“You can observe a lot by just watching.”

- Yogi Berra
"Perfect is the enemy of good"
- Voltaire
OFTEN COMBINED W/ VIDEO ANALYSIS TO INVESTIGATE RUNNING TECHNIQUE & GUIDE CLINICAL DECISION MAKING RELATED TO FOOTWEAR & GAIT RETRAINING IN A CONTROLLED ENVIRONMENT

CRITICS OFTEN ARGUE TM RUNNING REQUIRES LESS PROPULSION AS THE BELT MOVES THE SUPPORTING LEG UNDER THE BODY

Motorized Treadmills

Barton et al. BJSM 2016
Dingene et al. Phys Ther Sport 2019
Milgrom et al. BJSM 2003
Frequency & Sex Distribution

Top 10 injuries

<table>
<thead>
<tr>
<th>INJURY</th>
<th>MEN (N/%)</th>
<th>WOMEN (N/%)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFPS</td>
<td>124/38</td>
<td>207/62</td>
<td>331</td>
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<tr>
<td>ITBS*</td>
<td>63/38</td>
<td>105/62</td>
<td>168</td>
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<tr>
<td>Plantar Fasciitis*</td>
<td>85/54</td>
<td>70/46</td>
<td>158</td>
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<tr>
<td>Meniscal Injuries*</td>
<td>69/59</td>
<td>31/33</td>
<td>100</td>
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<tr>
<td>Tibial Stress Syndrome*</td>
<td>43/43</td>
<td>59/57</td>
<td>99</td>
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<tr>
<td>Patellar Tendinopathy*</td>
<td>50/57</td>
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<td>96</td>
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<tr>
<td>Achilles Tendinitis*</td>
<td>55/55</td>
<td>47/47</td>
<td>102</td>
</tr>
<tr>
<td>Gastroc-soleus Injuries*</td>
<td>112/46</td>
<td>52/75</td>
<td>104</td>
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<tr>
<td>Stress Frx - Tibia</td>
<td>21/40</td>
<td>46/60</td>
<td>67</td>
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<tr>
<td>Spinal Injuries</td>
<td>24/51</td>
<td>20/49</td>
<td>44</td>
</tr>
</tbody>
</table>

* Sig Sex Difference P <0.05

Adapted from Taunton et al. BJSM 2002

RRI – Volume & Pace

VOLUME INJURIES
- Assumed to be located at anterolateral part of the knee
- PFPS
- ITB Syndrome
- Patellar tendinopathy

PACE INJURIES
- Assumed to be located at posterior part of lower leg
- AT
- Gastroc-soleus
- Plantar

Nielsen et al IJSPT 2013
Is motorized treadmill running biomechanically comparable to overground running?
A systematic review and meta-Analysis of cross over studies

BIOMECHANICS OF MT RUNNING LARGELY COMPARABLE TO OG RUNNING

BONE COMPRESSION & STRAINS AS WELL AS PLANTAR FASCIA STRAINS FOUND TO BE LOWER IN MT RUNNING

PEAK FORCES & LOADING RATES ON ACHILLES TENDON HIGHER AS ARE MM FORCES IN THE GASTROC & SOLEUS 12.5%, 15.6% & 14.2% ↑ in peak AT force, loading rate, & estimated cumulative AT force/km

Milgrom et al. BJSM 2003
Willy et al. JOSPT 2016
Sinclair et al. Foot Ankle Online J 2014
Yao et al. Biomed Eng Online 2019
Considerations

STIFFNESS SHOULD BE MATCHED AS CLOSELY AS POSSIBLE TO SPECIFIC OG (CONCRETE) SURFACE TO IMPROVE GENERALIZABILITY OF RESULTS

INTRA-BELT SPEED VARIATIONS AFFECT RUNNING BIOMECHANICS
- Inadequate motor power
- Too low belt speed update frequency
- Slip of the belt over the drivers
- Heavier subjects & higher running speeds result in higher friction & braking forces

A HIGH MOTOR POWER & BELT SPEED UPDATE F REQUIRED TO MINIMIZE BIOMECHANICAL DIFFERENCES

LOWER QUALITY COMMERCIAL MTS OFTEN HAVE LOWER MOTOR POWER & BELT SPEED UPDATE F

Familiarization

FAMILIARIZATION OR LACK THEREOF CAN AFFECT MT RUNNING BIOMECHANICS

STABLE MT RUNNING BIOMECHANICS HAVE BEEN SHOWN TO OCCUR ANYWHERE FROM 30s – 9’ IN A SINGLE SESSION

A FAMILIARIZATION PERIOD OF 6-8 SERVES AS AN APPROPRIATE RECOMMENDATION

Clinical Implications

MT RUNNING MAY BE SUITABLE FOR REHAB FOR LOWER LUMB STRESS FRACTURES

EXERCISE CAUTION IN CASE OF AT, ACHILLES RUPTURES OR CALF STRAINS
Perceptual Differences

PERCEPTUAL DIFFERENCES MAY INFLUENCE MT RUNNING BIOMECHANICS

INDIVIDUALS OFTEN PERCEIVE MT RUNNING SPEED AS FASTER THAN OG RUNNING SPEED

Higher perceived MT running speed may result in higher stride f & shorter stride lengths vs OG running

Miller et al. Sports Med 2019
Caramenti et al. PLoS One 2018

Treadmill vs overground running gait during childhood:
A qualitative and Quantitative Analysis

use of an instrumented treadmill is not a surrogate to the study of OG running in a pediatric population.
Validity and reliability of 2-dimensional video based assessment to analyze foot strike pattern and step rate during running: A systematic review

Main Findings

Strong evidence suggesting that 2D video analysis is highly reliable for determining FSP & step rate

Evidence that 2D video analysis is valid for the same outcomes is still limited & more studies are needed

Considerations

3 parameters suggested as potential factors that could influence validity & reliability of 2D video analysis of FSP & step rate:

- Clinical experience of the assessor
- Settings for 2D video recordings
- Categorization of FSP
Clinical experience of the assessor
Video-based assessment of foot strike pattern and step rate is valid and reliable in runners with patellofemoral pain

Experience of the assessor does not affect reliability of a 2D video analysis in assessing the FSP or calculating step rate

Settings for 2D Video Recordings

2D CAMERA @ 120 HZ IS RELIABLE FOR ASSESSING IC, MS, & MIDFLIGHT DURING GAIT IN HEALTHY & INJURED RUNNERS
30 HZ CAMERA AFFORDS EXCELLENT INDEX OF RELIABILITY OF 2D VIDEO ANALYSIS ON FSP & STEP RATE
2D VIDEO ASSESSMENTS DON'T REQUIRE EXPENSIVE EQUIPMENT SINCE LOWER FRAME RATE CAMERA DID NOT AFFECT RELIABILITY OF THE 2D VIDEO ASSESSMENTS

Categorization of FSP

3-POINT SCALES AFFORD A BETTER OPTION FOR DETERMINING FSP TO OPTIMIZE RELIABILITY OF 2D VIDEO ANALYSIS
2D VIDEO SETUP IS NOT COMPROMISED BY THE NUMBER OF CATEGORIES IN WHICH THE FSP IS CLASSIFIED
IN THIS CONTEXT, OUR RESULTS CONFIRMED THAT THE NUMBER OF CATEGORIES OR SCALES USED FOR EXAMINING THE FSP SEEMS NOT TO AFFECT THE RELIABILITY OF THE 2D VIDEO ANALYSIS
GOOD TO EXCELLENT CONCURRENT VALIDITY WERE OBSERVED USING 2 (REARFOOT, NON-REARFOOT STRIKE) OR 3 CATEGORIES (REARFOOT, MIDFOOT, FOREFOOT STRIKE)
# The S's of TM Analysis™

<table>
<thead>
<tr>
<th>Attribute</th>
<th>RFS</th>
<th>MFS</th>
<th>FFS</th>
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<tbody>
<tr>
<td><strong>Strike</strong></td>
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<tr>
<td><strong>Step Rate</strong></td>
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<td>165-175</td>
<td>&gt;175</td>
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<td>Loud</td>
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<td>No</td>
<td></td>
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<tr>
<td><strong>Step Width</strong></td>
<td>Presence of crossover: Y/N</td>
<td>Side: L/R</td>
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<td><strong>Shank</strong></td>
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<td>0-10</td>
<td>10+</td>
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<tr>
<td><strong>Speed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Swing</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Shoes</strong></td>
<td></td>
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</table>
Demystifying Footstrike

REARFOOT STRIKE (RFS)
Contact initiated w/ lateral aspect of the heel

MIDFOOT STRIKE (MFS)
Contact initiated across the met heads w/ heel subsequently contacting the ground

FOREFOOT STRIKE (FFS)
Contact also occurs on met heads though heel never touches the ground

Foot strike patterns of recreational and sub-elite runners
In a long-distance road race
Foot strike patterns for relay, ½ marathon & marathon runners @ ~ 10km

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<tr>
<th>Pattern</th>
<th>Count</th>
<th>Percentage</th>
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<td>88.9</td>
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<td>Midfoot</td>
<td>32</td>
<td>3.4</td>
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<tr>
<td>Forefoot</td>
<td>17</td>
<td>1.8</td>
</tr>
<tr>
<td>Asymmetrical</td>
<td>55</td>
<td>5.9</td>
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</table>

Foot strike patterns for marathon runners @ ~ 10km and 32 km

<table>
<thead>
<tr>
<th>Foot Strike Pattern</th>
<th>10km Count</th>
<th>10km Percentage</th>
<th>32km Count</th>
<th>32km Percentage</th>
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<tbody>
<tr>
<td>Rearfoot</td>
<td>251</td>
<td>87.8</td>
<td>266</td>
<td>93.0</td>
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<tr>
<td>Midfoot</td>
<td>9</td>
<td>3.1</td>
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<td>3.5</td>
</tr>
<tr>
<td>Forefoot</td>
<td>4</td>
<td>1.4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Asymmetrical</td>
<td>22</td>
<td>7.7</td>
<td>10</td>
<td>3.5</td>
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</tbody>
</table>

Foot strike patterns of runners at the 15 km point

During an elite-level half marathon
Strike Patterns Among Runners

AMONG ALL ANALYZED RUNNERS (N=283)
- RFS - 74.9%
- MFS - 23.7%
- FFS - 1.4%

AMONG THE TOP 50 RUNNERS
- RFS - 62%
- MFS - 36%
- FFS - 2%

Making Sense of Strike

**RFS**
- Defined impact peak in vertical GRF
- Higher loading rate in early stance

**FFS**
- Eliminates impact peak
- Greater knee flexion angle @ IC
- Greater eccentric loading of calf musculature
- Results in shorter stride length

**MFS**
- More variable
- Falls somewhere b/w RFS & FFS
PEAK HIP ADD REDUCED 3-4º
3-6% LOWER AT FORCE
10% REDUCTION IN PLANTAR LOADS
15-20% REDUCTION IN PFJ LOADS
18-20% REDUCTION IN VERTICAL GRF LOAD RATES
9-11% LOWER DEMAND ON GMED & GMAX

Why Not Just Turn Your Feet Over Faster?

Neal et al. 2018
Rohweder et al. 2017
Boersma et al. 2017
Bennet et al. 2016
Gibbons et al. 2016
De Smet et al. 2015
Sheehan et al. 2015
Kinematics

**HIP**
- Sig less peak hip flexion & ADD during LR with ↑d step rate

**KNEE**
- Most affected by manipulation of step f
- Sig more flexed knee @ IC
- Less peak knee flexion during stance (greater stiffness)

**ANKLE**
- More PF'd position @ IC with ↑d stride rate

**Effects of step rate manipulation**
**On joint mechanics during running**

“5-20”
Results

REDUCTION IN ENERGY ABSORPTION @ KNEE & HIP WHEN STEP RATE ↑ ABOVE PREFERRED

WHEN STEP LENGTH & STEP RATE MANIPULATED INDEPENDENTLY
Energy absorption observed only if step length ↓

The Knee

PEAK KNEE FLEXION DURING STANCE & COM VERTICAL EXCURSION OBSERVED TO ↓ AS STEP RATE ↑
Greater lower extremity stiffness

ONLY THE KNEE DISPLAYED SIG CHANGES IN ENERGY ABSORPTION B/W ALL STEP RATE CONDITIONS
20% decrease observed when preferred step rate was only increased 5%

APPEARS THAT REDUCING THE MAGNITUDE OF LOADING OUTWEIGHS THE DETRIMENTS OF INCREASED LOADING CYCLES
The Hip

5%-10% ↑ IN STEP RATE CAN SIGNIFICANTLY REDUCE PEAK HIP ADD DURING LR

REDUCTION IN HIP ABD & IR MOMENTS NOT REALIZED UNTIL STEP RATE ↑'D BY 10%

RUNNING WITH STEP RATE > THAN PREFERRED REDUCES THE HIP BIOMECHANICAL DEMANDS IN FRONTAL & TRANSVERSE PLANES

Energy Demands

↑'ING STEP RATE BY 10% ABOVE DID NOT ↑ O₂ CONSUMPTION OR HR

REDUCTION IN PEAK KNEE FLEXION OBSERVED @ HIGHER STEP RATE CONDITIONS

Improved economy?

Conclusion

REDUCTION IN ENERGY ABSORPTION OCCURS @ HIP & KNEE WHEN STEP RATE IS ↑'D TO 10% ABOVE PREFERRED

5% ↑ SEEMS TO REDUCE TOTAL WORK PERFORMED BY THE KNEE

REDUCTION IN JT LOADING VIA STEP RATE MANIPULATION MAY HAVE DISTINCT BENEFITS IN TX & PREVENTION OF COMMON RRIS
Influence of stride frequency and length on running mechanics: A systematic review

Ground Contact Time (GCT) seems to be a strong & direct determinant of leg stiffness.

\[ \text{↓'ing GCT yielded a sig ↑ in leg stiffness} \]

Conversely, ↑'ing CCT sig ↓'d leg stiffness.

\[ \text{↑'d step f results in ↓'d GCT, vertical displacement of COM, & leg length variation (compression)} \]
ASSOC EXISTS B/W LE STRESS FXS & IMPACT LOADING VARIABLES
↑'s in vertical impact peak (VIP) & vertical avg loading rate (VALR)
PROSPECTIVE RESEARCH HAS SHOWN THAT♀ RUNNERS WHO RECEIVED A MEDICAL DX OF INJURY vs RUNNERS W/O HX OF INJURY HAD HIGHER IMPACT VARIABLES
LANDING SOUND INTENSITY EXPLAINED 42% OF VARIABILITY IN MAGNITUDE OF VGRF DURING SINGLE LEG DROP LANDINGS

SOUND INTENSITY (DECIBELS)
A RUNNER'S IC MAY BE USEFUL TO REDUCE IMPACT LOADING
FEEDBACK W/ EXTERNAL FOCUS OF ATTN SHOWN TO ENHANCE MOTOR LEARNING
SOUND INTENSITY PROVIDES A MORE EXTERNAL FOCUS FOR BIOFEEDBACK THAN FOCUSING ON SPECIFIC BODY MVMT

RUNNERS W/ GREATER IMPACT PEAKS & HIGHER LOADING RATES HAVE SIG FEWER RRIS VS THOSE W/ LOWER IMPACT PEAKS & LOADING RATES. IMPACT FORCES FUNCTION TO PRE-TENSION OR TUNE THE MUSCLE OF THE LEG BEFORE IMPACT
Rapid & explosive mvmts (i.e. JUMPING & RUNNING) ENGENDER A GREATER STIMULUS FOR ↑ 'D BONE DENSITY & STRENGTH RELATIVE TO SIMILAR TOTAL LOADS APPLIED MORE SLOWLY
VGRF IMPACT & LOADING RATES IN ISOLATION DO NOT NECESSARILY EXPLAIN RRIS
May even play a protective role
Cumulative loads increase at the knee joint with slow-speed running compared to faster running:

A biomechanical study

Findings

CUMULATIVE LOAD @ KNEE JT FOR A GIVEN DISTANCE IS GREATER @ SLOW VS FAST-SPEED RUNNING

KNEE JT LOADS/STRIDE ↓'D WHEN RUNNING @ SLOWER SPEED

RUNNING @ A COMBINATION OF SLOW & FAST SPEEDS VS A SINGLE MODERATE SPEED, ↑'D CUMULATIVE VALR BUT NOT CUMULATIVE TIBIAL LOAD OR FREE MOMENT

Fast running does not contribute more to cumulative load than slow running.
RUNNING VELOCITY AFFECTS LOWER EXTREMITY KINEMATICS & KINETICS

SET TM SPEED TO A SIMILAR SPEED TO WHICH AN INJURED RUNNER EXPERIENCES SX

MATCH RUNNING VELOCITY OF THE RUNNER TO THAT WHICH CORRESPONDS TO THE PACE OF THE MOST RECENT "LONG RUN"

Uphill Running

↑'D MM ACTIVITY
Quads, hip flexors & PFs

↑'D HIP POWER GENERATION

COMPARE TO LEVEL & DH RUNNING
↓'d impact
↑'d energy costs

Vernillo et al. 2016
Telhan 2010
Ho 2018
Downhill Running

↑D HIP POWER ABSORPTION
↑D KNEE POWER ABSORPTION
↑D PF STRESS
↓D ANKLE POWER GENERATION
COMPARE TO LEVEL & DH RUNNING
↑d impacts
Energy costs
↓d if grade <20%
↑d if grade >20%

↑dimpacts
↓d  if grade <20% 
↑d  if grade >20%

Shank – Tibial Angle

OVERSTRIDING
Pattern in which the foot lands in front of the person's COM is assoc w/ reaching, including hip flexion & knee extension before IC

Distance from the heel @ IC to the runner's COM is a sig predictor of knee external moment (sagittal plane torque across knee jt during stance) & braking impulse during running

Important kinematic metric to consider when advanced technology (i.e force platforms or tibia accelerometers) are unavailable
↑d stride length assoc w/ ↑d increased risk of tibial stress fxs in runners

Presence & magnitude of overstriding may be the key risk factor

↑d Hip power absorption, ↑d Knee power absorption, ↑d PF stress, ↓d Ankle power generation compared to level & downhill running due to increasing impacts and energy costs. Overstriding is a pattern where the foot lands in front of the person's COM, associated with reaching and hip flexion/knee extension before IC. Distance from the heel at IC to the runner's COM is a significant predictor of knee external moment (sagittal plane torque across knee joint during stance) and braking impulse during running. An important kinematic metric to consider when advanced technology is unavailable. An increased stride length is associated with an increased risk of tibial stress fractures in runners. The presence and magnitude of overstriding may be the key risk factor.
Step Width

SIG INFLUENCES LE BIOMECHANICS DURING RUNNING

AS STEP WIDTH IS ↑ D THE FOLLOWING ↓
- Peak hip ADD angle
- Peak knee ABD moment
- Knee ABD impulse
- Peak rearfoot eversion angle

WHEN STEP WIDTH IS ↑ D FROM NARROW TO WIDE
- PEAK IR ANGLE ↑ SLIGHTLY
- PEAK HIP IR ANGLE DOES NOT CHANGE IN RESPONSE TO STEP WIDTH

Meardon et al. Sports Biomech 2012
Brindle et al. Gait & Posture 2014
Meardon & Derrick J Biomech 2014
Boyer & Derrick AJSM 2015

INVERSE RELATIONSHIP B/W STEP WIDTH & ITB STRAIN & STRAIN RATES
↑ D ITB STRAIN & STRAIN RATES ASSOC W/ ITB SYNDROME IN RUNNERS
LOWER STRAINS & STRAIN RATES SEEN IN WIDER RUNNING CONDITIONS SUGGEST...
- Wider step width may be beneficial in addressing ITBS

STEP WIDTH CHARACTERISTICS DESERVE CONSIDERATION ESP IN CONTEXT OF NARROW STEP WIDTH OR “CROSSOVER” PATTERN

Meardon et al. Sports Biomech 2012
Brindle et al. Gait & Posture 2014
Meardon & Derrick J Biomech 2014
Boyer & Derrick AJSM 2015
What We’ve Come To learn

INJURY RATES SIMILAR B/W BAREFOOT & SHOD RUNNERS WHEN CONTROLLING FOR MILEAGE BUT TEND TO AFFECT DIFFERENT REGIONS OF THE LOWER EXTREMITY.

Shod - more likely to experience injuries at level of knee
Barefoot - prone to injuries involving the tibialis posterior & plantar tissues

FURTHERMORE...

High impact loading & high loading rates are not necessarily linked to RRIs

[Reference: Altman & Davis BJSM 2016]
Benefits Cont’d

RELATIVE TO SHOD RUNNING, BAREFOOT RUNNING:...
  ↓ knee flexion excursion during MS
  ↓ subsequent peak knee extension moment

REDUCTION IN KNEE EXTENSION MOMENT MAY BE ADVANTAGEOUS FOR PFJ
PFJ stress = force/contact area
PFJ CONTACT AREA ↑ W/KNEE FLEXION ANGLES UP TO 60°
REDUCTION IN THE KNEE FLEXION ANGLE DURING BAREFOOT RUNNING MAY BE DELETERIOUS TO THE PFJ.

Take your shoes off to reduce patellofemoral joint stress during running
Cumulative loads increase at the knee joint

Results

IN COMPARISON TO SHOD CONDITION, THERE WAS A 12% REDUCTION IN PEAK PFJ STRESS

PREDOMINANT INFLUENCE FOR ↓ IN PFJ STRESS WAS A REDUCTION IN PFJ RXN FORCE

REDUCTION IN PFJ RXN FORCE OCCURRED DUE TO SMALLER KNEE FLEXION ANGLE DURING STANCE PHASE THEREBY ↓ING DEMAND ON QUADS
(A)Symmetry

NOT UNCOMMON

A SIGN OF INCOMPLETE REHAB?

AN ADAPTIVE RESPONSE TO SHIELD TISSUE(S)?

GREATER METABOLIC COST
FREE OF NSAIDS & NARCOTIC USE FOR AT LEAST 48-72 HRS PRIOR TO TESTING
NO HX OF A CORTICOSTEROID INJECTION IN A WB JOINT WITHIN PAST 4WKS
NO OPEN OR HEALING WOUNDS ON THE PLANTAR ASPECT OF THE FEET
ABILITY TO FULLY WB THROUGH AFFECTED EXTREMITY靜MATICALLY & DYNAMICALLY
ABILITY TO ADVANCE THE LEG OVER THE FOOT (ANKLE DF)
ABILITY TO REPETITIVELY HOP ON EACH LEG W/O MARKED PAIN OR COMPENSATION
NO DOCUMENTED CARDIOPULMONARY PRECAUTIONS OR CONTRAINDICATIONS

Non-Negotiables
General Recommendations

AT A MINIMUM, 2 ORTHOGONAL VIEWS
Lateral & posterior

PREFERENCES NEED TO BE MODIFIED TO WORK UNDER CONSTRAINTS OF CLINICAL ENVIRONMENT

MAINTAINING A REPRODUCIBLE CAMERA LOCATION & FIXED ORTHOGONAL ANGLE TO THE TM IS IMPORTANT FOR RELIABILITY

Suggested Views

LATERAL VIEW
- Head-to-toe
- Waist down

ANTERIOR VIEW
- Head-to-toe
- Waist down

POSTERIOR VIEW
- Head-to-toe
- Waist down
- Ground level
  **For waist down views, position camera @ level of involved region**
ACTIONS ALWAYS HAVE EFFECTS THAT ARE UNANTICIPATED OR UNINTENDED

Law of Unintended Consequences
IF IT AIN'T BROKE DON'T FIX IT!
THE S’S OF TREADMILL RUNNING ANALYSIS™
A PRACTICAL, EVIDENCE-BASED APPROACH TO 2-D RUNNING GAIT ANALYSIS

GETTING STARTED

Have runners bring their least supportive running shoe to gain a window into their mechanics without constraining the foot. If shoeing down is a concern, simply have the runner bring their preferred training shoe. Before having the runner step onto the belt, take one last moment to ensure that they have securely laced their shoes. Next, have the runner take the speed up to a brisk walk (3.2-3.5mph) while pumping the arms in a manner similar to running. Set the TM at 0-1% incline.

TARGET SPEED

The easiest place to start when selecting a speed is to simply have the runner take it up to a conversation pace. For those familiar with using rating of perceived exertion (RPE) as a measure of intensity, we suggest aiming for an RPE of 3-4/10 based on the scale by Foster and colleagues. It may also be helpful to have the runner demonstrate the fastest speed that they are comfortable running provided that there are no precautions. The ultimate goal is to eventually get a window into one’s running that reflects the speeds or intensities that they encounter or expose their body to while training and racing. While this may not always be appropriate in a rehab capacity when first reintroducing running, strive to progressively work runners up to relevant speeds.

EQUIPMENT REQUIREMENTS

- Calibrated and inspected TM
- Video capture system – smartphone or tablet
- Tripod or holster for video capture system
- Metronome/Tempo Meter

Developing a systematic, science-based approach to conducting a treadmill (TM) running analysis lends to safety, efficiency, and meaningful results. It also affords the practitioner or coach the ability to go back and review video footage, which can serve as an invaluable learning tool. From a clinical standpoint, by enhancing one’s understanding of key variables related to running and gait retraining, loads can effectively be shifted away from sensitized or pathologic tissue which has the potential for patients to appreciate that their running related pain is malleable. Below is a list of key considerations geared towards conducting a formal TM running analysis using The S’s of Treadmill Running Analysis™.

SUGGESTED VIEWS

- Lateral (head-to-toe & waist down)
- Anterior (head-to-toe & waist down)
- Posterior view (head-to-toe & waist down)
- Aerial view (provided that an overhead mount is accessible)

**For the waist down views, we recommend positioning the camera at the level of the involved region.

RPE SCALE

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<tr>
<th>RPE</th>
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<td>0</td>
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<td>1</td>
<td>REALLY EASY</td>
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<td>EASY</td>
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<tr>
<td>10</td>
<td>JUST LIKE HARDEST RACE</td>
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*Adapted from Foster et al. JSCR 2001

THE S’S OF TM ANALYSIS™

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<th>RFS</th>
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<th>FFS</th>
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<td>STEP RATE</td>
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</tr>
<tr>
<td>SHOES (BRAND, MODEL, WEIGHT, HEEL-TOE OFFSET):</td>
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<td>SLOPE:</td>
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<tr>
<td>SWING:</td>
<td></td>
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<tr>
<td>STEP WIDTH:</td>
<td>PRESENCE OF CROSSOVER? Y / N</td>
<td>SIDE: L / R</td>
<td></td>
</tr>
<tr>
<td>SHANK:</td>
<td>-10 DEGREES TO 0</td>
<td>0-10 DEGREES</td>
<td>10+ DEGREES</td>
</tr>
<tr>
<td>SYMMETRY:</td>
<td>Y / N</td>
<td></td>
<td></td>
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<tr>
<td>NOTES:</td>
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<tr>
<td>OTHER:</td>
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</tbody>
</table>
PRIMARY DRILLS
FOR RUNNERS

RUN-CENTRIC EXERCISES

MARCH
• STANDARD
• "PRISONER"
• OVERHEAD REACH
• MARCHING BAND SERIES
• TIP-TOE

FRONTAL PLANE
• SLS + HIP ABD
• LATERAL TOE TAP
• SIDE PLANK +/- HIP ABD
• QUICK CRABWALKS

STEP-UP
• TOE-OFF
• FLUID
• CONTINUOUS
• FOUR-WAY COMPLEX

BRIDGE
• STANDARD
• MARCH
• BRIDGE + SLR
• LONG LEVER

Calf Raise
• ISOMETRIC (B/L & U/L)
• ISOTONIC (B/L & U/L W/ STEP ASSIST)
• SOLEUS RAISE

Squat
• AIR SQUAT
• GOBLET SQUAT
• REARFOOT ELEVATED SPLIT
• BACK SQUAT

Deadlift
• HIP HINGE
• RACK-PULL
• KETTLEBELL
• BARBELL

Plank
• PUSH-UP
• FRONT PLANK +/- ALTERNATING KNEE TAPS

Fundamental Human Movements

Energy Storage & Release

Countermovement Jump (CMJ)
• ONTO PLATFORM, OVER PLATFORM
• 2:2 >> 2:1

Skipping
• A, B, & C

POGO JUMPS
• IN PLACE
• A-P & M-L, ZIG ZAG
• ON-OFF STEPPER

Single Leg Hopping
• A-P & M-L, WITH LEG SWING

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