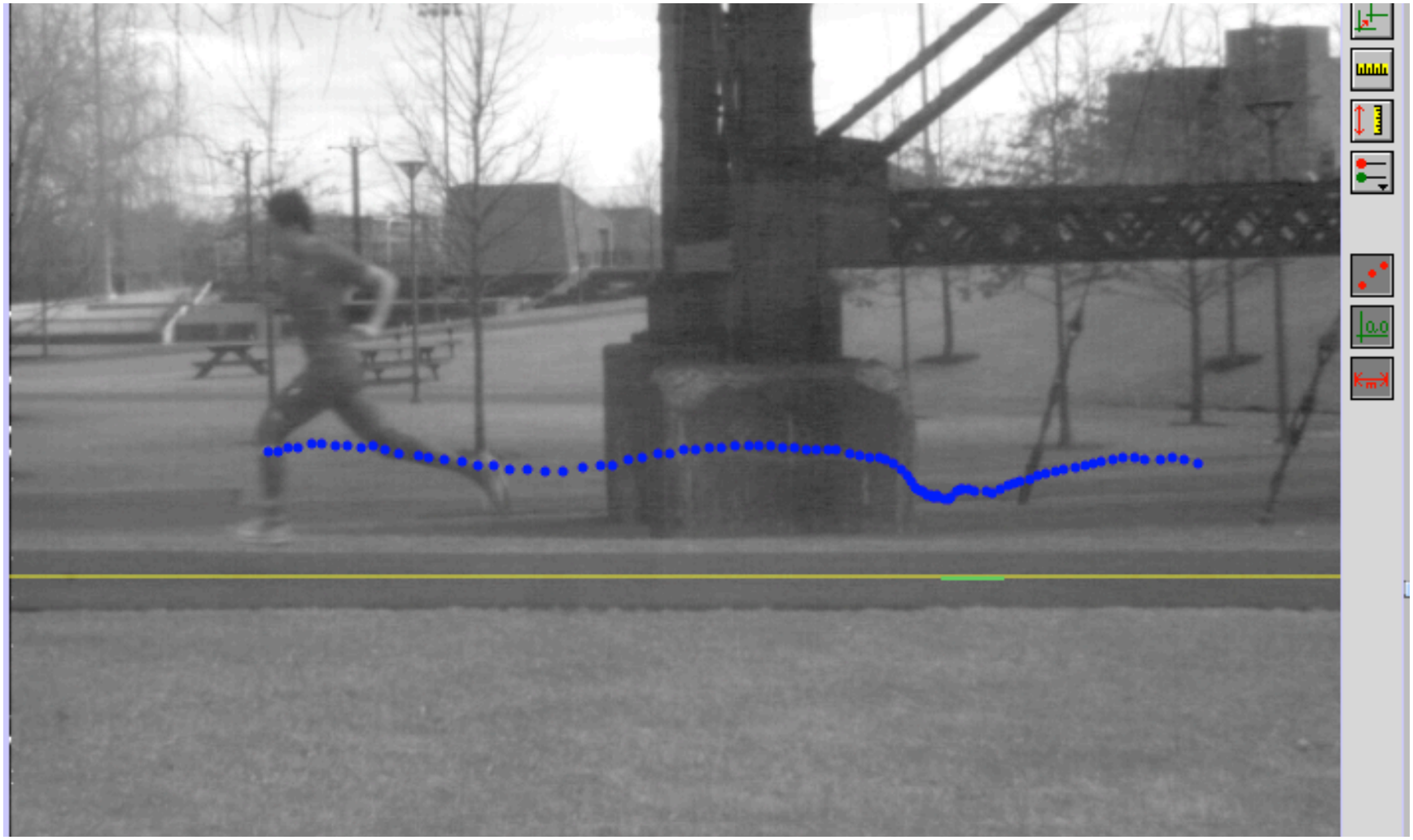
- Cushioning on belts reduces impact and injury
- Convenience
- Easier tracking of distance, heart rate, speed, etc.

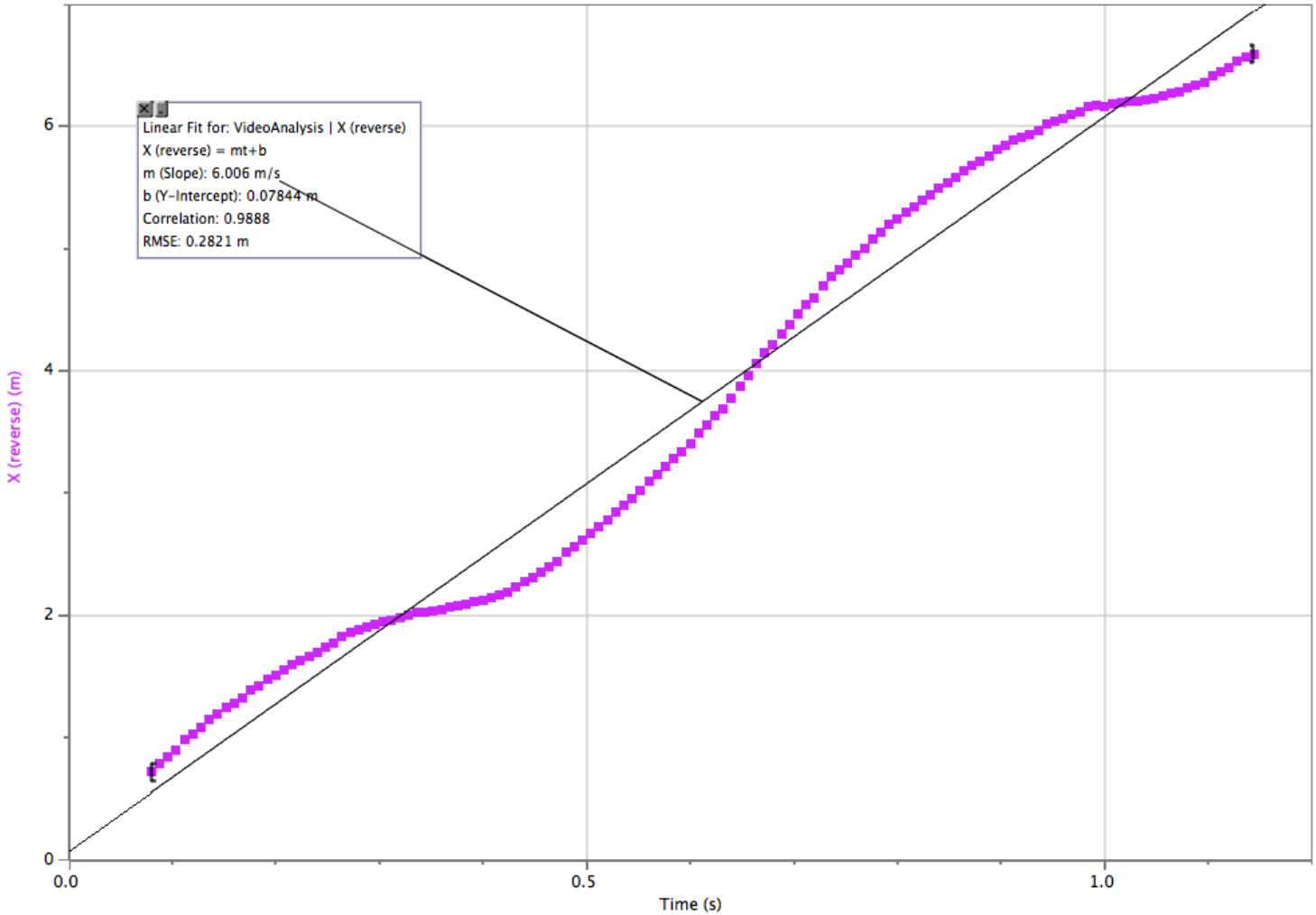
The main difference: the moving belt

The ground is being pulled underneath your feet and your body is not being propelled forward stride for stride

How does this affect the biomechanics?

Video Analysis of Sprinting

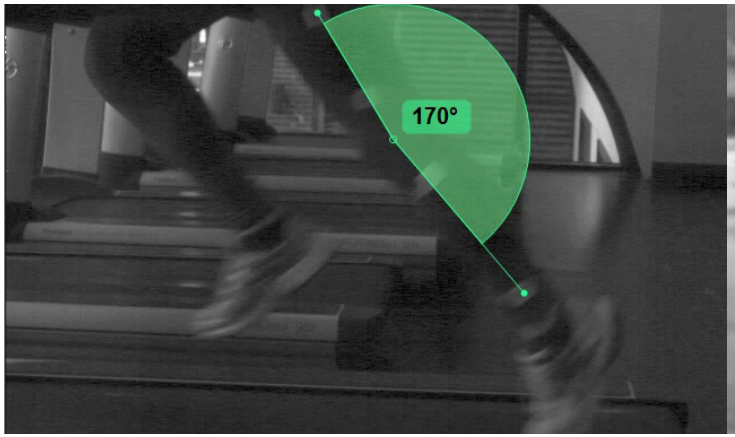


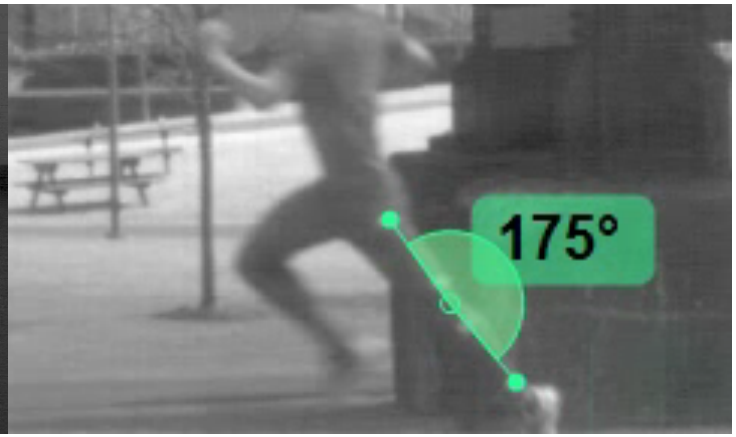


Average velocity = 6.006 m/s = 13.4 mph (set on treadmill)

Knee Extension

TREADMILL	ROAD
Angle: 170°	Angle: 175°
Backward motion of the belt assists the runner by pulling the feet back	Hamstrings are recruited more often to help lift the leg behind and to propel the runner forward and off the ground
	Over extension of the knee can cause inflammation and pain





Patellofemoral Pain (Runner's Knee)

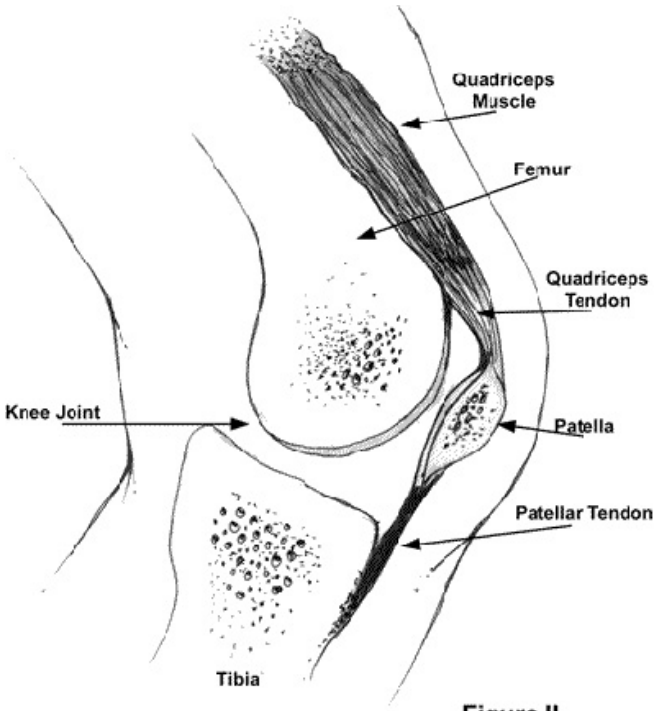
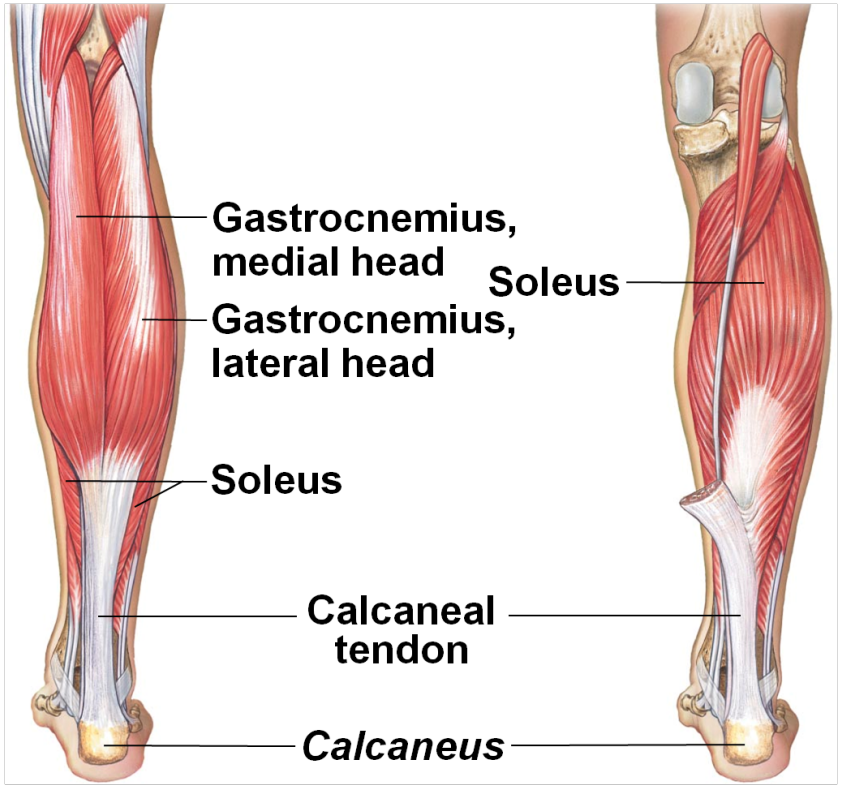


Figure II
Side View of Knee Joint

Excessive rotation around the knee can cause straining of the of the quadriceps and patellar tendon and can also lead to the softening and breakdown of the cartilage on the patella and cause pain in the underlying bone and irritation of the joint lining

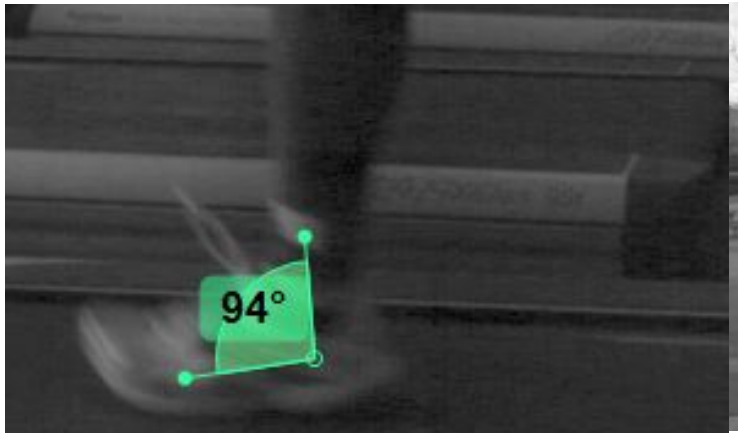
Some review…

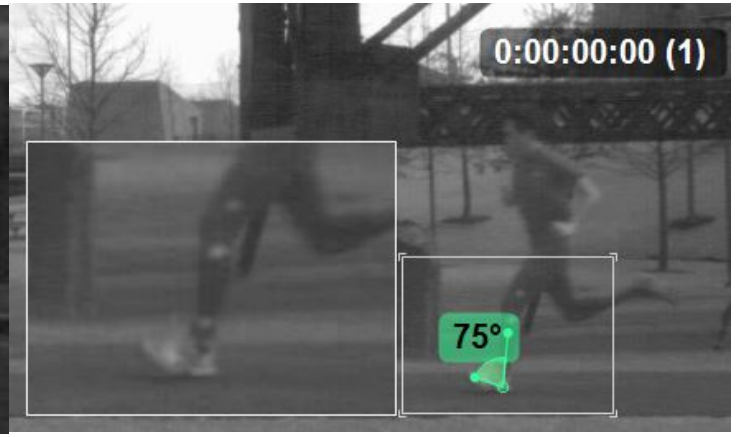


Superficial muscles, posterior view

Ankle at moment of impact

TREADMILL	ROAD
Angle: 94°	Angle: 75°
Ankle is slightly plantarflexed.	Ankle is dorsiflexed.
Encourages a ***midfoot strike***	Encourages ***heel strike***





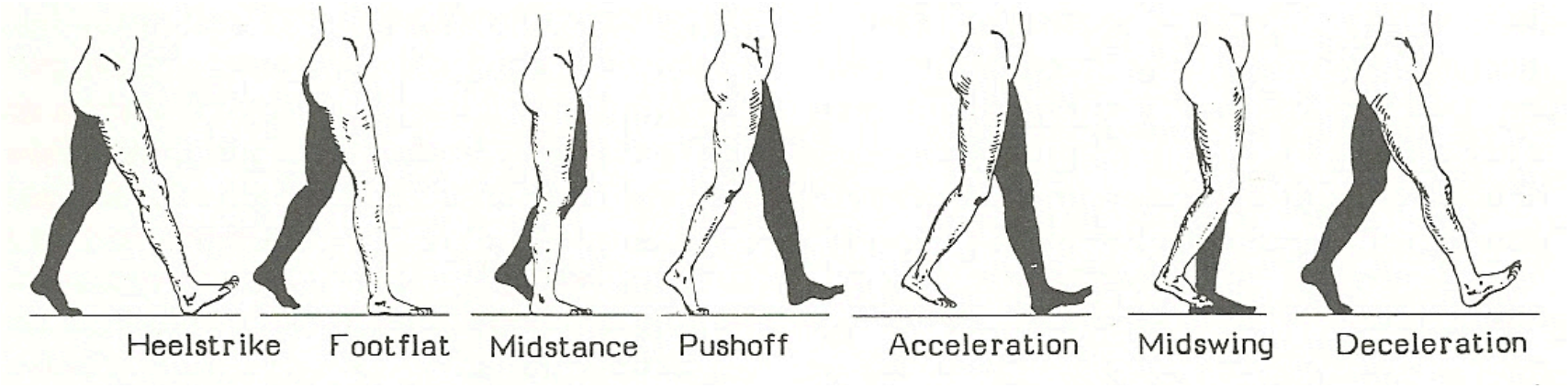
Midfoot vs Heel Strike (Lieberman et al. 2010)

	MIDFOOT STRIKE	HEEL STRIKE
Moment of Impact	Whole foot hits the ground together (largely distributing the impact force over a large surface area)	Heel hits the ground first
Between stance to toe off	Ankle dorsiflexes, stretching the calf muscles and Achilles tendon	Ankle dorsiflexes less and calf muscles and Achilles tendon does not store as much potential energy
Vertical Momentum	Converted into rotational momentum	Absorbed upon impact

Stride Frequency/Rate

- Generally, the frequency remains relatively the same at any speed.
  - Runners simply vary the stride length to run faster or slower

- A individual's natural or preferred stride frequency is a product of the stiffness of the legs and quality of tendons/ ligaments.



Actual Video of Treadmill Running

Actual Video of Road Running

Calculation

Treadmill:

$$\frac{85\,frames}{stride} \times \frac{8ms}{frame} \times \frac{1s}{1000ms} = 0.68\,\mathrm{s}\,/\,stride$$

$$\frac{1}{0.68s\,/\,stride} \times \frac{60s}{\min} = 88.24\ strides\,/\,\min\,(per\ leg)$$

$$\frac{88.24\ strides}{\min} \times 2 = 176.47\ strides\,/\,\min$$

Road:

$$\frac{90\,frames}{stride} \times \frac{8ms}{frame} \times \frac{1s}{1000ms} = 0.72\,\mathrm{s}\,/\,stride$$

$$\frac{1}{0.72s\,/\,stride} \times \frac{60s}{\min} = 83.33\ strides\,/\,\min\,(per\ leg)$$

$$\frac{83.33\ strides}{\min} \times 2 = 166.67\ strides\,/\,\min$$

5 frames (40 ms) fewer results in a 5.88% increase in stride frequency!

As soon as the foot makes contact with the moving band, the band grabs and pulls the leg backward faster, increasing the turnover rate.

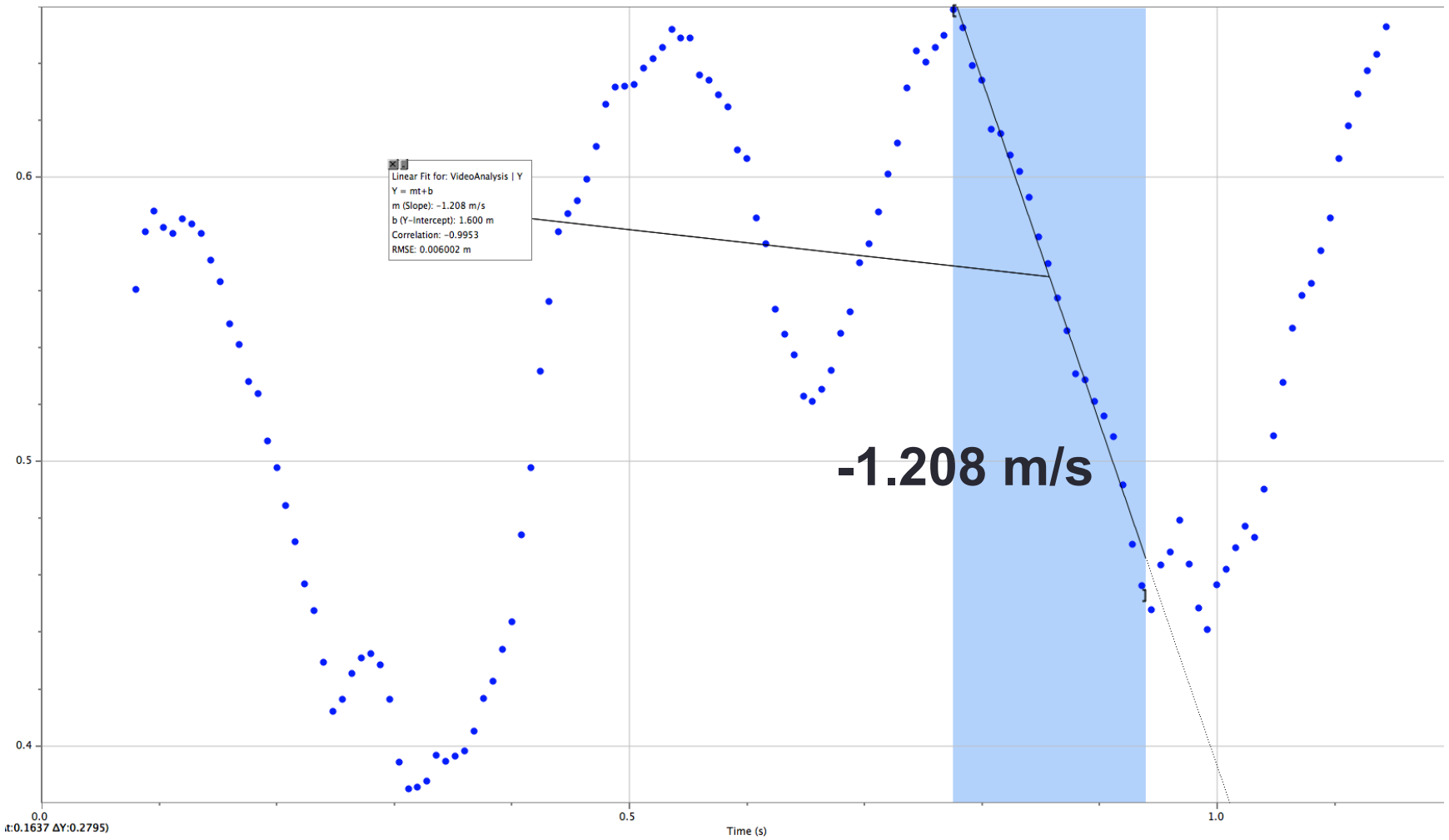
Higher Step Rate and Biomechanics
(Heiderscheit et al. 2011)

- Forces smaller strides length, which brings a runner's feet more directly under them instead of out in front.

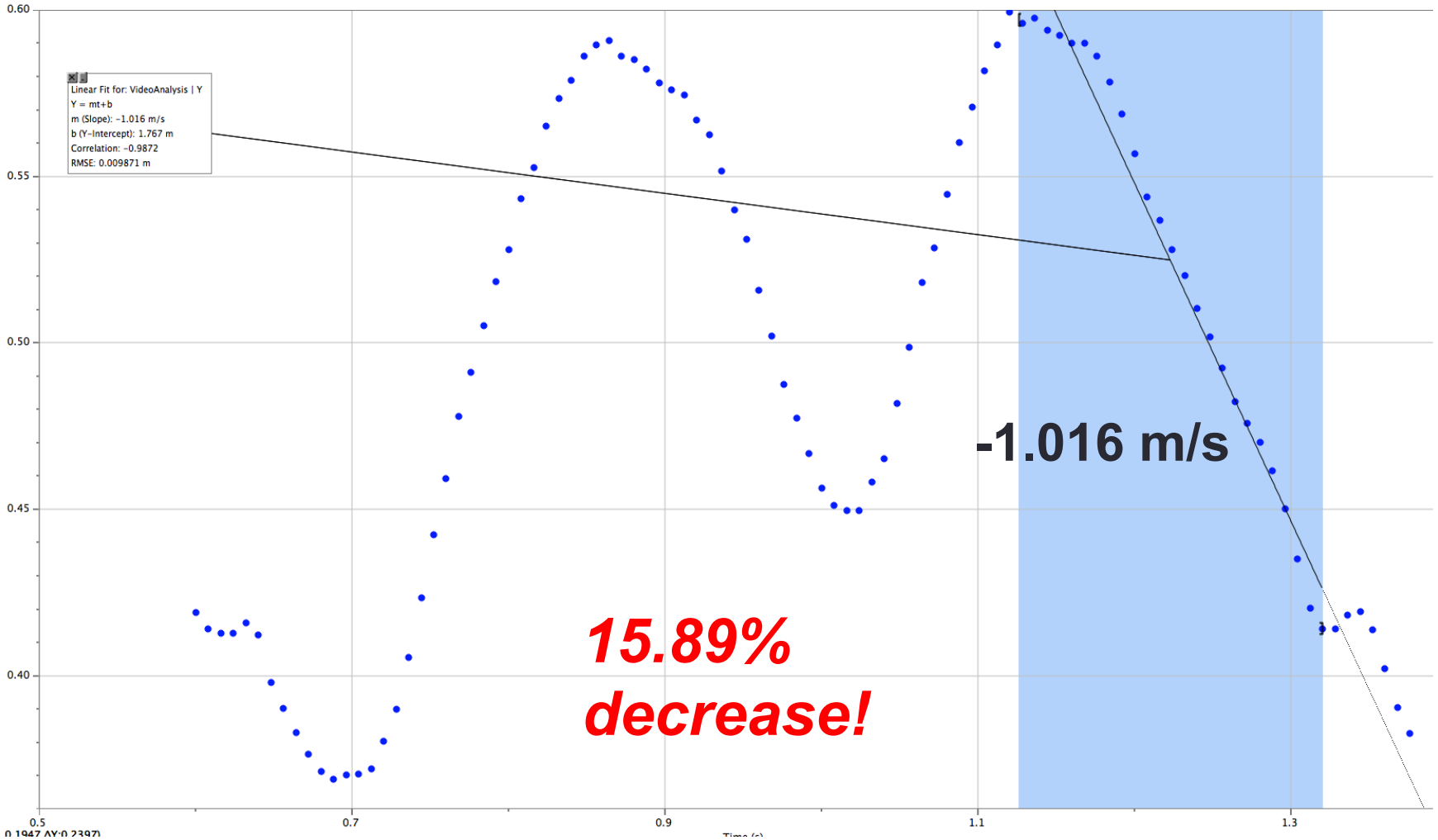
- Decreases the aerial phase (time spent in the air)
  - *Smaller* vertical velocity at landing
  - Thus, less energy absorption (negative work) is required by the lower extremity joints.
  - Reducing risks of injury!

- Elite runners typically run at a higher stride frequency between 180-200 steps/min
  - more of a "rolling motion"

Vertical Velocity for Road Running



Vertical Velocity on Treadmill



Summary

1. When used properly, treadmill reduces the injury to the runner's knee as it decreases extension.

2. Encourages a midfoot strike, a preferred form that reduces impact force

3. The "pull" force of the treadmill increases turnover rate of the leg

Other areas to consider

- Wind resistance
- Different running velocity
- Barefoot vs. footwear
- Road/surface conditions
- VO2 consumption

References

Heiderscheit, Bryan C., Elizabeth S. Chumanov, Max P. Michalski, Christa M. Wille, and Michael B. Ryan. "Effects of Step Rate Manipulation on Joint Mechanics during Running." *Medicine & Science in Sports & Exercise* 43.2 (2011): 296-302. Print.

Lieberman, Daniel E., Madhusudhan Venkadesan, William A. Werbel, Adam I. Daoud, Susan D'Andrea, Irene S. Davis, Robert Ojiambo Mang'Eni, and Yannis Pitsiladis. "Foot Strike Patterns and Collision Forces in Habitually Barefoot versus Shod Runners." *Nature* 463.7280 (2010): 531-35. Print.

QUESTIONS?