

ANKLE ANGLE AND LOCALIZED MUSCLE FATIGUE EFFECTS ON TIBIAL RESPONSE DURING HEEL IMPACTS

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INTRODUCTION

Following heel impact, the shock wave is attenuated as it travels through the musculoskeletal system as a result of active manipulation of body kinematics and joint positions (Hamill et al., 1995), as well as passive attenuation by ‘wobbling masses’ (e.g., muscles, soft tissues, and the heel pad) (Chu et al., 1986; Hamill et al., 1995). A decrease in the amount of shock, measured as accelerations at the knee, has been found when shank muscles were voluntarily fatigued (Flynn et al., 2004; Holmes & Andrews, 2006). However, in these studies, the relative influence of ankle angle and muscle fatigue on tibial response was not considered. Therefore, the purpose of this study was to compare the tibial response when tibialis anterior (TA) was fatigued and when not fatigued, while at the same ankle joint angle.

METHODS

Ten males and ten females participated in this study (21.8 ± 2.9 years old). An accelerometer was preloaded just medial to the tibial tuberosity; an electro-goniometer was placed across the ankle joint; and TA and lateral gastrocnemius (LG) muscle activity were recorded via EMG. Each subject’s dorsiflexion angle range (min to max) was recorded, and then 4 relative positions within this full range were used for testing.

Subjects were heel-impacted into a vertically mounted force platform using a human pendulum apparatus at each of the 4 ankle angle ranges. Impacts occurred when TA was either not fatigued (NF) or fatigued (F). Dependent Measures included Peak Tibial Acceleration (PA), Time to Peak Tibial Acceleration (TPA) & Acceleration Slope (AS). AS was calculated between 30% and 70% of the time to PA (AS time) or amplitude of PA (AS amplitude).

RESULTS AND DISCUSSION

The maximum dorsiflexion angle recorded for subjects was $16.6^\circ \pm 6.4^\circ$. On average, subjects were not able to maintain the same ankle angles when fatigued (Figure 1). Four ankle angle ranges of approximately 2° each were examined, where the F and NF curves overlapped (Figure 1, Table 1).

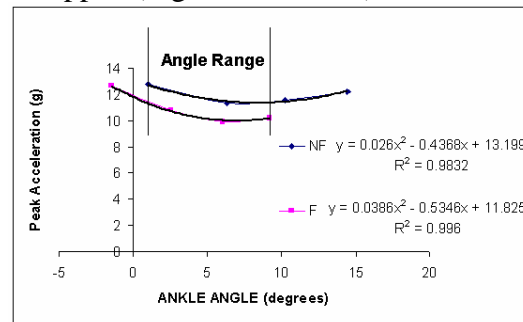


Figure 1: Peak Tibial Acceleration Across Ankle Angle Ranges for F and NF States.

Table 1: Four Ankle Angle Ranges.

1	2	3	4
1.0° - 3.0°	3.0° - 5.1°	5.1° - 7.1°	7.1° - 9.2°

TA mean power frequency values decreased by over 30% following the fatigue protocol.

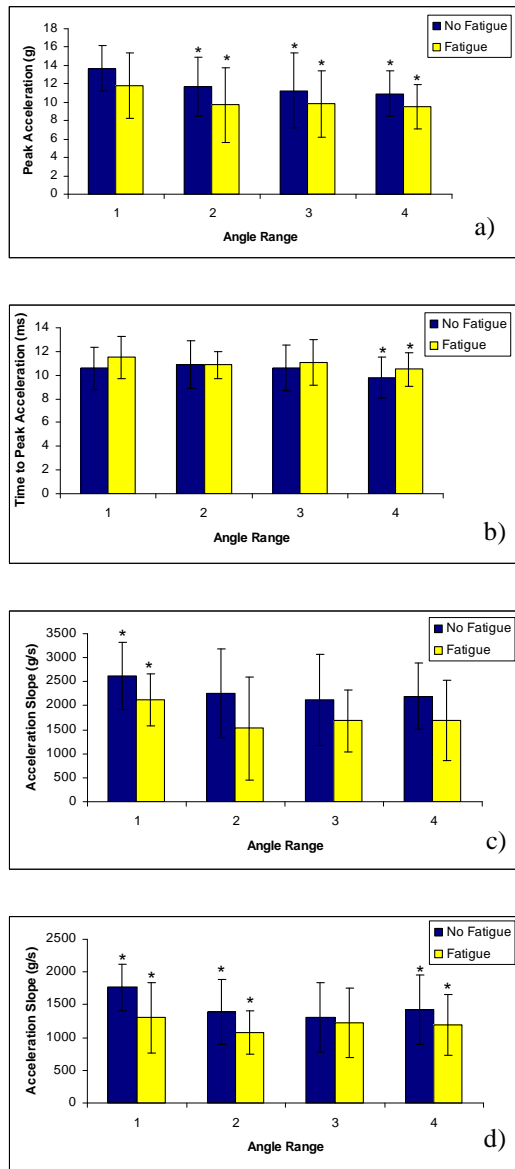


Figure 2: Fatigue effects for a) Peak Tibial Acceleration; b) Time to Peak Tibial Acceleration; c) Acceleration Slope based on Amplitude; and d) Acceleration Slope based on Time (* = p<0.05).

Fatigue effects were seen in PA, TPA, and AS (Figure 2a-d). An average difference of 1.1g, 1.1ms, 439g/s, and 302g/s were found between the F and NF states when the same ankle angle was recorded for PA, TPA, AS (amplitude), and AS (time), respectively. Although there was an obvious difference in magnitude between AS (amplitude) and AS (time), the same overall trends were noted. All values corresponded to those found in previous studies (Flynn et al., 2004; Holmes & Andrews, 2006).

CONCLUSIONS

The effect of ankle angle alone does not account for the differences seen in the tibial response during localized muscle fatigue. The wobbling mass reduces PA and AS, while increasing the TPA.

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