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

<table>
<thead>
<tr>
<th><strong>TREADMILL</strong></th>
<th><strong>ROAD</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle: 170°</td>
<td>Angle: 175°</td>
</tr>
<tr>
<td>Backward motion of the belt assists the runner by pulling the feet back</td>
<td>Hamstrings are recruited more often to help lift the leg behind and to propel the runner forward and off the ground</td>
</tr>
<tr>
<td></td>
<td>Over extension of the knee can cause inflammation and pain</td>
</tr>
</tbody>
</table>
Patellofemoral Pain (Runner’s Knee)

Excessive rotation around the knee can cause straining 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...
Ankle at moment of impact

<table>
<thead>
<tr>
<th>TREADMILL</th>
<th>ROAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle: 94°</td>
<td>Angle: 75°</td>
</tr>
<tr>
<td>Ankle is slightly plantarflexed.</td>
<td>Ankle is dorsiflexed.</td>
</tr>
<tr>
<td>Encourages a <strong>midfoot strike</strong></td>
<td>Encourages <strong>heel strike</strong></td>
</tr>
</tbody>
</table>
## Midfoot vs Heel Strike

(Lieberman et al. 2010)

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

\[
\frac{85 \text{ frames}}{\text{stride}} \times \frac{8 \text{ ms}}{\text{frame}} \times \frac{1 \text{ s}}{1000 \text{ ms}} = 0.68 \text{ s/stride}
\]

\[
\frac{1}{0.68 \text{ s/stride}} \times \frac{60 \text{ s}}{\text{min}} = 88.24 \text{ strides/min (per leg)}
\]

\[
\frac{88.24 \text{ strides}}{\text{min}} \times 2 = 176.47 \text{ strides/min}
\]

**Road:**

\[
\frac{90 \text{ frames}}{\text{stride}} \times \frac{8 \text{ ms}}{\text{frame}} \times \frac{1 \text{ s}}{1000 \text{ ms}} = 0.72 \text{ s/stride}
\]

\[
\frac{1}{0.72 \text{ s/stride}} \times \frac{60 \text{ s}}{\text{min}} = 83.33 \text{ strides/min (per leg)}
\]

\[
\frac{83.33 \text{ strides}}{\text{min}} \times 2 = 166.67 \text{ strides/min}
\]

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

-1.208 m/s
Vertical Velocity on Treadmill

-1.016 m/s

15.89% decrease!
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


QUESTIONS?