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Metatarsal fracture mechanism: accelerating loads the fifth ray more than cutting

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Introduction

Metatarsal fractures, especially of the 5th metatarsal are an increasingly common orthopedic problem among athletes [1]. Sports with a substantial amount of sprint and cutting movements appear to be at greater risk for both stress and acute fractures of the fifth metatarsal. One mechanism of injury is proposed to be the cumulative effect of the many bending moments applied to the fifth ray during cutting maneuvers, specifically to the foot on the inside of the turn [2]. This hypothesis has been bolstered by observing several athletes fracturing their 5th metatarsal during cutting maneuvers in games recorded on video, but no rigorous evidence exists to support cutting as the cause of the fracture. The purpose of this study was to identify the loading pattern of the fifth metatarsal during several typical sport maneuvers to determine if a bending moment is likely to occur.

Methods

Foot pressure was recorded using a Pedar (Novel, GmbH, München) insole system (99 Hz) on ten male college-aged athletes while they ran a course that included running straight, cutting left, cutting right, accelerating, jumping and landing. Using a videotape, each footstep was matched to a step processed in Emedlink to identify which maneuver was being performed. Seven regions of the foot were evaluated for peak pressure with specific focus on the fifth metatarsal head and fifth metatarsal base. The purpose was to determine which maneuver had the highest pressure on the fifth metatarsal head, and which maneuver had the greatest pressure differential between the base and the head of the fifth metatarsal – a corollary to a bending moment. A mixed-effects 2-way ANOVA (2 regions × 6 maneuvers) with Scheffe's tests post hoc were used for statistical analysis.

Results

The highest peak pressure occurred at the head of the fifth metatarsal during accelerating (41.8 ± 9.0 N/cm^2; $p < 0.001$), 61% higher than the pressure during all other maneuvers (see Figure 1). Accelerating also had the greatest difference between the pressure at the head and the base of the fifth metatarsal (30 N/cm^2), indicating the largest bending moment across the length of the fifth metatarsal during this maneuver.

Conclusion

Based on the pressure data from this study, bending moments applied to the fifth metatarsal appear highest when attempting to increase running speed (accelerating). Sudden increases in training load, especially activities involving sprint starts, should be tempered with adequate rest. Athletes may be able to continue light work in practice if rapid changes in running speed are avoided.

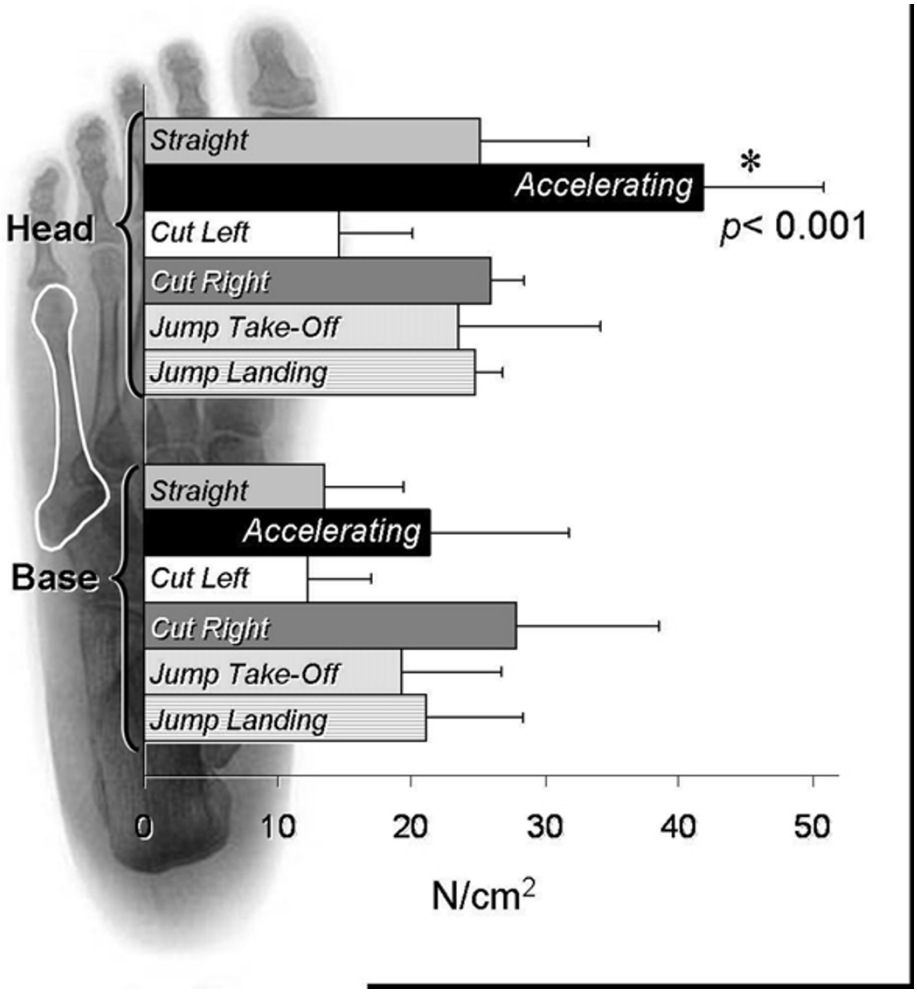

Figure 1
Peak plantar pressures (N/cm^2) at the head and base of the fifth metatarsal during running straight, accelerating, cutting left, cutting right, jump take-off and jump landing.

References

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