Running Biomechanics

Optimising running form for improved performance & injury outcomes

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University of Salford MANCHESTER 1967-2017 50 YEARS

Manchester Institute of Health & Performance

The Running Clinics

The Manchester Institute of Health & Performance

Overground running analysis: impact forces/ movement patterns

www.mihp.co.uk

Salford University: Running Performance Clinic

Treadmill running analysis: movement patterns

www.runningperformanceclinic.com

Session Aims

The aim of the session is to identify & discuss aspects of running biomechanics that may optimise running performance & reduce the incidence of running related injuries, including:

- Identify aspects of running form associated with high performance & economical running.
- Identify aspects of running form that may increase the risk of running related injuries.
- Discuss practical methods for improving running form.
- Discuss how this can be integrated into the training program.

Running Economy

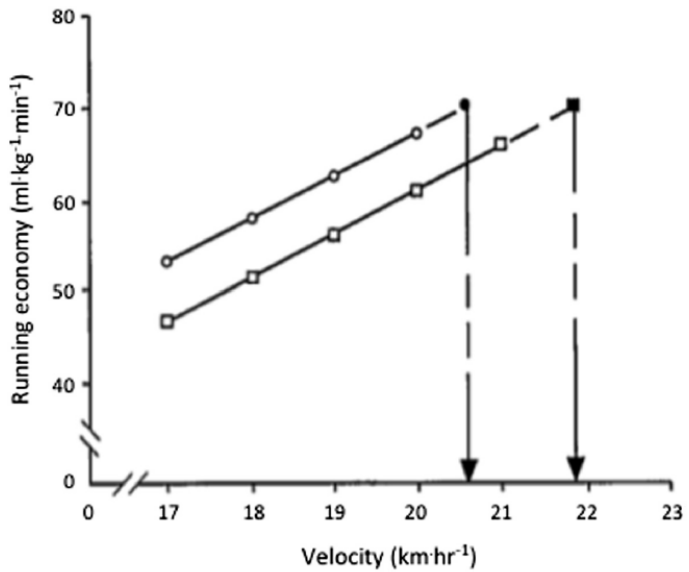


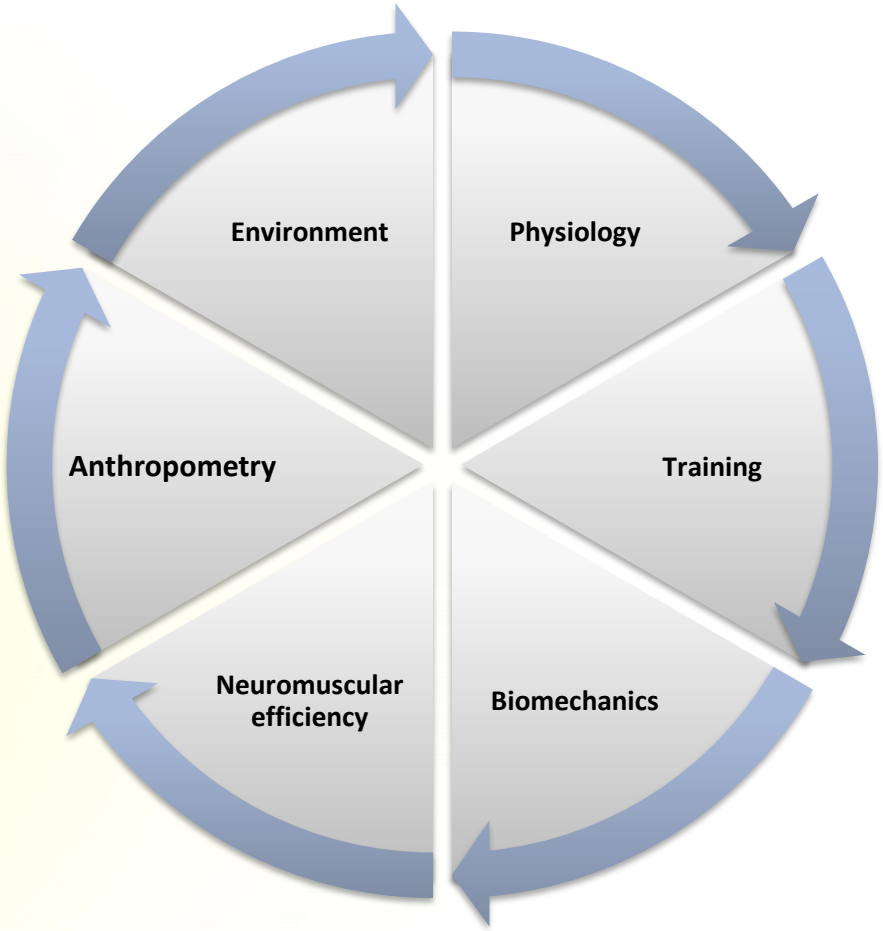
Figure 1 Running economy profiles of two runners of equal VO_2max.

Steady state oxygen consumption or energy cost, at a given running velocity

(Barnes & Kilding, 2015)

Contributors to Running Economy

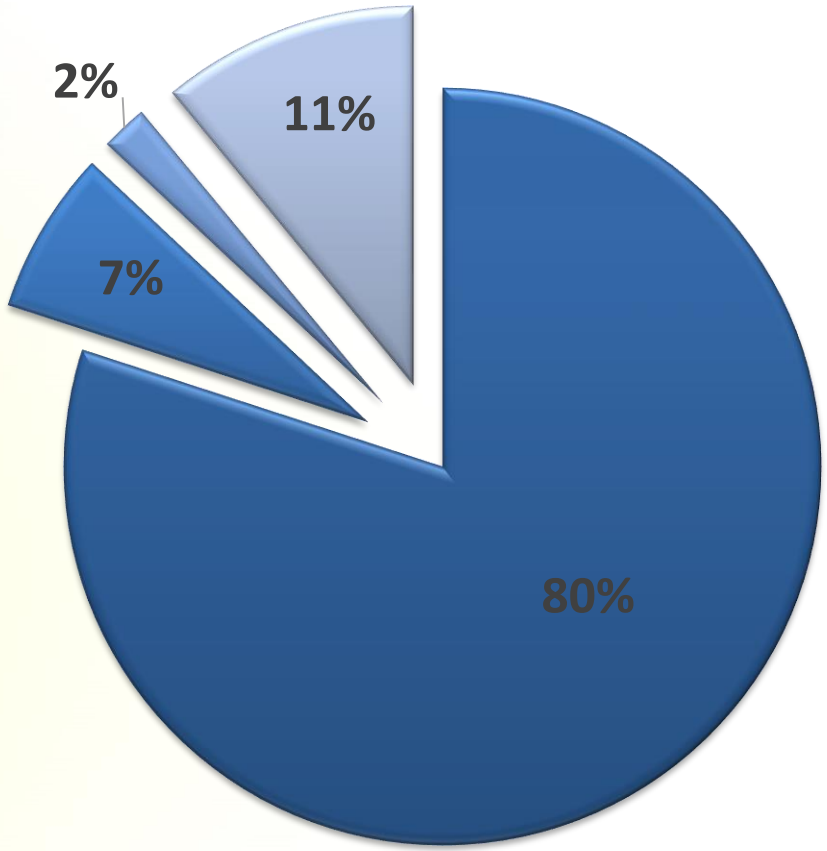
- Multifactorial process
- Interrelation between multiple components
- Each component equally important



(Barnes & Kilding, 2015)

Energy Cost of Running

- Body Weight Support & Forward Propulsion
- Leg Swing
- Lateral Balance
- Unexplained



(Arellano & Kram, 2014)

Does running form matter?

Improve economy:

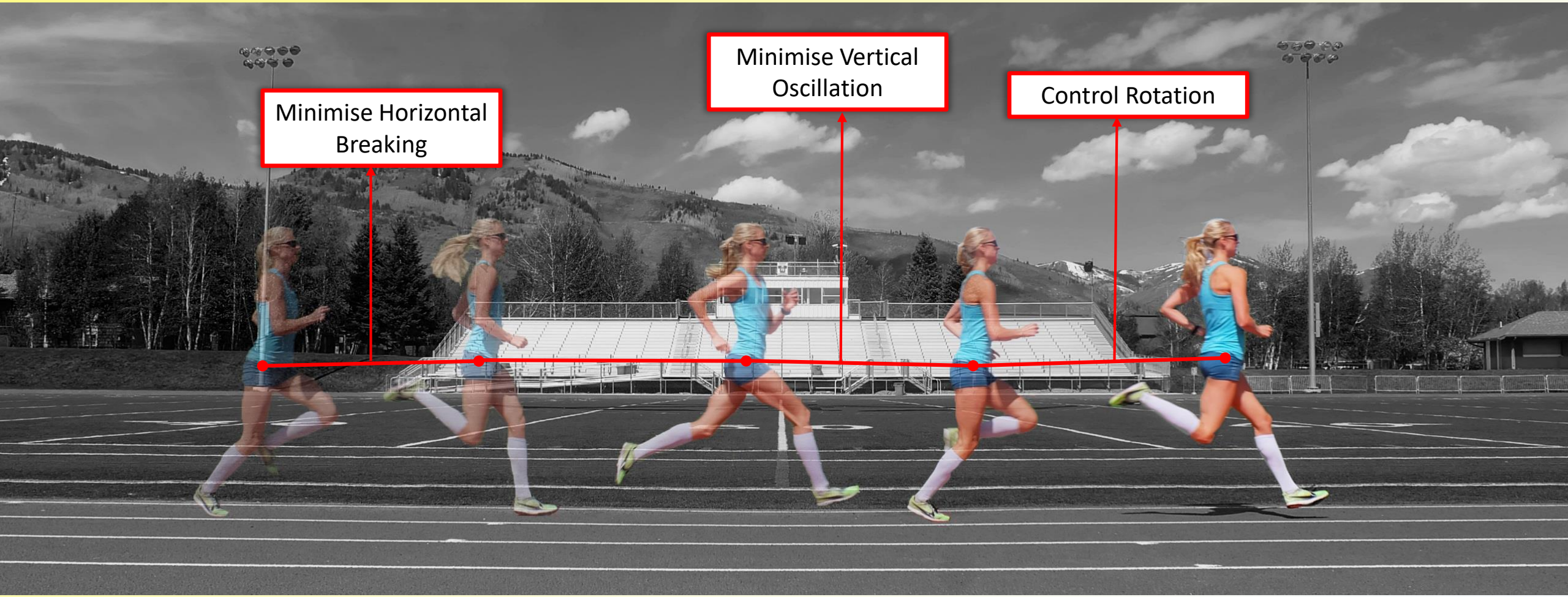
1. Minimise energy cost of force absorption & force generation
2. Storage & return of elastic energy

Reduce injury risk:

1. Reduce stress to musculoskeletal system
2. Maximise training time

The Gait Cycle

Maintain Horizontal Velocity of the Pelvis



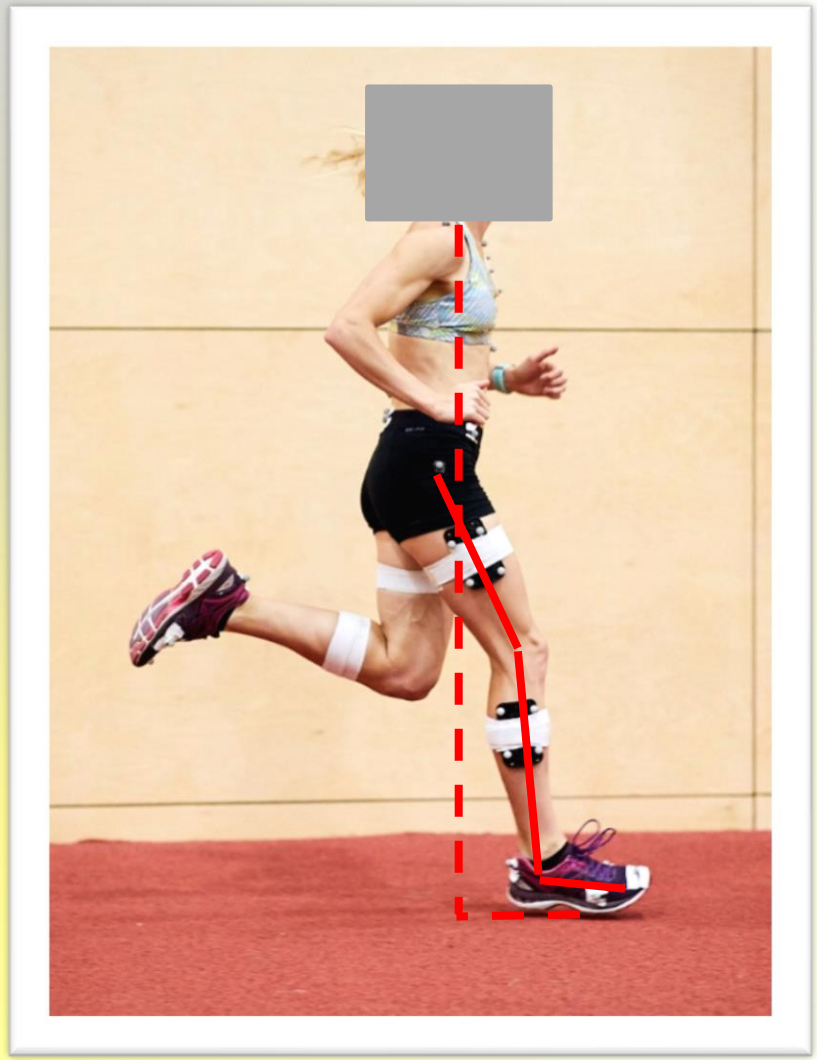
(Folland et al, 2017)

Trunk Positioning: Forward Lean

- Conflicting literature as to whether forward lean is beneficial/ economical
- Balance between too far forward v too upright
- Forward lean may maintain forward CoM movement
- Lean from the ankles, not the waist

(Williams & Cavanagh 1987; Moore et al, 2016; Preece et al 2016)

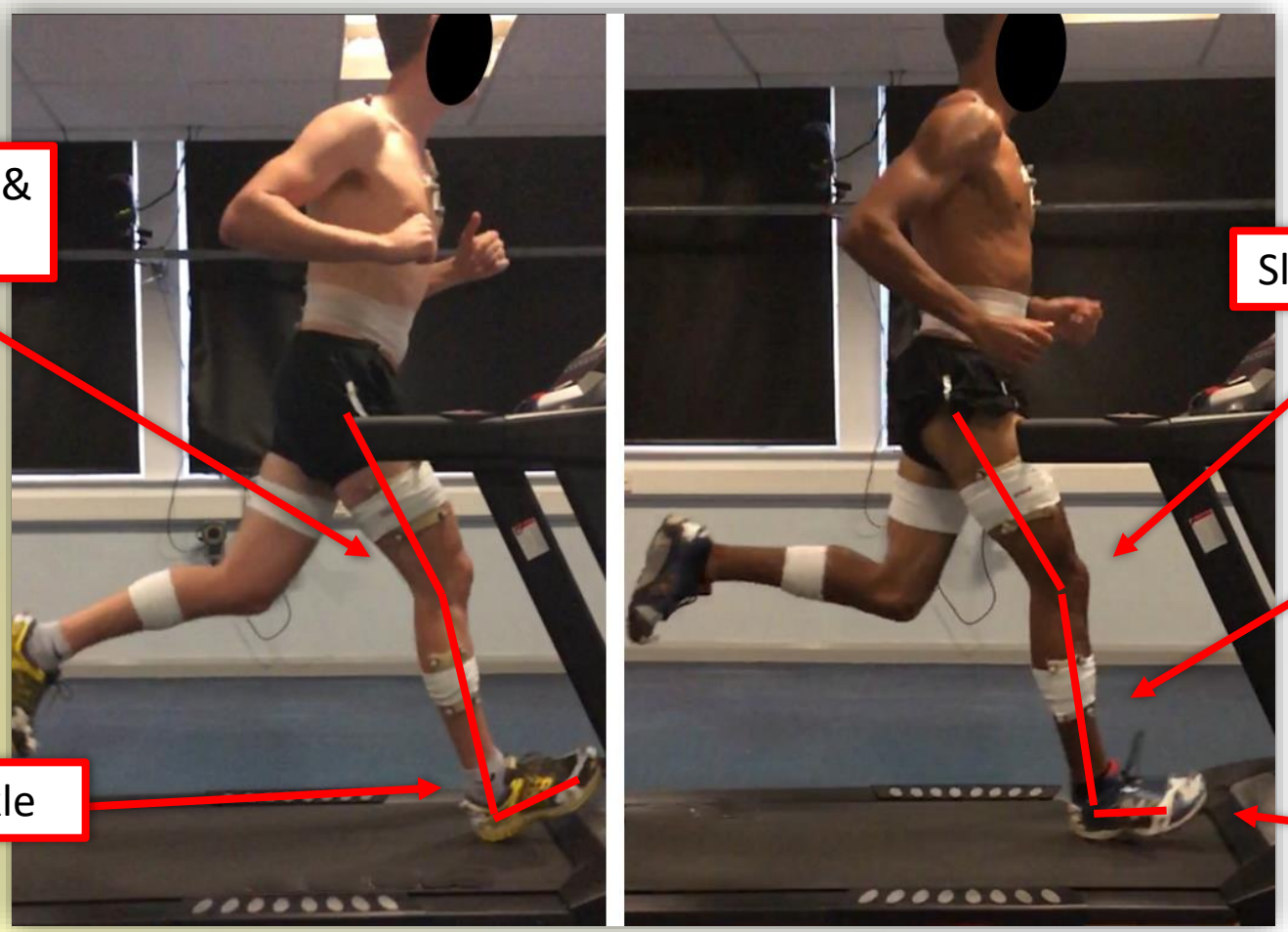
Initial Contact



- Vertical shin
- Slight knee flexion
- Low foot inclination
- Foot close to centre of mass

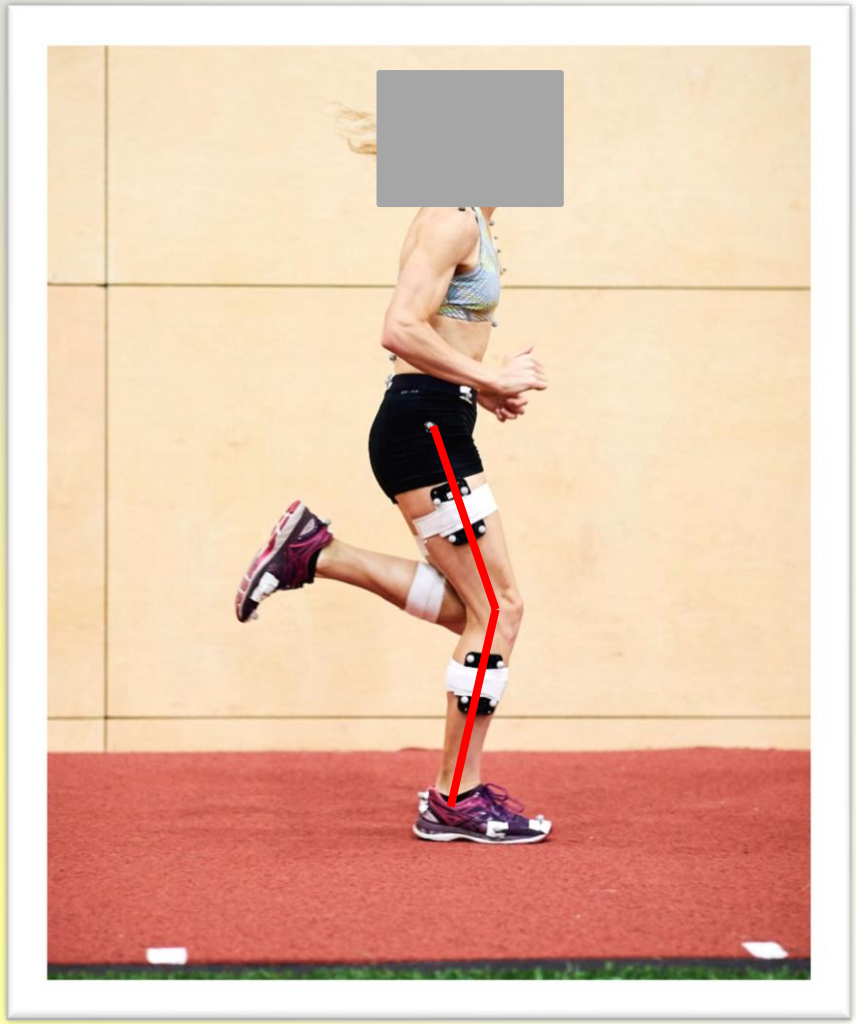
(Folland et al, 2017; Williams & Cavanagh 1987)

Initial Contact



(Bramah et al, 2018)

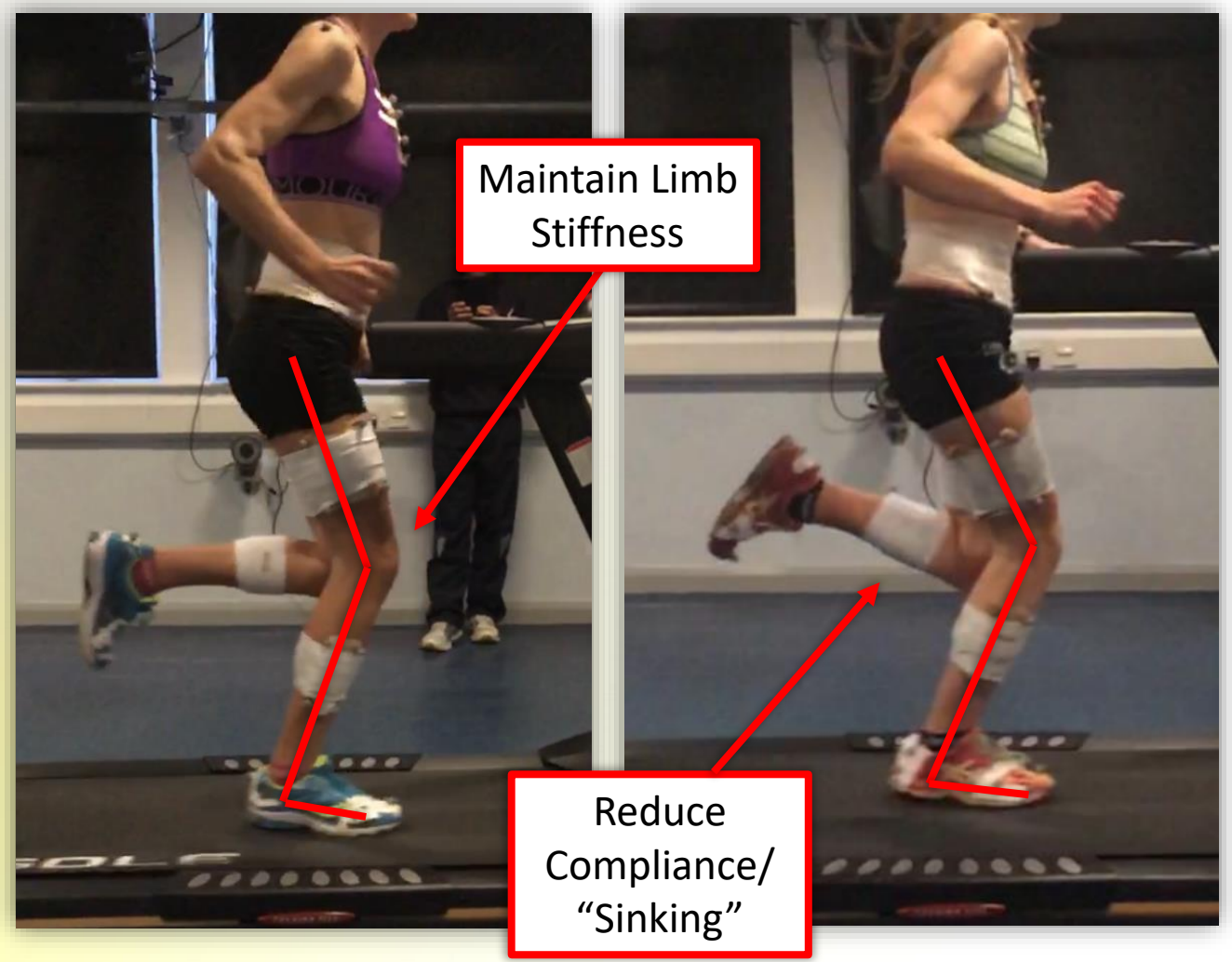
Mid – Stance



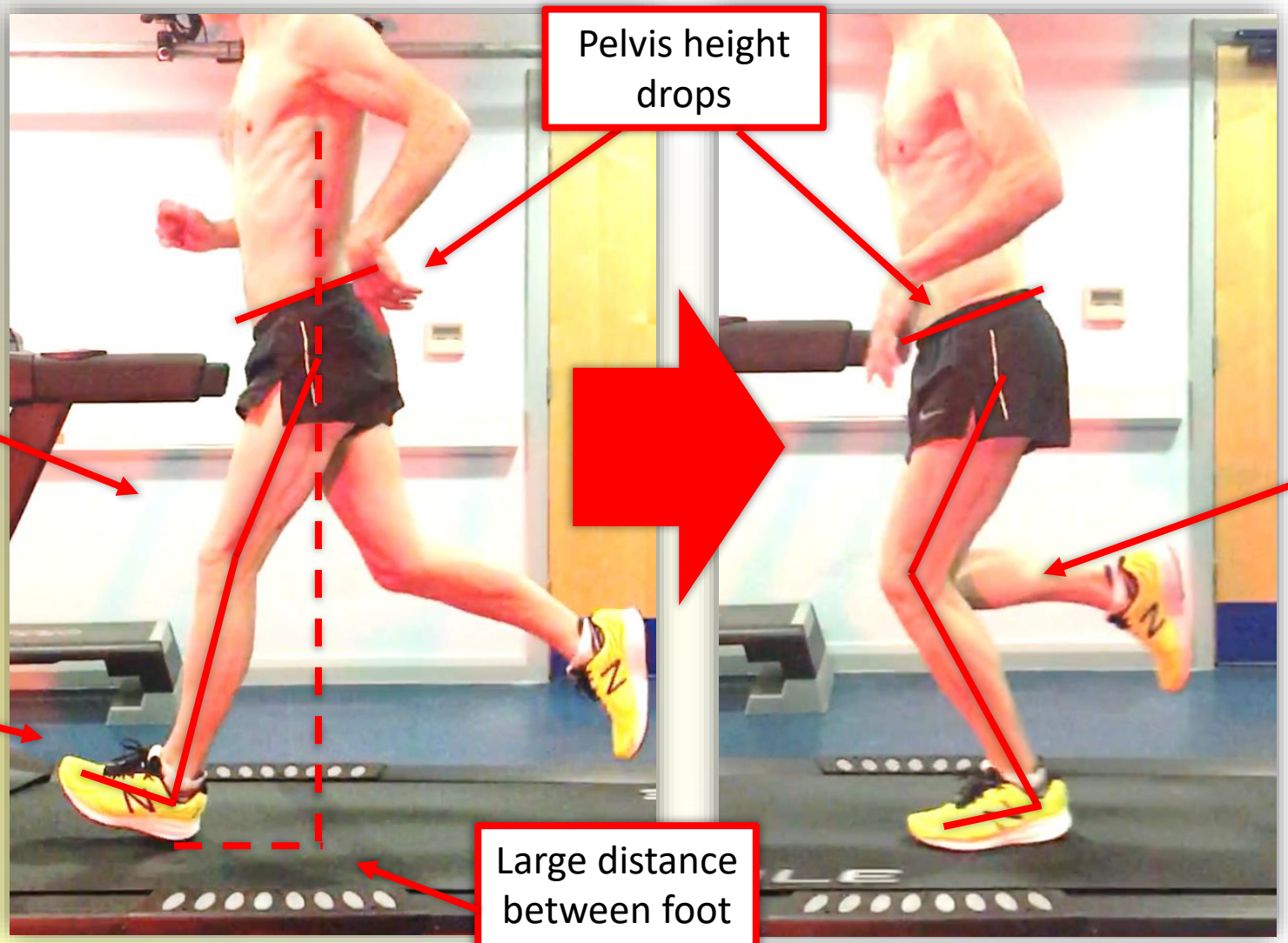
- **Pelvis**
  - Minimise vertical drop/ sinking
  - Minimise horizontal breaking
  - Minimise rotation
- **Lower limb**
  - Balance between stiffness & compliance
  - Minimise sinking
  - Optimise store & return of energy

(Folland et al, 2017; Tam et al 2018)

Mid Stance



Initial Contact to Mid stance



Pelvis height drops

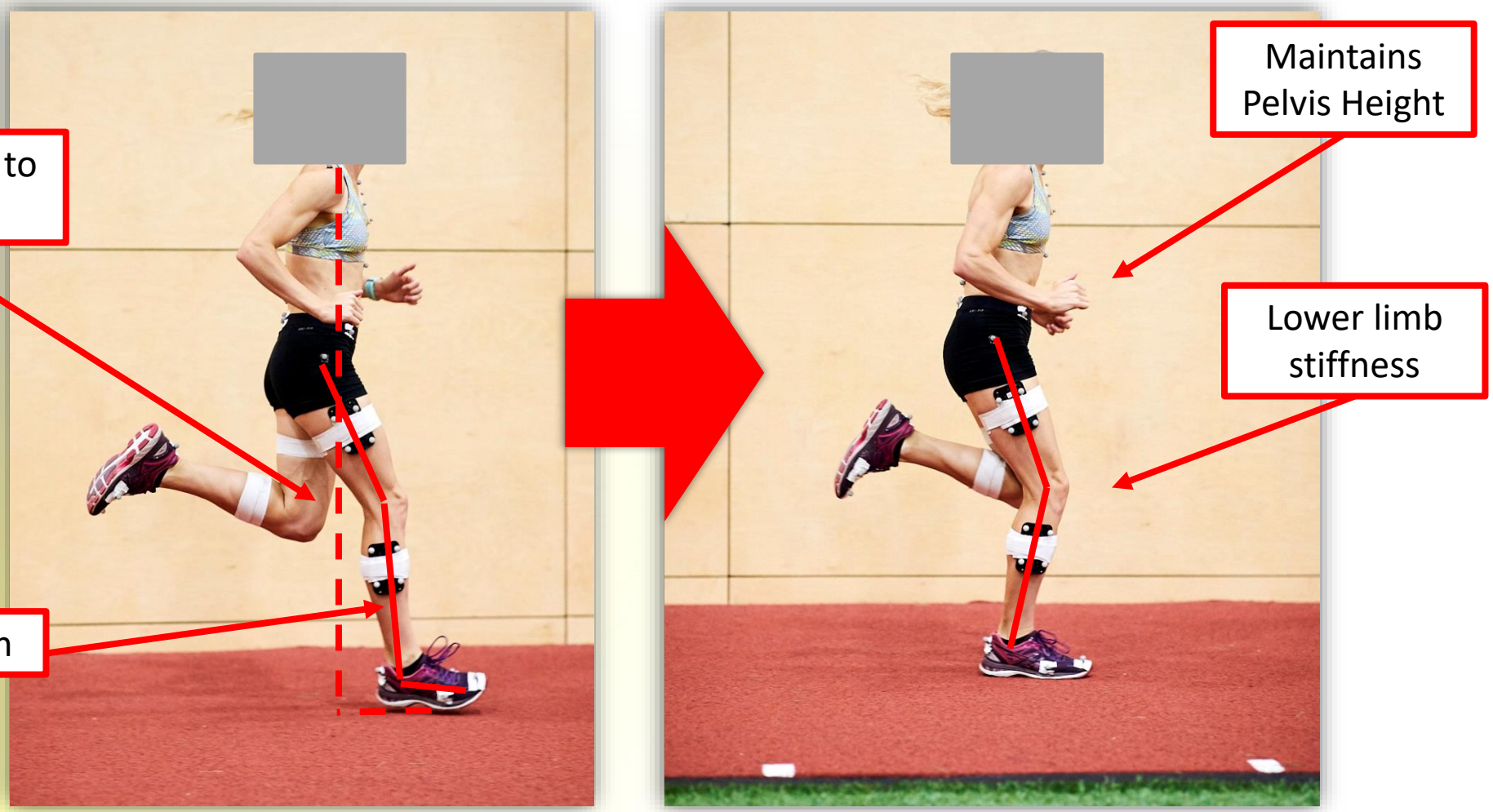
Extended Leg

Compliant lower limb

Inclined Ankle

Large distance between foot & CoM

Initial Contact to Mid stance

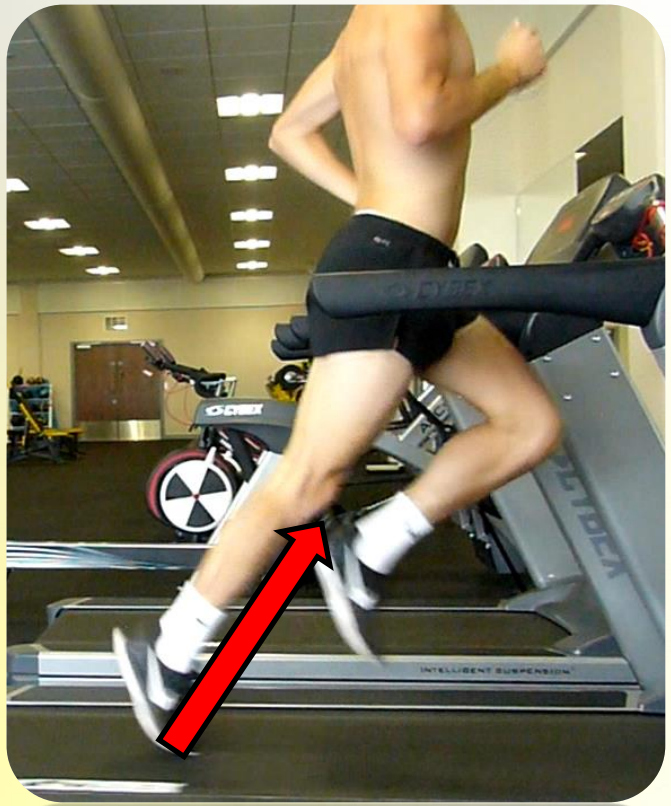


Toe off

- Triple extension is a myth
- Improved running economy associated with less leg extension at toe off
- Force application in the horizontal direction, not the vertical direction

(Moore et al, 2012; 2015; 2016)

Toe off

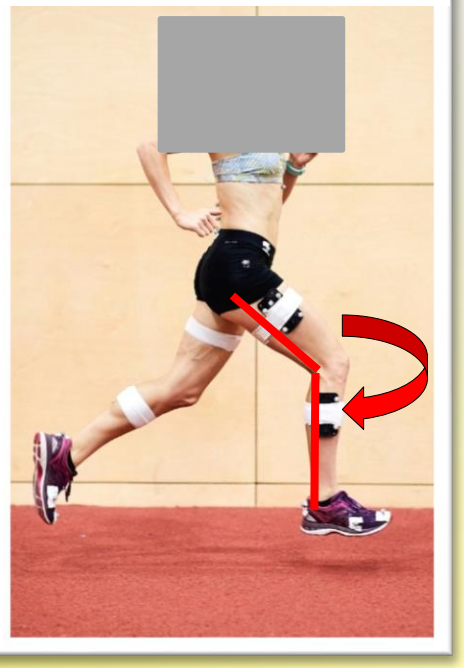
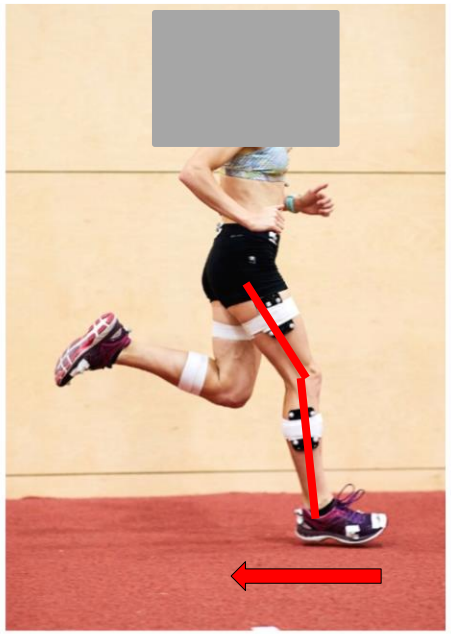
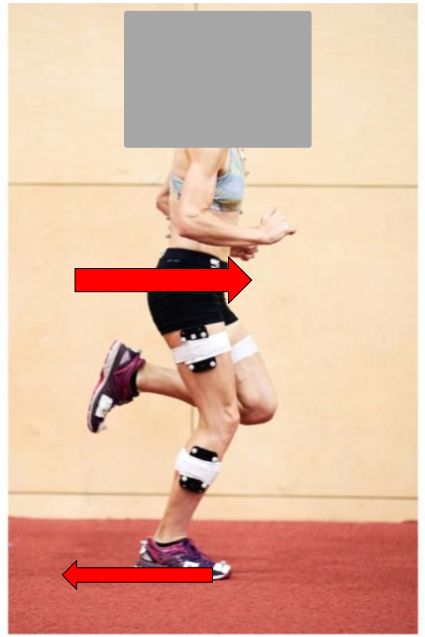


Swing Phase

What we do before touchdown really matters!

(Preece et al, in review)

The Gait Cycle

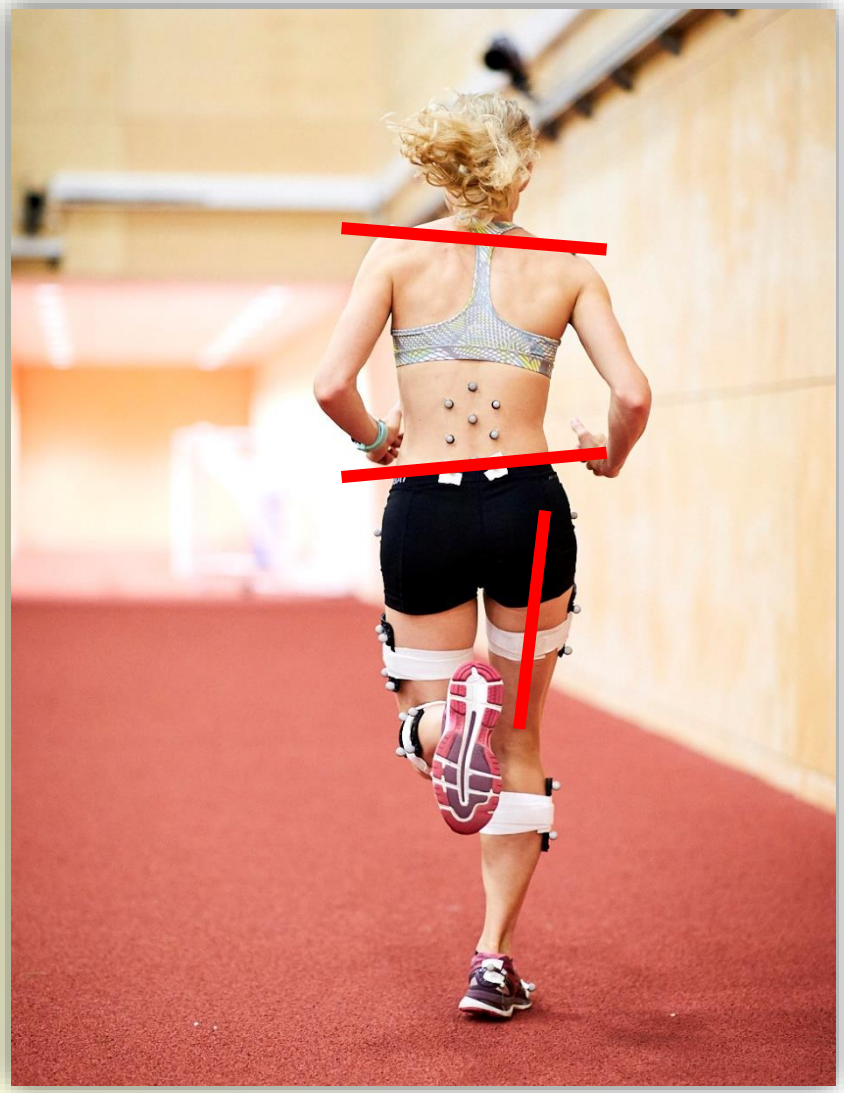
Terminal Swing	Initial Contact	Mid Stance	Mid Stance	Toe Off
				
• Knee flexes backwards	• Achieve lower limb positioning at contact	• Pelvis moves forward over the foot	• Foot positioned further back • Lower limb stiffness maintained	• Energy stored released in optimal direction

(Preece et al, in review)

Mid – Stance: Frontal Plane

Trunk & Pelvis:

- Controlled & balanced movement between the two
- Pelvic drop may increase stress on lower limbs
- **Optimise: minimise side to side displacement**



Hip & Knee:

- Control inward thigh movement
- Hip & knee collapse associated with injury
- **Optimise: Control alignment of hip and knee**

(Bramah et al, 2018)

Technical Model of Running Gait

Pelvis	Trunk	Contact	Mid stance	Toe off	Swing
Maintain Horizontal Velocity	Balance between too upright & too far forward	Minimise foot distance from centre of mass	Leg stiffness: balance between too stiff or too compliant	Avoid over extension of knee & ankle	Avoid excessive knee & lower limb flexion
Minimise Vertical Oscillation	Arms: controlled forward & back	Vertical Shin & Slight knee flexion	Knee & Ankle Angle: Balance between too much RoM & too little	Apply force in the horizontal direction	Recovery leg: Hip flexion following toe off Thigh inline with torso at mid stance
Control Rotation		Low foot inclination angle	Minimise excessive side to side position of pelvis & hip		Knee flexion prior to contact Foot to swing down and back

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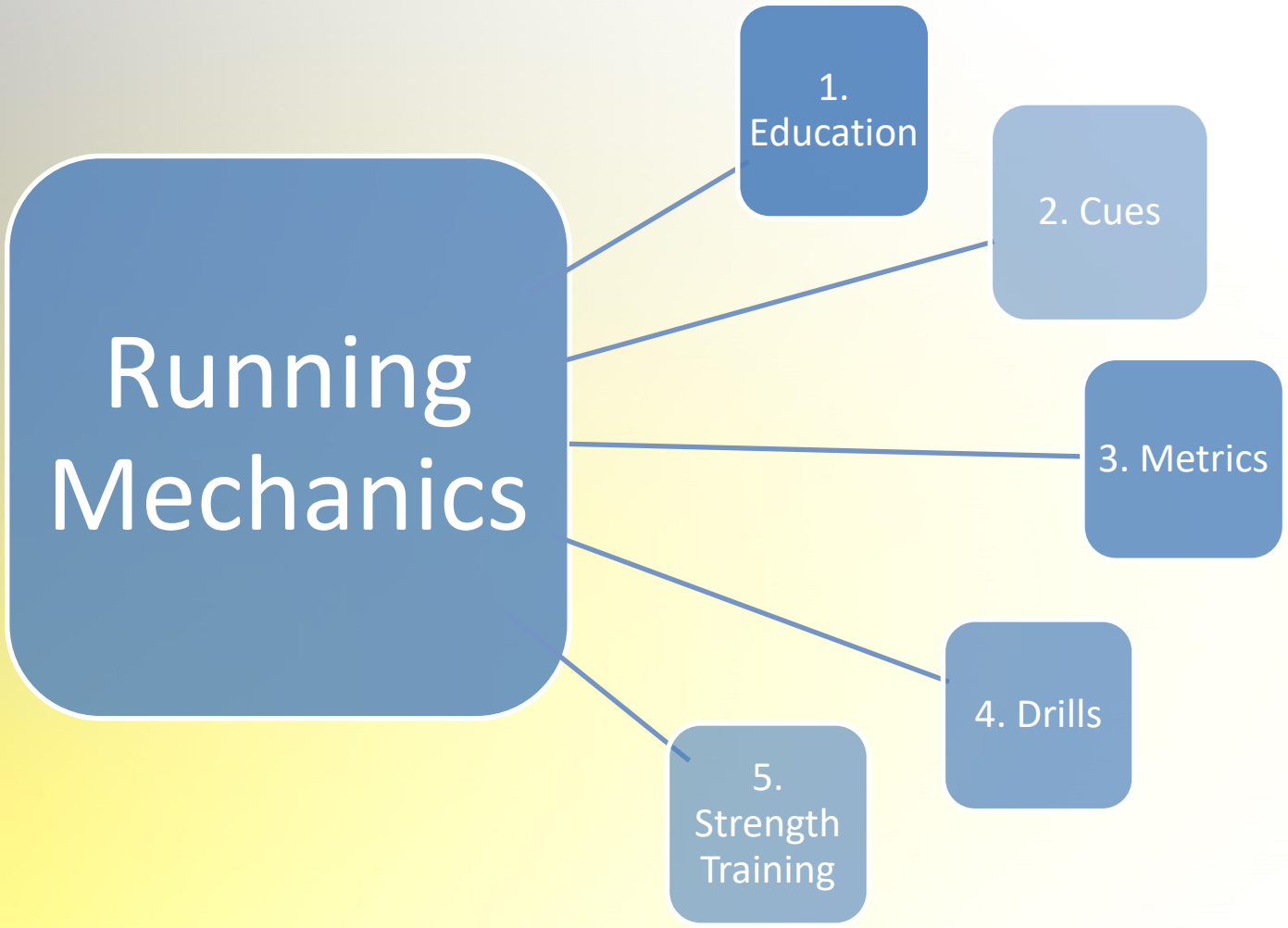
How do we influence mechanics?



1. Visual & verbal communication

2. Internal/ external cues

3. Step rate/ step length/ contact time

4. Neuromuscular re-education/ skill acquisition

5. Physical qualities/ neuromuscular function/ Musculotendinous Stiffness

Athlete Education

- What they are doing?
- What they are trying to achieve?
- Visual & verbal feedback

- Cue versus cure
- Opportunity to internalise problem solving

Metrics We Can Measure

Stride rate

- Influence kinematics & kinetics
- Inverse relationship with stride length

Stride length

- Balancing act
- Too high: energy cost swinging limbs
- Too low: energy cost absorb & generate force

Contact time

- Lower limb stiffness

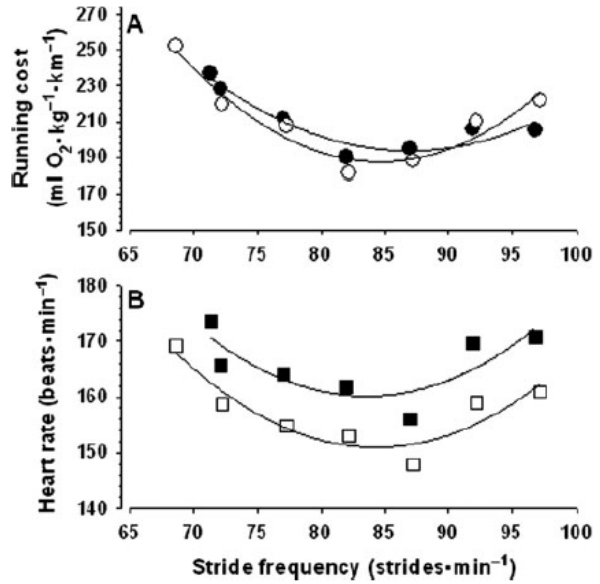


Figure 3. Running cost (A) and heart rate (B) as a function of stride frequency, obtained on two different days (black and white) in a trained runner (no. 10). Irrespective of the relationship used, optimal stride frequency was near 85 strides·min^{-1}.

Subtle changes may have a big impact, both positive & negative. Closely monitor changes made!

(de Ruiter et al, 2013)

Strength Training

Improve running economy (2% to 8%)

Improve time trial performance

Develop physical qualities for economical running

Greater motor neurone recruitment

Musculotendinous stiffness

Improve force generating capacity

Improve vVo2 (3% to 4%)

(Blagrove et al, 2017; Beattie et al, 2017)

Running Drills

- Neuromuscular exercise that aim to simulate aspects of running mechanics
- Challenge neuromuscular coordination & activation, stretch shorten cycle & rate of force development
- Overall aim to transfer movement pattern to function
- Integrated into warm up or as stand alone sessions
- However, the effectiveness of running drills remains speculative

(Azevedo et al, 2015)

Example of Internal/ External Cues

	Pelvis	Trunk	Contact	Mid stance	Swing
Target Parameter	Minimise Vertical Oscillation	Balance between too upright & too far forward	Minimise foot distance from centre of mass Vertical shin/ knee flexion/ low foot angle	Leg stiffness: reduce leg compliance	Recovery leg Knee flexion prior to contact Foot to swing down and back
Example Cue	"Hips Up" "Don't let your hips sink"	"Drop your chest forward" "Drift" or "Fall forwards"	"Get your foot underneath your body"	"React off the ground" "Quick foot contacts"	"Drive the thigh through" "Catch the ground"

Drills: Modified A-Skip

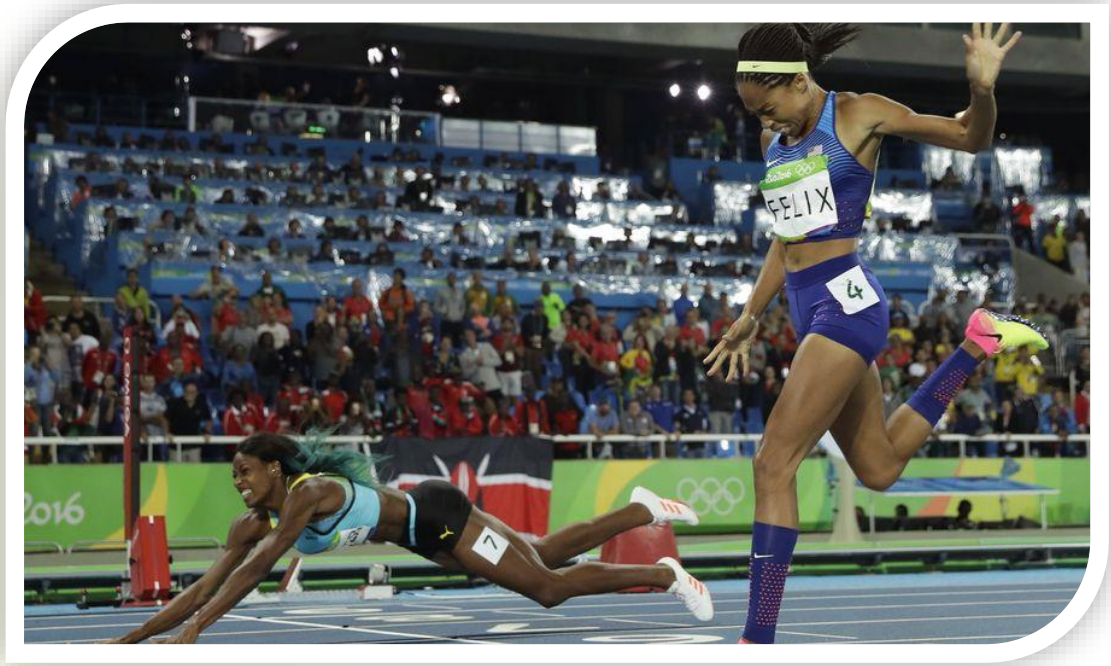
Drills: Fast Leg-A

Summary

- Current evidence highlights clear mechanical differences between “economical” and “uneconomical” runners
- “Poor” mechanics may increase the risk of injury leading to absence from training
- **If we can optimise running mechanics to reduce the risk of injury & improve economy = long term performance success**

Word of caution…

- Lack of evidence investigating acute and long term effects on running gait changes
- In some cases attempting to change mechanics may worsen economy & increase injury risk
- Mechanical changes & adaptations need to considered on an individual basis



Risk versus reward!