Do Biomechanics Matter For Running Injury Prevention?

By Raphael Bender

Synthesis of 10 systematic reviews

- We can't predict who is going to get an injury
- Biggest predictors, strong correlation with low certainty of evidence:
    - Previous injury*
    - Higher BMI
    - higher age
    - Male sex
    - No previous running experience
    - Lower running volume under 2h/week
    - **Big spikes in training load (i.e. weekly km)
- Biomechanical factors have very low quality or conflicting evidence and very small effect size e.g. reduced quad strength, increased hip adduction, vertical ground reaction force, reduced knee flexion on landing

*The definition of a "previous injury" ranged from missing sports practice with an unclear timeframe to injuries due to running in the 12 months preceding an event. Although there is no uniform definition of previous RRIs (running-related injuries) and current RRIs, many articles confirmed the association and it may be assumed that a previous injury increases the risk of a new injury. It remains unclear whether a higher injury risk is related to incomplete healing of a previous injury, changed biomechanics due to a previous injury, or other reasons.

**ACWR (acute->chronic workload ratio) has been extensively studied in athletes and is associated with injury incidence, but can't predict injuries

The 80/20 of injury prevention for runners

- Avoid big spikes in training volume
- Build up gradually to a relatively high training volume (>20km/wk)
- Strength train the legs
- Don't run injured - rehab properly

Biomechanical interventions that may have a small effect *but only do them after you're already doing the above:*

- Gait retraining has limited evidence - but increasing step count 5-10% and moving to a non-rearfoot strike (NRFS) can both change multiple biomechanical risk factors
- Landing softly (also achieved with NRFS / may promote NRFS)

Higher level concepts:

The factors that are most associated with injury are general - not specific biomechanical factors

- Rehab injuries properly
- Build weekly km gradually up to 2 hours/20km per week and maintain it consistently
- Strength train
- Even when we want to address biomechanical factors, probably the best way is to use a general intervention like increasing step cadence
- TLDR - it's a lot simpler than you think

Key points of individual studies reviewed

Maupin et al. 2020

The Relationship Between Acute: Chronic Workload Ratios and Injury Risk in Sports: A Systematic Review
https://pubmed.ncbi.nlm.nih.gov/32158285/

- ACWR is associated with injury but high heterogeneity between measuring workload and injury
- May be a trend to .8-1.3 (i.e. 20-30% increase/decrease) is associated with the lowest injury incidence

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Griffin et al. 2019

The association between the acute: chronic workload ratio and injury and its application in team sports: a systematic review
https://pubmed.ncbi.nlm.nih.gov/31691167/

- ACWR has solid evidence of association with injury but is not able to predict injury
- High chronic workloads are associated with reduced injuries

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Petersen et al. 2022

Biomechanical and Musculoskeletal Measurements as Risk Factors for Running-Related Injury in Non-elite Runners:A Systematic Review and Meta-analysis of Prospective Studies

https://pubmed.ncbi.nlm.nih.gov/35254562/

A systematic review and meta-analysis of 30 prospective studies (3404 runners), testing over 100 discrete biomechanical and musculoskeletal risk factors for RRI, were included. Nineteen studies were pooled in twenty-five separate meta-analyses

- Reduced quad strength in runners who developed RRI with trivial effect size 0.19 - not clinically significant

- Lower hip adduction velocity - very wide confidence interval
- Remaining meta-analysis found no relationship between biomechanical variables and RRI

Christopher et al. 2019

Do alterations in muscle strength, flexibility, range of motion, and alignment predict lower extremity injury in runners: a systematic review

https://pubmed.ncbi.nlm.nih.gov/30805204/

The evidence for the 7 clinical assessment categories was very weak.

- One study found that strong hip abductors were linked to more running injuries.
- Another study showed that stronger hip ER (external rotation) and less hip IR (internal rotation) protected against injuries.
- One study found in women, less navicular drop (reduced foot arch height) predicted fewer injuries

Due to very low quality of evidence for each assessment, confounders present within the studies, a limited number of studies, different measurement methods among studies, measurement variability within clinical assessments, inconsistent definitions of injury and runner, different statistical modeling, and study bias, caution is suggested in interpreting these results.

Willwacher et al. 2022

Running-Related Biomechanical Risk Factors for Overuse Injuries in Distance Runners: A Systematic Review Considering Injury Specificity and the Potentials for Future Research

https://pubmed.ncbi.nlm.nih.gov/35247202/

Sixty-six articles fulfilled our eligibility criteria. Levels of evidence for specific RRI ranged from conflicting to moderate evidence. We identified limited evidence for most ROI-specific risk factors, highlighting the need for performing further high-quality studies in the future

- While some BRFs (biomechanical risk factors) appeared for several RRIs, most BRFs were specific for a particular RRI.
- Most BRFs derived from lower-extremity joint kinematics and kinetics were located in the frontal and transverse planes of motion.
- Plantar pressure & vertical ground reaction force loading rate were identified as kinetic BRFs
- Running related biomechanical risk factors are injury-specific.
- Some factors were a trade-off between risk for different specific injuries, and possibly don't affect overall injury risk: Increased hip adduction angle increased risk for tibial stress fracture and decreased risk for ITB syndrome

Doyle et al. 2022

The Effectiveness of Gait Retraining on Running Kinematics, Kinetics, Performance, Pain, and Injury in Distance Runners: A Systematic Review With Meta-analysis
https://pubmed.ncbi.nlm.nih.gov/35128941/

We included 19 trials (673 participants).

- Moderate-certainty evidence indicated step rate gait retraining increased step rate and reduced average vertical loading rate
- Insufficient trials reported on pain outcomes. Two trials demonstrated reduced 1-year injury incidence following gait retraining

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Anderson 2022

What is the Effect of Changing Running Step Rate on Injury, Performance and Biomechanics? A Systematic Review and Meta-analysis
https://pubmed.ncbi.nlm.nih.gov/36057913/
37 articles

- Very limited evidence indicated that increasing running step rate is associated with improvements in pain and function in recreational runners with patellofemoral pain.
- Very limited evidence indicated that increasing step rate increases perceived exertion and very limited evidence that an increase in preferred step rate is associated with increased metabolic energy consumption
- Increasing running step rate was associated with strong evidence of reduced peak knee flexion angle, moderate evidence of reduced step length, peak hip adduction and peak knee extensor moment; moderate evidence of reduced foot strike angle ; limited evidence of reduced braking impulse, peak hip flexion, and peak patellofemoral joint stress ; and limited evidence of reduced negative hip and knee work
- In general, increasing running step rate results in a reduction (or no change), and reducing step rate results in an increase (or no change), to kinetic, kinematic, and loading rate variables at the ankle, knee and hip.
- At present there is insufficient evidence to conclusively determine the effects of altering running step rate on injury and performance. As most studies included in this review investigated the immediate effects of changing running step rate, the longer-term effects remain largely unknown

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Van Poppel et al. 2021

Risk factors for overuse injuries in short- and long-distance running: A systematic review

https://pubmed.ncbi.nlm.nih.gov/32535271/

29 studies

- A previous running-related injury was the strongest risk factor for an injury for long-distance runners, with moderate-quality evidence.
- Previous injuries not attributed to running was the strongest risk factor for an injury for short-distance runners, with high-quality evidence.
- Higher body mass index, higher age, sex (male), having no previous running experience, and **lower running volume** were **strong risk factors**, with moderate quality evidence, for short-distance runners.
- **Low-quality evidence was found for all risk models** as predictors of running-related injuries among short- and long-distance runners.

Several risk factors for lower extremity injuries have been identified among short- and long-distance runners, but the quality of evidence for these risk factors for running-related injuries is limited. Running injuries seem to have a multifactorial origin both in short- and long-distance runners.

Correia et al. 2024

Risk factors for running-related injuries: An umbrella systematic review
https://pubmed.ncbi.nlm.nih.gov/38697289/

Umbrella review of 13 systematic reviews
quality varied from critically low (n = 8) to low (n = 5)
Our analysis showed unsatisfactory quality for all the included SRs, ranging between critically low and low quality.

- Different definitions of what constitutes a running injury
- Different definitions of what constitutes a previous injury
- RRIs seem to share common risk factors, particularly those associated with running/training characteristics and health-related lifestyle factors.
- These factors likely play a significant role in multiple types of RRIs.
- Conversely, biomechanical and morphological factors might be more specific to certain types of injuries, such as iliotibial band syndrome, patellofemoral tendinopathy. However, this remains speculative as, most primary studies and SRs did not address a specific injury.

Despite the efforts of researchers in the field, the main risk factors, or the set of risk factors for RRIs, remain unclear. The existing meta-analyses focus only on biomechanical factors. However, despite the large volume of information, the current evidence remains insufficient to conclusively identify biomechanical risk factors.

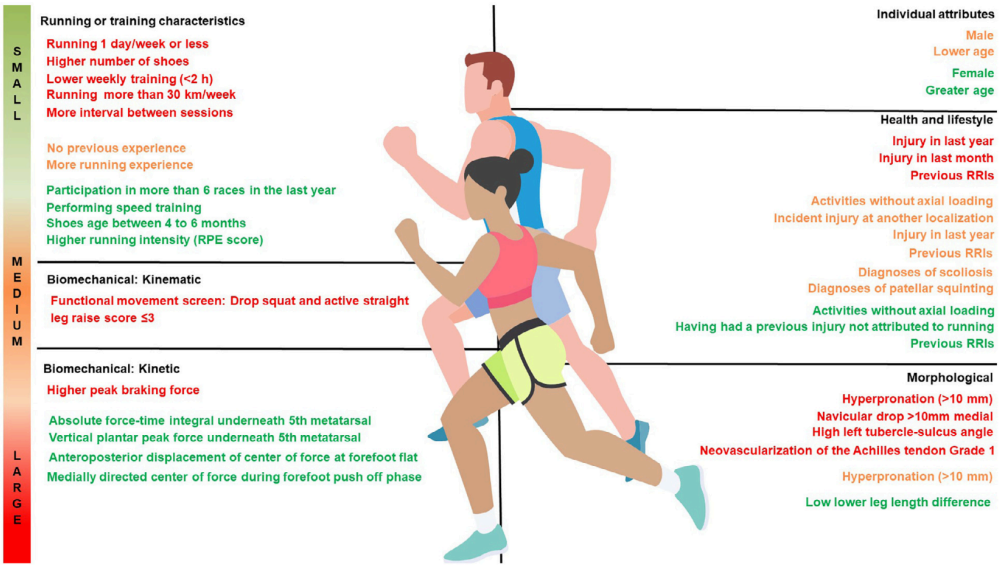

Fig 3. Overview of risk factors for RRIs considering only the systematic reviews with low quality, according to the classification of the effect size of the measures of risk (large, medium, and small effect sizes). Results are shown for studies that showed low quality ($n = 5$). RPE = rating of perceived exercise; RRIs = running-related injuries.

Lauersen et al. 2016

Strength training as superior, dose-dependent and safe prevention of acute and overuse sports injuries: a systematic review, qualitative analysis and meta-analysis
https://bjsm.bmj.com/content/52/24/1557.abstract

- Dose-response decrease in injuries associated with increasing strength training volume. Mainly hamstring injuries.
- A 10% increase in strength training volume reduced the risk of injury by more than four percentage points
- High strength of evidence