

# Changes In Lower Extremity Joint Stiffness With Landing After Fatigue

David Buschke, John Hart and Heather Johnson

Faculty Sponsors: Thomas W. Kernozek (Health Professions), Robert Ragan (Physics)

## ABSTRACT

The purpose was to examine the ankle and knee stiffness after fatigue. Kinematic and kinetic data were collected and analyzed on 8 male and 8 female participants. Custom software was used to model the lower extremity joints as rotational springs. Joint stiffness was calculated for pre and post fatigue conditions. Knee stiffness decreased significantly after fatigue while ankle stiffness increased.

**Key words:** biomechanics, impact, kinematics and kinetics.

## INTRODUCTION

There may be a specific level of joint stiffness necessary for optimal performance and injury reduction<sup>1</sup>. Too much joint stiffness has been linked to some shock related boney injuries such as stress fractures<sup>2</sup>. Others have suggested that too little joint stiffness may result in soft tissue injury<sup>3</sup>. As a result, there may be an optimal level of joint stiffness to minimize the injury risk. Current focuses of jump-training programs seem to be specific instruction to reduce lower extremity stiffness<sup>4</sup>.

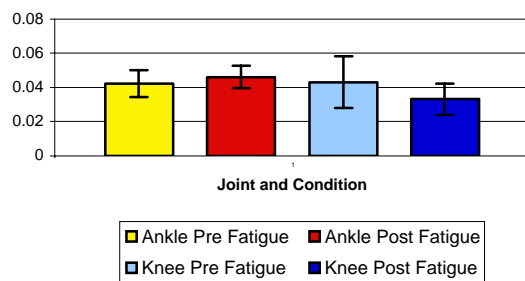
Other than paper by Madigan and Pidcoe<sup>5</sup>, landing after fatigue has not been investigated. As a result, this study examined the influence of fatigue on the lower extremity stiffness of the knee and ankle in landing.

## METHODS

Eight male and eight female recreational athletes volunteered to be in the study. Eight single legged landing trials were performed from a 40-centimeter height. Kinematic data were recorded using a six-camera three-dimensional motion analysis system with 16 retro-reflective markers using the Helen-Hayes marker set. Kinematic data were collected at 240 Hz and raw coordinate data were filtered at 10 Hz. Kinetic data were recorded simultaneously using a Bertec force platform and were synchronized in time with the kinematic data. Kinetic data were sampled at 1200 Hz. Subjects were then asked to perform a protocol consisting of performing a squatting activity on a Smith machine until fatigue ensued. Subjects performed four sets of 60% of their one-repetition maximum squat, each to fatigue failure. Three sets were performed before four single-limb landings were recorded from a 40-centimeter height. The subjects then performed one more squat set to fatigue, to control for muscle recovery, before landing four more times. Inverse dynamics calculations were performed in the Kintrak software package and rotational spring stiffness was calculated with a custom program in Matlab. Joint angles and moments at the knee and ankle were used to calculate rotational stiffness before and after fatigue. Stiffness was calculated by dividing the joint moment by the change in angular displacement respectively for the knee and ankle<sup>6</sup>. Averages of the eight trials per condition were used. A two-way analysis of variance with one between factor (gender) and one within factor (fatigue) were used to compare stiffness at the ankle and knee.

## RESULTS AND DISCUSSION

Lower extremity stiffness was different at the ankle and knee joint with fatigue ( $p < 0.05$ ). Figure 1 depicts how these stiffness variables at the knee and ankle change with fatigue. The joint stiffness was not different across gender, nor was there an interaction between gender and fatigue. Stiffness at the ankle increased about 10% with fatigue while knee stiffness decreased about 22% with fatigue.



**Figure 1.** Landing joint stiffness changes pre and post fatigue.

## CONCLUSIONS

Not surprisingly, the squat-induced fatigue protocol reduces knee stiffness. The fact that ankle stiffness appears to compensate by increasing is somewhat surprising, and is perhaps in response to the lower knee stiffness. Further research should investigate how this adapted strategy influences injury.

## REFERENCES

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