Please note that this online educational module is intended to provide a brief overview of the research about the effects of running shoes on biomechanics and injury prevention.

Footwear represents only one part of the prevention and treatment of running injuries, along with training loads, biomechanics and recovery. No studies on treatment were included given the lack of scientific evidence. This module should not be used to determine a treatment plan if you have a running injury. You should consult a qualified healthcare professional if you have an injury.

Only references with the highest level of evidence (systematic reviews, randomized controlled trials) or those addressing timely topics (e.g. maximalist shoes, minimalist shoes) have been included.

Several healthcare professionals, shoe retailers and runners have provided input on the module before reaching the final version.

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Before we start...
Which biomechanical factors are associated with running injuries?
1. **GROUND IMPACT PEAK & LOADING RATE**

*Force applied on the shoe by the ground (measured by force plates)*

- *Impact peak*
- *Loading rate (steepness of curve)*
- *Time*
- *Foot strike*
- *Midstance*
- *Push off*

**BIOMECHANICAL FACTORS RELEVANT FOR INJURIES...**

**WHY IS THIS IMPORTANT?**

- Multiple studies have associated an increase in loading rate with injuries.
- One study reported that runners who learned to "run softer" had 62% less injuries over the following year compared with runners who did not.

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2. van der Worp et al. (2016) Do runners who suffer injuries have higher vertical ground reaction forces than those who remain injury-free? A systematic review and meta-analysis, *Br J Sports Med*.
BIOMECHANICAL FACTORS RELEVANT FOR INJURIES...

2. JOINT FORCES & LOADING RATE

*Estimated using 3D motion capture and force plates. The ground reaction force is needed to estimate joint forces.*

Why is this important?

- Forces can potentially overload joint structures beyond tolerance and lead to injury
- Injured runners can potentially benefit from reductions in forces to allow for healing

Forces at the knee & knee cap

Forces at the ankle & pressure measured at the bottom of the foot


#1

Does running shoe cushioning affect running biomechanics and joint forces?
Different levels of running shoe cushioning...

Maximal shoes (Hoka)  Traditional shoes (Brooks)  Minimal shoes (New Balance)

Note that minimalist and maximalist shoes are defined by more than just cushioning (weight, flexibility, technologies, rocker sole, etc.). Shoes can be given a % score on 'how minimalist' they are:

MINIMALIST INDEX

0%  100%

Very minimalist

Not minimalist

#1 Does Maximal Cushioning Affect Running Biomechanics & Joint Forces?

### Study 7
- **Traditional (Adidas)**
  - Downhill loading rate in Maximal: +11.5%
  - Level ground Same impact

- **Maximal (Hoka)**

### Study 8
- **Minimal (Vibram)**
- **Traditional (New Balance)**
- **Maximal (Hoka)**
  - Knee cap forces in Maximal & Traditional vs. Minimal: +20% each step +10% each mile

### Study 9
- **Traditional (Brooks)**
  - Vertical ground reaction force: Loading rate in Maximal: +14%

- **Maximalist (Hoka)**

### Study 10
- **Traditional (New Balance)**
  - Vertical ground reaction force: Loading rate in Maximal: +33%

- **Maximalist (Hoka)**

### Maximal Cushioning Increases Ground Impact and Knee Joint Forces

#1 Does Minimal Cushioning Affect Running Biomechanics and Joint Forces?

## Study 11

**Minimalist Index**

- 0%
- 100%

## Study 12

- Knee cap forces in Minimal vs. Traditional
- -17%

### Minimalist Shoes

- Knee forces
- Achilles tendon forces

### Traditional (Asics)

### Minimal (Vibram)

## Study 13

- Overall ground impact loading rate in Minimal vs. Traditional

### Traditional (Nike)

### Minimal (Inov8)

## Study 14

- Knee cap forces in Minimal (Vibram & Inov8) vs. Partial minimal & Traditional
  - -20%

- Achilles tendon forces in Minimal (Inov8) vs. Partial minimal & Traditional
  - +16%

## Summary of the Effects of Minimal Cushioning

- **Knee Joint Forces**
- **Achilles Tendon Forces & Foot Pressure**
- **Ground Impact if Not Landing on Heel**
- **Ground Impact if Still Landing on Heel**

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#2
Do cushioning features in running shoes reduce injuries?
TWO CUSHIONING FEATURES IN RUNNING SHOES

1. Midsole density
   How soft or hard the shoe sole is when compressed by the foot

2. Heel to toe drop
   Difference in thickness between the heel and the front of shoe

With impact:

Harder midsole

Soft midsole

10 mm drop

Zero drop
#2 DO CUSHIONING FEATURES IN RUNNING SHOES REDUCE INJURIES?

247 recreational runners randomized to...

Harder sole OR Softer sole

5 months of regular running

NO DIFFERENCE IN RUNNING INJURY RISK BASED ON MIDSOLE DENSITY

#2 Do cushioning features in running shoes reduce injuries?

553 recreational runners randomized to different heel to toe drops...

0 mm OR 6 mm OR 10 mm

6 months of regular running

Overall, heel to toe drop does not influence running injury risk

#3
Changing to a different category of running shoes: Does it cause injuries?
#3 Changing to a Different Category of Running Shoes: Does It Cause Injuries?

A scientific article summarizing 20 previous studies concluded that:

Some studies report ↑ injury risk while others don’t.
It depends on how big the change is, and how gradual the transition is.

Transitioning to minimalist shoes? Consider AT LEAST 4-8 weeks!
(greater changes on the Minimalist Index require more time to adapt muscles, tendons and bones)


Going to more cushioning: ↑ risk of knee injury

Going to less cushioning: ↑ risk of injury to foot/Achilles tendon
#4
Selecting running shoes based on foot type: Does it reduce injuries?
COMMON STRATEGY OF SELECTING SHOE BASED ON FOOT TYPE

1. Scan foot
2. Determine foot type
3. Select corresponding shoe

High arch
- Neutral shoe
  - Cushioned shoe designed to provide more pronation

Low arch
- Motion control shoe
  - Cushioned shoe designed to control excessive foot pronation

"Normal" arch
- Stability shoe
  - Cushioned shoe with moderate motion control characteristics

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#4 Selecting running shoes based on foot type: Does it reduce injuries?

**Study 18**
7,213 soldiers
- Shoe assigned based on foot type
- Shoe not assigned based on foot type

6 to 12 weeks of military training

**Study 19**
81 runners
- Randomly assigned a shoe

13-week half-marathon program

**Study 20**
372 runners (all foot types)
- Assigned a neutral shoe
- Assigned a motion control shoe

6 months of regular running

Selecting running shoes based on foot type does not ↓ running injury risk

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Current state of research on running shoes

#1 Minimalist shoes tend to ↓ knee forces but ↑ Achilles tendon & foot forces.

Maximalist shoes tend to ↑ knee forces & ground impact but ↓ Achilles tendon & foot forces.

#2 Cushioning in running shoes does not prevent injury.

#3 Transition to a different category of running shoes should be gradual to reduce injury risk.

#4 Selecting running shoes based on foot type does not seem to ↓ injury.

#5 Selecting shoes based on comfort is a good idea.

*More research is needed to provide guidance, especially about effective treatment of running injuries*
References

2. van der Worp et al. (2016) Do runners who suffer injuries have higher vertical ground reaction forces than those who remain injury-free? A systematic review and meta-analysis, Br J Sports Med.
11. Esculier et al. (2017) Footwear characteristics are related to running mechanics in runners with patellofemoral pain, Gait Posture.