ROTATIONAL SPRING AND DAMPER MODEL PREDICTION DURING LANDING

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INTRODUCTION

Lower extremity stiffness is thought to be an important factor related to performance and injury. There have been three basic approaches to quantifying stiffness during impact related movement activities: vertical stiffness, total leg stiffness and torsional stiffness[1]. The assessment of torsional stiffness allows researchers to quantify changes in stiffness in each joint. This opens the opportunity to assess the relative change in stiffness with experimental perturbations. Some models have also incorporated the use of damping as seen in Derrick et al's study of running[2]. The purpose of this study was to use a spring and damping model to describe landing and describe the relative strength of the fit to drop landing for the joints in the lower extremity.

METHODS

Twelve male recreational athletes performed six single legged drop-landing trials from a 40-centimeter height. Kinematic data were recorded at 240 Hz using a six-camera three-dimensional motion analysis system. Sixteen retro-reflective markers were used with a modified Helen-Hayes marker set. Kinetic data were recorded at 1200 Hz simultaneously with kinematic data using a Bertec force platform. Raw data were smoothed at a 10 Hz cutoff. Inverse dynamics calculations were performed in the Kintrak software package and exported to a custom program in Matlab. Sagittal plane joint angles and moments at the hip, knee and ankle were used to calculate rotational stiffness coefficients[3]. Sagittal plane joint velocities and joint moments were used to calculate damping coefficients for the hip, knee and ankle. Averages of the six trials were used. Descriptive data of the spring and damping coefficients of the hip, knee and ankle were calculated as well as the relative fit using a regression model.

RESULTS AND DISCUSSION

The damped torsion spring model was found to fit the moment data during the impact part of the landing from initial contact until the peak joint moment (approximately 0.1 sec). Spring and damping constants for the knee and ankle maintained high R^2 values with and without the presence of damping (Table 1). Incorporating the effects of damping, however, consistently increased R^2 values in comparison to those without damping. Table 1 also shows that the ankle and knee joint of the lower extremity behave rather spring-like with minimal damping effects. Poor fits of this spring damping model were found for the hip joint where damping coefficients were negative. Also, the model failed to predict joint moments beyond their respective peak moments, where other factors such as central nervous system control need to be considered[4].

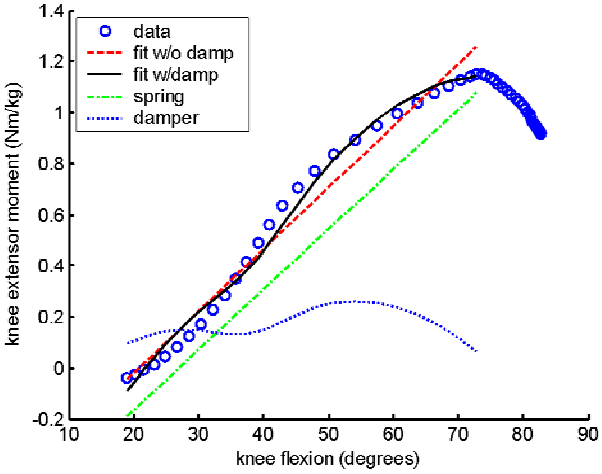

Figure 1 Knee fitting results for a single landing trial from initial foot contact to maximum knee flexion. The spring and damper curves show the contribution from each separately in the fit with and without damping.

CONCLUSIONS

Spring and damping model produces good results for the knee and ankle for the impact portion of landing. The damping effect for drop landing appears to be minimal for the knee and ankle. Much poorer fits were seen at the hip joint. Use of this model should be likely limited to more distal joints like the knee and ankle.

REFERENCES

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Table 1 Model fitting parameters across subjects (mean ± std. dev.) and R^2 values

	Damping Present			Damping Absent	
Joint	**Damping Constant**	**Spring Constant**	**R^2 Value**	**Spring Constant**	**R^2 Value**
Ankle	.000164 ± .000102	.0398 ± .0078	.9622 ± .0605	.0384 ± .0075	.9865 ± .0057
Knee	.000375 ± .000290	.0495 ± .0150	.9926 ± .0056	.0512 ± .0170	.9536 ± .0615