Atraumatic Lower Extremity Musculoskeletal Injuries and Running

CPT Brandon M. Carius, MPAS, PA-C  
LTC Amelia M. Duran-Stanton, PhD, DSc, MPAS, PA-C  

Fort Sam Houston, Texas
Cleared for public release. The views and information presented are those of the author and do not represent the official position of the U.S. Army Medical Department Center and School, Army Medicine, or the U.S. Army.
• Objectives
• Introduction
• Describing the problem: injury rates
• Contributing factors
• Risk Mitigation
• Review
• Conclusions
• Future Research
• Practice Take-Away
Objectives

1. Describe problems of ALE MSK injuries in the soldier population.

2. Identify multiple contributing factors to ALE MSK injuries in the soldier population.

3. Explain risk mitigation strategies for the prevention and treatment of the soldier population.
Upon arrival to the Republic of Korea (ROK), units were noticing a significant number of ALE MSK complaints.

Complaints primarily consisted of: knee pain, shin splints, and ankle pain.

From 17 October – 05 December 2016, 33% of initial visits (70 out of 214) were seen for complaints pertaining to these three areas of ALE MSK.

This rate was largely in-line with prior military studies.
“The Incidence of Injury in Light Infantry Soldiers” (Military Medicine, 2002)\(^1\)

- Soldiers from across 6 battalions of light infantry at Schofield Barracks, Hawaii
- 13-month retrospective record review of 339 records (60 per battalion prior to exclusion criteria)
- 372 injuries = 56% of sick-call diagnoses
- “Soldiers with lower extremity running injuries spent seven times more days on profile than those with nonrunning injuries

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. of Cases</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT run</td>
<td>103</td>
<td>30.4</td>
</tr>
<tr>
<td>PT other</td>
<td>65</td>
<td>19.2</td>
</tr>
<tr>
<td>Foot march</td>
<td>53</td>
<td>15.6</td>
</tr>
<tr>
<td>Job/field</td>
<td>46</td>
<td>13.6</td>
</tr>
<tr>
<td>Off-duty sports</td>
<td>27</td>
<td>8.0</td>
</tr>
<tr>
<td>Off-duty other</td>
<td>45</td>
<td>13.3</td>
</tr>
<tr>
<td>Total</td>
<td>339(^a)</td>
<td>100</td>
</tr>
</tbody>
</table>

\(^a\)339 of 372 injuries reported an associated activity.

<table>
<thead>
<tr>
<th>Site</th>
<th>Profile Days</th>
<th>No. of Cases</th>
<th>Average Loss per Case</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>C spine</td>
<td>84</td>
<td>11</td>
<td>7.6</td>
<td>0-35</td>
</tr>
<tr>
<td>T spine</td>
<td>54</td>
<td>12</td>
<td>4.5</td>
<td>0-30</td>
</tr>
<tr>
<td>L spine</td>
<td>423</td>
<td>43</td>
<td>9.8</td>
<td>0-30</td>
</tr>
<tr>
<td>Shoulder</td>
<td>683</td>
<td>23</td>
<td>29.7</td>
<td>0-150</td>
</tr>
<tr>
<td>Arm/hand</td>
<td>332</td>
<td>36</td>
<td>9.2</td>
<td>0-120</td>
</tr>
<tr>
<td>Hip/leg</td>
<td>247</td>
<td>23</td>
<td>10.7</td>
<td>0-60</td>
</tr>
<tr>
<td>Knee</td>
<td>1,335</td>
<td>67</td>
<td>19.9</td>
<td>1-200</td>
</tr>
<tr>
<td>Shin/calf</td>
<td>498</td>
<td>26</td>
<td>19.2</td>
<td>0-121</td>
</tr>
<tr>
<td>Ankle</td>
<td>1,061</td>
<td>51</td>
<td>20.8</td>
<td>0-173</td>
</tr>
<tr>
<td>Foot</td>
<td>762</td>
<td>61</td>
<td>12.5</td>
<td>0-90</td>
</tr>
<tr>
<td>Other</td>
<td>296</td>
<td>19</td>
<td>15.6</td>
<td>0-60</td>
</tr>
<tr>
<td>Total</td>
<td>5,775</td>
<td>922</td>
<td>15.5</td>
<td>0-200</td>
</tr>
</tbody>
</table>

| Lower extremity  | 3,903        | 228          | 17.1                  | 0-200 |

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. of Cases</th>
<th>Days on Profile (%)</th>
<th>Mean Days on Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT run</td>
<td>98</td>
<td>2,080 (53.5)</td>
<td>21.2</td>
</tr>
<tr>
<td>PT other</td>
<td>51</td>
<td>309 (7.9)</td>
<td>10</td>
</tr>
<tr>
<td>Foot march</td>
<td>38</td>
<td>598 (15.4)</td>
<td>15.7</td>
</tr>
<tr>
<td>Job/field</td>
<td>22</td>
<td>557 (14.3)</td>
<td>25.3</td>
</tr>
<tr>
<td>Off-duty sports</td>
<td>14</td>
<td>235 (6.0)</td>
<td>16.8</td>
</tr>
<tr>
<td>Off-duty other</td>
<td>17</td>
<td>111 (2.9)</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td>220(^a)</td>
<td>3,890 (100)</td>
<td>17.7</td>
</tr>
</tbody>
</table>

\(^a\)220 of 228 reporting cause and profile days.
“Atraumatic Lower Extremity Musculoskeletal Injuries and Running in U.S. Army Rotational Units in South Korea” (JSAMS, 2017)²

• Upon arrival to the Republic of Korea (ROK), units were noticing a significant number of ALE MSK complaints

• Complaints primarily consisted of: knee pain, shin splints, and ankle pain

• From 17 October – 05 December 2016, 33% of initial visits (70 out of 214) were seen for complaints pertaining to these three areas of ALE MSK
“Atraumatic Lower Extremity Musculoskeletal Injuries and Running in U.S. Army Rotational Units in South Korea” (JSAMS, 2017)²

- ALE MSK injuries can significantly increase physical profile rates and decrease overall unit medical readiness.
- What are the contributing factors to ALE MSK injuries, and how can we mitigate them?

Describing the Problem: ALE MSK Injuries in Korea
CONTRIBUTING FACTORS
Contributing Factors: The 5 S’s

- Historical research can be broken down into 5 main areas:
  - Stride
  - Shoe
  - Surface
  - Schedule
  - Self (BMI)
Contributing Factors: Stride

• Each stride in running creates an impact of 1.5-3x the runner’s body weight (BW)$^3$
• This pressure is more sudden and significant with a rearfoot strike (RFS) and lessened and well-distributed with a forefoot strike (FFS)$^3$
Contributing Factors: Stride

Rearfoot Strike:
- Impact
- Foot flat
- Midstance
- Toe off

Forefoot Strike:
- Impact Transient Absent

Contributing Factors: Shoe

- Running shoes reduce the mass effect of each stride, but effectiveness decreases over time
  - Tradition dictates changing shoes every 300-500 miles
  - However, this does not incorporate numerous factors that contribute to shoe degradation.
- The majority of shoe soles are made of an ethelyne and vinyl acetate (EVA) foam composite
- As distances logged and wear on shoes increases, pressures increase at a faster rate with subsequent usage

Contributing Factors: Shoe

- Total Patients With LE MSK Complaints n=70
  - Reported increase in intensity, distance and schedule of running n=70 (100%)
  - BMI > 25 n=49 (70%)
  - Brought Shoes n=25 (47%)
    - Severely Worn n=24 (96%)
    - BMI > 25 n=19 (79%)
  - Total Patients Asked to Bring Shoes n=54
    - Owned > 6 mos n=17 (68%)
  - Wore shoes outside of running n=9 (36%)
Contributing Factors: Surface

- Grass and synthetic surfaces have been shown to reduce peak foot pressures\(^6\)
- Conversely, concrete and asphalt surfaces increase peak foot pressures
- Pressures are transferred into bones and joints, cause increased bone stress
- Running at a sprint pace on concrete produced a greater than twice the impact on the tibia compared to jogging on a synthetic sports surface (SSS)\(^6\)

<table>
<thead>
<tr>
<th>Footwear</th>
<th>Running condition</th>
<th>Peak tibial acceleration (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asics Gel Lethal</td>
<td>Jogging on SSS</td>
<td>4.5 ± 1.4</td>
</tr>
<tr>
<td></td>
<td>Running on SSS</td>
<td>9.1 ± 2.7</td>
</tr>
<tr>
<td></td>
<td>Jogging on concrete</td>
<td>5.5 ± 1.8</td>
</tr>
<tr>
<td></td>
<td>Running on concrete</td>
<td>10.3 ± 2.4</td>
</tr>
</tbody>
</table>

Table courtesy of Greenlagh, et al.
Every patient in our study reported an increase in intensity, distance, and schedule of running.

“Extreme Conditioning Programs and Injury Risk in a US Army Brigade Combat Team” (US Army Med Dep J, 2013)\textsuperscript{7}

- Higher injury risk for increased mileage run per week during unit physical training ($> 16$ miles/wk $+ 7$ miles/wk)
• Increased body mass index (BMI) has been shown to increase injury
  • “BMI and Lower Extremity Injury in U.S. Army Soldiers” (Am J Prev Med, 2016)\textsuperscript{8}
    • Increased risk of musculoskeletal injury/disorder (MID)
    • For overweight (BMI = 25-29.9): 11%
    • For obese (BMI > 30): 33%
    • Additionally, risks were highest for those who were obese at accession into the Army
  • “Risk Factors for Sustaining a Lower Extremity in an Army Reserve Officer Training Corps Cadet Population” (Mil Med, 2015)\textsuperscript{9}
    • 6x increased rate of injury amongst ROTC cadets with BMI > 25
• Body fat percentage has not been studied for ALE MSK risk
RISK
MITIGATION
• Patient education and motivation is critical
• Likewise, unit education and buy-in is also critical
• Most intervention are behavioral/activity modifications
• Difficult to monitor compliance on modifications other than scheduled follow-up
Risk Mitigation: Stride

- FFS is ideal

“Risk of Lower Extremity Injury in a Military Cadet Population After a Supervised Injury-Prevention Program” (J Athl Train, 2016)\textsuperscript{10}
  - Lower extremity injury risk decreased 41% with professional supervision for dynamic integrated movement enhancement

“Gait Re-Training to Alleviate the Symptoms of Anterior Exertional Lower Leg Pain” (Int J Sports Phys Ther, 2015)\textsuperscript{11}
  - 60-minute gait retraining sessions (3x max) over a 6-week period
  - EILP questionnaire score measured
    - 40.3% improvement at 6 weeks
    - 49.2% improvement at 1 year
Risk Mitigation: Shoe

- No study has been able to definitively look at the proper lifespan of a shoe (too many variables – size, brands, models, surface, user)

  - Industry representatives state general rule is to replace every 300 miles

    - Increased risk of injury with running shoes that were 4-6 months old

- Issues with current limited literature is that the variables is not transferrable to military populations
  - Running shoes are not used only for running (recreational sports, gym, casual wear)

- **This is a leadership issue!**
Risk Mitigation: Shoe

Patient education:

Beginner’s Guide to Running Shoes
Running shoes are incredibly important!
Shoe Anatomy 101

Toolbox

Fabric "upper"
Heel Counter
Footbed
Midsole
Outsole (Tread)

Ways to tell your shoes are worn

- You cannot see shoe treads (outer and midsole are worn)
- The outsole/tread is separating from the midsole
- Fabric "upper" is fraying, coming apart, or separating from the footbed

How often do I need to replace my shoes, and why do I need to replace my shoes so much?

- Running shoes are like tires on a car, they need to be replaced at regular mileage intervals
- For running shoes, studies have shown that shoes need to be replaced every 300-500 miles
- HOWEVER, these studies were largely based on using the shoes only for running. If you use your shoes for weight lifting, other-than-running PT days, and casual wear, this number of miles should be decreased and shoes should be changed every 200-300 miles
- Use of running shoes beyond their suggested lifespan decreases their shock absorption by up to 50%, which then translates into more pain in your bones, joints, and muscles!

Microscopic view of the cushioning of a running shoe after 300 miles of use. This image indicates structural damage that decreases shock absorption

1) Body Frame/Type – the larger you are, the more cushioning you need. For example
   - 6'2"/200 lbs. – ASICS Kayano, ASICS Nimbus, Saucony Triumph
   - 5'9"/130 lbs. – Brooks Adrenaline, Nike Air Pegasus

2) Cushioning Preference – how much padding you want under your feet

   - Level 5 - Maximum cushion
     - ASICS Kayano
     - ASICS GEL-Nimbus
     - Brooks Ghost
     - New Balance 1310
   - Level 4 - High level of cushion
     - Good for long and short runs
     - ASICS GEL-Cumulus
     - Brooks Adrenaline GTS
     - Brooks Ghost
     - Hoka OneOne
     - New Balance 1310
   - Level 3 – Lightweight cushion
     - More flexible/responsive
     - ASICS GEL-DS
     - Brooks PureCadence
   - Level 2 – Incredibly light
     - Extreme flexibility
     - Nike Free
     - New Balance 1400
     - Merrell Trail Glove
   - Level 1 – Lightweight construction
     - Thinnest layer of protection
     - Vibram Five Fingers

3) Arch Type/Stability Control

   HIGH ARCH
   - Tends to be less flexible
   - Requires minimum level of support
   - Traditionally referred to as "neutral" shoes
   - ASICS Cumulus
   - Brooks Ghost
   - New Balance 1400
   - Nike Free
   - Nike Free Flyknit

   MEDIUM ARCH
   - Moderate flexibility
   - Requires medium support
   - Traditionally referred to as "stability" shoes
   - ASICS GEL-Nimbus
   - Brooks Adrenaline GTS
   - Brooks PureCadence
   - New Balance 1400
   - Nike Free

   LOW ARCH
   - Very flexible
   - Requires maximum level of support
   - Traditionally referred to as "motion control" shoes
   - Brooks Beast
   - New Balance 1400
   - New Balance 1540

4) How to save money when buying:
   - Find the model that works for you, then buy last year’s model online and save!
Contributing Factors: Surface, Schedule, Self

- **Surface:** increase use of softer surfaces for decreased impact risk (synthetic turf, grass, trail)
  - Grass/trail > turf > pavement > concrete
  - However, individuals must also mitigate risks of unstable surface (i.e. sprained ankles)

- **Schedule:** importance of slowly increasing distance/intensity of training, ensuring proper acclimatization of distance/intensity

- **Self:** decreasing BMI = decrease impact (1.5-3x BW)
  - However, underweight (BMI < 18) also at risk for injury
In Review

• High rates of ALE MSK injuries occur throughout the Army, and decrease the overall medical readiness

• ALE MSK injuries are multifactorial in nature, largely attributing to the 5 S’s (stride, shoe, surface, schedule, self)

• Many of these risk factors have been shown to be easily mitigated through low-/no-cost changes to the soldier, and can improve their outcomes significantly
• Healthcare providers must be vigilant in identifying injuries and trends amongst Soldiers

• Injuries affect medical readiness, and providers must be able to provide preventative/mitigating measures to improve outcomes for soldiers and units

• Atraumatic injuries are preventable and healthcare providers are vital in counseling soldiers and commanders in addressing them
• Whole patient evaluation of ALE MSK complaint, not the isolated complaint itself
  • Bring running shoes to each visit and document condition
  • Questions about mileage/intensity of training
  • BMI/dietary considerations
• Discuss stride, consider gait analysis (referral to PT)
• Patient education is key (running shoe buyer’s guide)
1. Described the problems of ALE MSK injuries in the soldier population.

2. Identified multiple contributing factors to ALE MSK injuries in the soldier population.

3. Explained risk mitigation strategies for the prevention and treatment of the soldier population.


Questions?