Mechanical Risk Factors for Stress Fracture in Elite Runners

Kenneth Hunt, MD, Nathaniel Fogel, MS, Rishi Trikha, BS, Adam Tenforde, MD

INTRODUCTION

- Bone stress injuries (BSI) are responsible for significant missed competition and training in distance runners
- Greater than half of NCAA-level runners at Stanford sustained one or more BSI over a three-year period
- These fractures can be high risk and require surgical management, making it important to identify athletes that may be predisposed to these injuries
- Research has focused on known risk factors, such as the female athlete triad, foot strike patterns and strength and flexibility deficits
- Static force plate studies are inadequate to show loading during athletic movement, and most dynamic loading studies focus only on a specific movement
- Studies investigating dynamic loading during a range of athletic movements are limited, particularly in the elite running population

STUDY AIMS

1) Characterize the dynamic loading patterns of elite distance runners during athletic movement
2) Determine the difference in dynamic loading magnitude and location in runners who have history of a BSI compared to uninjured runners
3) Establish a database of “healthy runners” for long-term follow-up evaluation

HYPOTHESIS

- Athletes with a history of BSI in the lower extremity apply greater dynamic loads during athletic movements compared to uninjured athletes

METHODS

- We recruited 40 healthy varsity distance runners (16 F, 24 M)
- Past medical history was gathered using IRB approved questionnaire and chart review
- Dynamic loading data was collected using the Pedar-X Insole System (Novel Electronics, Inc., St. Paul, MN, USA)
- Each subject completed standard athletic movements
  - Treadmill run (2.91 m/s)
  - Two-footed vertical jump
  - 10 m shuttle run
  - 15 m zigzag course
- Peak pressure, maximum mean pressure, maximum force, contact area and force-time integral were measured and normalized to body-mass for each athletic movement
- Dynamic loading data was analyzed using Ayasdi Core topological network analysis software (Ayasdi, Menlo Park, CA, USA); paired t-tests were performed to compare the two groups.
- Studies investigating dynamic loading during a range of athletic movements are limited, particularly in the elite running population

RESULTS

Athletes with a history of bone stress injury trended toward greater peak pressures (p = .13; left) during running activities compared to uninjured controls, and displayed significantly greater peak pressures (p < .05; middle) in the forefoot during cutting movements. When isolating athletes with bone stress injury of the foot and ankle, we found that those with history of stress injury displayed greater force-time integral in the forefoot during running (p = .06; right)

DISCUSSION

- Our findings suggest that elite runners with history of BSI exert greater pressures and force-time integral in the forefoot and medial midfoot during running and cutting compared to uninjured athletes
- We are collecting bone mineral density scans, nutrition assessments and mileage tracking to provide further context to dynamic loading and its association with BSI

CONCLUSIONS

- Greater loads in the forefoot and medial midfoot may play a role in the incidence and recurrence of BSI in running athletes
- Further study this cohort may allow elucidation of relationships between specific loading patterns and related specific BSI
- Dynamic loading analysis may allow us to investigate the utility of preventative measures such as orthotics, corrective footwear and gait retraining in both injury naïve and post-operative rehabilitative populations