DOES LEG OR BODY TISSUE MASS COMPOSITION AFFECT TIBIAL ACCELERATION RESPONSES FOLLOWING IMPACT?

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INTRODUCTION

Leg muscle activation has been shown to influence the acceleration response of the tibia following impact [1,2]. However, the passive role that whole body and leg tissue masses play in the tibial response to impact has yet to be examined directly. Therefore, the purpose of this study was to investigate the effects of differences in whole body and leg segment tissue mass compositions on the tibial impact response of men and women across a range of body types.

METHODS

Three groups of six males and six females each (n = 36; range of ages, heights and masses were: 18 to 28 years, 1.58 to 1.88 m, and 48.64 to 141.82 kg, respectively) were established based on their %body fat, as estimated from skinfold measurements [3, 4]. The %body fat groups were defined as low: <21%/<8% (female/male), medium: 21-33%/8-21%, and high: >33%/>21% [5]. The lean, fat, and wobbling masses (LM, FM, WM=LM+FM) and bone mineral content (BMC) of the shank were estimated using prediction equations that require anthropometric measurements of the leg segment (e.g. lengths, breadths, circumferences) as inputs [6].

Each participant completed nine trials in which a human pendulum was employed to deliver consistent impacts to the unshod right heel [1,2]. Participants lay supine on the pendulum bed with the right leg extended. Each participant impacted a vertically mounted force platform at a velocity of 1.0-1.15 m/s and with an impact force between 1.8 and 2.8 x body weight (BW). A low mass accelerometer was attached just medial to the tibial tuberosity to record the acceleration waveform during impact, from which three tibial response parameters were determined: peak acceleration (PA), time to peak acceleration (TPA), and acceleration slope (AS). Differences in acceleration responses with respect to whole body and leg segment tissue composition were assessed using a mixed ANOVA. Acceleration data were also normalized to the magnitudes of each leg tissue mass type in order to adjust for the larger absolute tissue masses characteristic of males on average.

RESULTS AND DISCUSSION

There were no consistent effects of whole body composition (low, medium, and high groups) on the tibial response parameters in absolute terms. When stratified by gender, females experienced higher PA, TPA, and AS than males. When acceleration responses were normalized to specific tissue masses, females experienced significantly higher values per unit mass for LM, BMC, and WM than males (Table 1).

The results of this study indicate that the magnitude of leg tissue mass influences the tibial impact response. Specifically, lean mass and bone mineral content appear to contribute significantly to decreased acceleration responses following impact. The mechanistic relationship between these tissue masses and the impact response implies that males may be protected against impact to a greater extent than females, as males were observed to possess greater quantities of both tissues in the leg. This may explain, for example, why females experience more tibial stress fractures than males [7]. Additionally, this study emphasizes the importance of examining the individual tissue masses locally during impact analysis due to their influence on the passive attenuation of the impact response through the segment.

CONCLUSIONS

This study identified the contributions of local segment tissue mass to tibial response following impact and revealed a possible mechanism by which the increased susceptibility of females to impact-related injuries may be explained.

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Table 1: Mean (SD) for tibial response parameters normalized to specific tissue masses for males and females. * indicates a significant difference between the normalized male and female responses ($p<0.05$).

	PA ($g \cdot gram^{-1}$)				TPA ($ms \cdot gram^{-1}$)				AS ($g \cdot s^{-1} \cdot gram^{-1}$)			
	FM*	LM*	BMC*	WM*	FM*	LM*	BMC*	WM	FM	LM*	BMC*	WM*
Males	0.022 (0.014)	0.0038 (0.0010)	0.042 (0.015)	0.0032 (0.0010)	0.032 (0.024)	0.0056 (0.0016)	0.062 (0.023)	0.0047 (0.0015)	3.57 (3.24)	0.60 (0.30)	6.69 (4.00)	0.51 (0.28)
Females	0.014 (0.007)	0.0068 (0.0024)	0.068 (0.031)	0.0046 (0.0018)	0.017 (0.007)	0.0083 (0.0021)	0.082 (0.025)	0.0055 (0.0015)	2.47 (1.86)	1.16 (0.74)	11.97 (8.44)	0.80 (0.54)