DOES SUSTAINING A LOWER EXTREMITY STRESS FRACTURE ALTER LOWER EXTREMITY MECHANICS IN RUNNERS?

Clare E. Milner[1], Irene S. Davis[1,2] and Joseph Hamill[3]

[1] Department of Physical Therapy, University of Delaware, Newark, DE, USA
[2] Joyner Sportsmedicine Institute, Lexington, KY, USA
[3] Department of Exercise Science, University of Massachusetts, Amherst, MA, USA
E-mail: milner@udel.edu Web: http://www.udel.edu/PT/davis/Lab.htm

INTRODUCTION

Stress fractures are common in runners, particularly in females who sustain approximately twice as many as males. A stress fracture is one of the most serious running injuries, requiring six to eight weeks rest from running, and the risk of reinjury is high. The risk of reinjury may be up to 36%, compared to between 1% and 21% risk of initial stress fracture (Hauret et al., 2001). There is some evidence that stress fractures are related to running gait mechanics. In cross-sectional studies, runners who had sustained a stress fracture had higher instantaneous loading rate (ILRZ) and peak tibial shock (PPA) and reduced knee flexion excursion (KEXC). The effect of a previous stress fracture on running mechanics is unknown and could be a factor in the high rate of reinjury in this group.

The aim of this study was to determine whether pre-injury running mechanics are altered following the occurrence and recovery from a lower extremity stress fracture. In addition, impact peak (IPEAK) and braking load rates (ILRY, ALRY) will be examined, as they may also be linked to injury in runners. It was expected that the magnitudes of ILRZ, PPA and KEXC that have been related to stress fracture would be present prior to the injury, and that they would remain the same post injury.

METHODS

These data are part of an ongoing prospective study of female distance runners. Currently uninjured adult female runners, typically running at least 20 miles per week, are recruited into a two year longitudinal study. An instrumented gait analysis is performed on entry into the study. Subjects run overground at 3.7m/s in standard laboratory running shoes. Five trials are recorded using a six camera motion capture system at 120 Hz and a force platform and accelerometer at 960 Hz. Three-dimensional kinematics and kinetics are calculated for both lower extremities.

Subjects are then followed monthly for two years. Running mileage and injuries are tracked. All participants who sustain a stress fracture of the lower extremity are asked to return to the laboratory for a second instrumented gait analysis. The post-injury analysis is performed when they have recovered from injury and returned to at least 50% of their pre-injury mileage.

To date, six runners (30±13 y, 24±12 mpw) have sustained a lower extremity stress fracture or tibial stress reaction. A tibial stress reaction is operationally defined as bone pain and tenderness located over a diffuse area of several centimeters. The pain is alleviated by rest and worsens with continued running. Essentially this is the early stage of development of a full stress fracture and will likely progress to fracture if the training load is not removed (Batt et al., 1998). We have included stress reaction in this group as it indicates susceptibility to stress fracture. A control group of 6

Presented at the American Society of Biomechanics annual conference 2004

uninjured runners matched for age and mileage (23± 8 y, 26±1 mpw) was also included. Comparisons were made between controls and injured runners' pre- and post-injury data. Statistical analyses were not conducted due to the small sample size.

RESULTS AND DISCUSSION

Using a 15% change as being clinically relevant, several variables showed a notable increase following stress fracture in these runners (Table 1). ILRZ and PPA were higher in the stress fracture group compared to controls prior to injury. In addition, ILRZ and PPA became notably higher post-injury in the fracture group. Since stress fractures are essentially fatigue fractures of the bone, their occurrence relates to the load per cycle and the number of cycles. Increasing either of these factors increases the risk of exceeding the fatigue limit of the tissue. ILRZ and PPA indicate the magnitude of compression loading per cycle, therefore higher values indicate increased risk.

Table 1: Changes in selected variables following a lower extremity stress fracture or reaction in female runners (mean ± SD).

	CTRL	PRE	POST
ILRZ (BW/s)	97.7	120.20#	146.19*
PPA (g)	5.22	9.10#	10.88*
KEXC (º)	35.5	34.4	32.1
IPEAK (BW)	1.55	1.87#	1.96
ILRY (BW/s)	34.00	39.13#	50.74*
ALRY (BW/s)	7.10	7.04	11.13*

Greater than 15% difference between control and pre-injury.* Greater than 15% change pre- to post-injury.

These data suggest that runners who sustain a stress fracture have a more risky gait prior to injury and are adopting an even more risky gait following recovery from stress fracture. This finding may explain the high incidence of reinjury following a lower extremity stress fracture in runners.

Of the additional variables studied, both ILRY and ALRY increased notably following recovery from stress fracture. ILRY was also increased compared to controls in the fracture group prior to injury. These shear loading rates indicate the magnitude of bending loads that the lower extremity is subject to, in addition to the compressive loading that occurs during initial weight acceptance in stance. It has been shown that anterior-posterior bending strength is related to the risk of tibial stress fracture (Milgrom et al., 1989). Therefore, the magnitude of anterior-posterior loading rates may be directly related to stress fracture. The secondary planes of ground reaction force are often overlooked in gait analyses, but these substantial changes indicate that they are worthy of further investigation in relation to stress fracture injuries in runners.

SUMMARY

Runners who sustain a lower extremity stress fracture have higher lower extremity load rates and shock prior to injury in comparison with controls. Post-injury subjects adopted a more risky gait, with further increases in lower extremity load rates and shock.
These preliminary data suggest that interventions to reduce loading post fracture need to be developed.

REFERENCES

Batt, M.E. et al. (1998). *Med. Sci. Sports Exerc.*, **30**, 1564-1571.
Hauret, K.G. et al. (2001). *Military Med.*, **166**, 820-826.
Milgrom, C. et al. (1989). *J. Biomechanics*, **22**, 1243-1248.

ACKNOWLEDGEMENTS

Supported by Dept of Defense grant DAMD17-00-1-0515.