EFFECT OF ACUTE FATIGUE ON TIBIAL BONE LOADS DURING BASKETBALL MANEUVERS

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Summary

Tibial BSIs are a common injury in athletes and soldiers. The current study used a standardized fatigue protocol to show that performance fatigue had minimal impact on tibial bone loading in collegiate-level basketball players. This suggests that factors other than fatigue may play a more important role in BSI risk in these athletes.

Introduction

Performance fatigue is a multifaceted phenomenon involving central and peripheral factors which cumulate in slowing of motor unit firing and a decrease in force and power production. The reduced performance can be coupled with altered joint kinematics and kinetics which potentially impact musculoskeletal loading and injury risk. For instance, fatigue has been suggested as a contributing factor to tibia bone stress injuries (BSIs) – a common overuse injury in athletes and soldiers. The aim of the current study was to use subject-specific muscle-driven finite element (FE) models and computational whole-body musculoskeletal models to assess the effect of fatigue on tibial strains and lower body kinematics during common basketball maneuvers.

Methods

Ten college-level basketball players (22.7 ± 1.4 years old, 1.92 ± 0.09 m tall, and weighed 90.2 ± 11.4kg) participated in this IRB approved study. Subject-specific FE models were created using computed tomography images of the tibia (Biograph128 mCT). Participants completed a 5-minute warm-up of treadmill running at a self-selected speed prior to baseline vertical jump height testing using a Vertec vertical jump meter. Biomechanical testing was performed with retro-reflective markers positioned on 28 upper and lower body landmarks, based on established marker set (Dorn et al., 2012). Participants performed a land-jump maneuver ('Jump'), sprinting ('Sprint'), and a lateral cut maneuver ('Lateral Cut'). Kinematic data were collected with a 10-camera motion capture system (VICON Vero v2.2) and kinetics data were collected at 2400 Hz via an in-ground force plate (AMTI OR6-7). After initial testing, participants were fatigued via cycles of three activities while wearing a a 40 lb weighted vest: 1) step-ups for 3-minutes on an 18-inch step at a cadence of 96 steps per minute; 2) 30 double leg calf raises performed on a step; 3) wall site for 1-minute. After each cycle, the vest was removed and vertical jump reassessed. Fatigue was judged by a reduction in vertical height to below 80% of that measured at the start of the test. Once fatigued, participants then repeated the lateral cut, jump, and sprint tasks. For each participant and activity, the 95th percentile principal tensile and compressive strain were computed at each time frame. The time of peak strain during the stance phase was identified. All models were spatially normalized to a common template, and the middle sections of the bone models were divided into 120 regions. The principal strains, at the time of peak strains, were compared within the 120 regions. Kinematics and torques at the hip, knee, and ankle were extracted. All post-processing was performed in MATLAB and Rstudio .

Results and Discussion

Participants completed 4.9±1.4 cycles (25 min 39 s ± 9 min 23 s) of the fatigue exercise protocol. Stance duration was not affected by fatigue for any task; however, joint kinematics and torques during Jump were influenced by fatigue. Peak ankle dorsiflexion angle was 6° lower and participants generated 25% lower ground reaction forces at mid-stance during Jump after fatigue ($p = 0.03$). In addition, peak hip and knee joint torques were 23% and 32% lower following fatigue during Jump, respectively ($p = 0.002$). There were no differences in peak tensile or compressive strains between pre- and post-fatigue for any of the tasks (all $p = 0.37$-0.83). However, tensile strain in post-fatigue Jump was generally lower than pre-fatigue. Also, the timing of peak strains during Lateral Cut appeared delayed after fatigue, although statistical significance was not reached (Figure 1).

Fatigue in the current study altered joint kinematics and kinetics during a land-jump task, reducing tibial bone strains. These findings align with a decrease in muscle force and power due to fatigue. The change in outcomes after the Jump task, but not the Lateral Cut and Sprint tasks, likely reflects the fatiguing protocol's focus on jump performance.

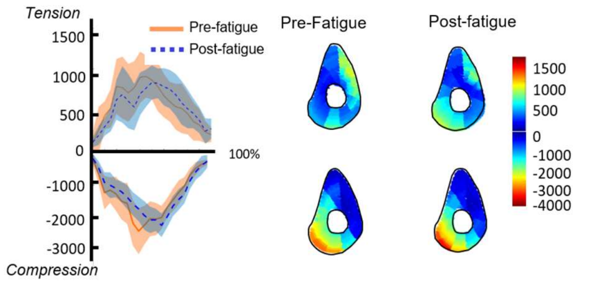

Figure 1 Strain magnitude and distribution during pre- and post-fatigue Lateral Cut

Conclusions

In conclusion, our data suggest that performance fatigue had minimal impact on sagittal joint kinematics and kinetics and tibial bone strains in collegiate-level basketball players.

Acknowledgments

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