JOINT TORSIONAL STIFFNESS CONTRIBUTIONS TO LEG STIFFNESS VARY DURING DROP LANDINGS ONTO ONE OR TWO LEGS

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INTRODUCTION

Vertical ground reaction force (GRFv) descriptors of landing on one leg are less than twice the two leg landing values[1], suggesting neuromuscular control strategy adjustments according to the number of limbs available to absorb energy. Quantifying leg stiffness and individual joint stiffness allows evaluation of neuromuscular control strategies [2]. When hopping in place, leg stiffness adjustments to alter hopping frequency or height occur primarily by adjusting ankle joint stiffness [2]. Landing differs from hopping since landing does not require a subsequent flight period. Landing research identifies the knee as the primary contributor to energy absorption, but the ankle contribution increases if a "stiffer" landing technique is used [3,4]. The purpose of this study was to compare measures of leg and joint stiffness between one and two leg drop landings. It was hypothesized that higher vGRF values in one leg landing reflect increased leg stiffness. We were also interested in how the individual joint stiffnesses contribute to the altered leg stiffness.

METHODS

Eleven physically active females, each accustomed to landing, participated in the study. All landings were performed from a box set at 25% of body height. Ten trial blocks of one leg and two leg landings were collected in random order from each subject. Instructions were to "land comfortably".

To collect ground reaction force data (GRF), subjects landed with the right foot on a force platform (960 Hz). Markers secured on the right side of the body defining the trunk, thigh, shank and foot segments were digitized with a high-speed infra-red tracking system (240 Hz). Custom software was used to calculate joint torques (JMF) using an inverse dynamic analysis combining the synchronized GRF, kinematic, and subject anthropometric data. Leg stiffness (k_{leg} = Peak $GRF_{vertical}$ / Leg compression) and individual joint stiffness (k_{joint} = ΔJMF/ ΔJoint Angle) were subsequently calculated [2]. Paired t-tests were used for statistical comparisons ($\alpha = .05$)

RESULTS AND DISCUSSION

All GRF and kinematic measures were significantly different between one and two legged landings (table 1). Peak GRFv values were not twice as high. A more extended body position was used in a one leg landing and the leg compresses less. Joint positions are more extended at contact and less flexion ROM is utilized at all joints when landing on one leg; peak knee flexion is reached in a shorter period of time. All joint and leg stiffness measures were significantly different between one and two leg landings (figure 1). Leg stiffness was ~2 times higher during a one leg landing compared to a two leg landing. The increase in leg stiffness was attained by increasing joint stiffness slightly more than 50% at the ankle and hip, and tripling joint stiffness at the knee.

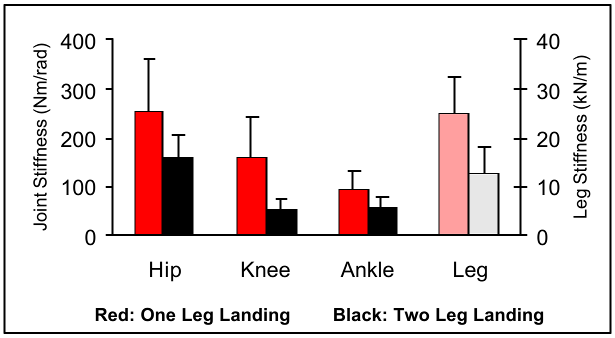

Figure 1: Leg and joint stiffness measures.

CONCLUSIONS

A twofold increase in leg stiffness during landing on one leg results in GRFv values that are 1.5 fold as high as when landing on two legs. While increased joint stiffness is evident at the hip, knee and ankle, the disproportionate increase in knee joint stiffness suggests modulation of knee joint stiffness is the primary mechanism of adapting to a landing on one leg.

REFERENCES

1. McCaw, ST et al. *Proceedings ASB (CD),* 2004.
2. Farley CT & Morgenroth DC. *J Biomech,* **32**,267-273, 1999.
3. Zhang, S et al. *Med Sci Sprt Ex,* **32**, 812-819, 2000.
4. DeVita P & Skelly WA. *Med Sci Sprt Ex,* **24**,108-115, 1992.

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Table 1: Descriptive statistics of selected GRF and kinematic variables.

# Legs	GRFv (kN)	Leg Compress (m)	Time to Mx Knee ? (seconds)	TD Angle (radians) Hip	Knee	Ankle	Joint Flexion ROM (radians) Hip	Knee	Ankle
One	2.62 ± .59	.11 ± .02	.179 ± .043	2.92 ± .08	2.96 ± .06	2.15 ± .08	.38 ± .17	.79 ± .16	.89 ± .09
Two	1.71 ± .50	.15 ± .03	.199 ± .050	2.86 ± .09	2.86 ± .07	2.09 ± .17	.66 ± .24	1.05 ± .18	.89 ± .13