CALCULATION METHOD AFFECTS TIBIAL ACCELERATION SLOPE VALUES

Adriana M. Holmes[1], Nikki L. Nolte[2] and David M. Andrews[2]

[1]Department of Kinesiology, University of Waterloo, Waterloo, ON, Canada
[2]Department of Kinesiology, University of Windsor, Windsor, ON, Canada,
dandrews@uwindsor.ca

INTRODUCTION

Considerable variability in tibial acceleration slope (AS) values, and different interpretations of injury risk based on these values, have been reported in the literature. Variability in AS values may be due, at least in part, to variations in the method used to quantify slope from the acceleration waveforms (Flynn et al., 2004; Holmes & Andrews, 2006; Lafortune & Lake, 1995; Lafortune et al., 1996). Therefore, the purpose of this study was to quantify differences in AS magnitudes determined using end points at various percentage ranges between impact and peak tibial acceleration (PA), as a function of either amplitude or time.

METHODS AND PROCEDURES

Tibial accelerations were recorded at the tibial tuberosity from 10 male and 10 female participants (21.8 ± 2.9 years) during 24 unshod heel impacts using a human pendulum apparatus. AS was calculated as the slope between two end points described by percentages, as a function of the PA amplitude ($AS_{Amplitude}$) or the time to PA (AS_{Time}) (Figure 1). Nine percentage ranges were tested from 5-95% (widest range) to 45-55% (narrowest range) at 5% increments.

RESULTS

The magnitudes of $AS_{Amplitude}$ values were larger and more sensitive to changes in percentage range than AS_{Time} values derived from the same impact data (p=0.00). The $AS_{Amplitude}$ magnitudes increased consistently across all ranges, and levelled off at the narrowest ranges, from 35-65% to 45-55%; while all AS_{Time} magnitudes narrower than 5-95% were statistically the same (Figure 2).

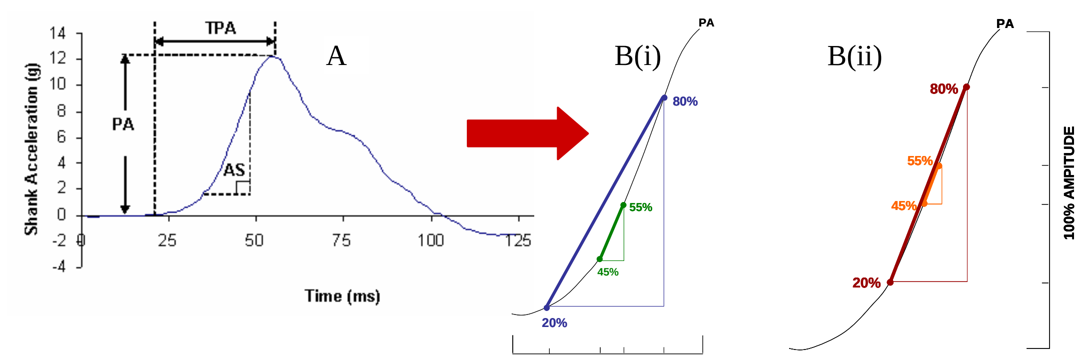

Figure 1. A) Tibial acceleration waveform with Peak Tibial Acceleration (PA), Time to Peak Tibial Acceleration (TPA), and Acceleration Slope (AS) highlighted. B) Sample Ranges for Acceleration Slope (AS) calculations as a function of (i) time and (ii) amplitude.

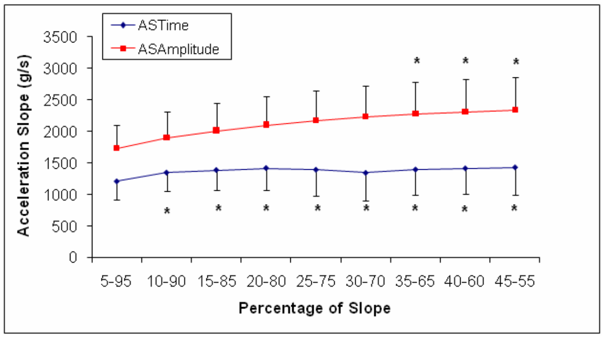

Figure 2. Acceleration Slope (AS) calculated as a function of amplitude ($AS_{Amplitude}$) or time (AS_{Time}). * = Statistically the same.

DISCUSSION

When characterizing tibial acceleration waveforms, a decision must be made regarding what portion of the waveform most appropriately describes the acceleration slope. Most authors have assessed the linear portion of the acceleration waveform, yet major inconsistencies in methods of quantifying slope have been reported (Flynn et al., 2004; Holmes & Andrews, 2006; Lafortune & Lake, 1995; Lafortune et al., 1996).

The current study has shown that $AS_{Amplitude}$ values were significantly higher and more sensitive to changes in percentage range than AS_{Time} values derived from the same impact data. Despite differences in magnitude and variability, AS values calculated by both methods fell within the range of those previously reported in the literature (Table 1).

Magnitudes of AS are highly dependent on the method used to calculate them. Researchers are encouraged to carefully consider the choice of method when calculating AS following impact, so that equivalent comparisons and assessments of injury risk across studies can be made.

REFERENCES

Flynn, J.M. et al. (2004). *Clinical Biomechanics*, 19(7): 726-732.
Holmes, A.M. & Andrews, D.M. (2006). *J. Applied Biomechanics*, 22(4): 275-284.
Lafortune, M.A. & Lake, M.J. (1995). *J. Biomechanics*, 28(9) : 1111-1114.
Lafortune, M.A. et al. (1996). *J. Biomechanics*, 29(12): 1523-1529.

ACKNOWLEDGEMENTS

Thank you to NSERC for funding this project and to Don Clarke for his technical expertise.

Table 1. Comparison of the Acceleration Slope Means (± Standard Deviations) across studies in the literature that used similar methodologies.

Reference	Slope Method Used	Acceleration Slope (g/s)
Current Study	Amplitude	2121 (463)
Current Study	Time	1374 (375)
Holmes & Andrews (2006)	Amplitude	1563 (614)
Flynn et al. (2004)	Time	2742 (1426)
Lafortune & Lake (1995)	Amplitude	671 (220)
Lafortune et al. (1996)	Amplitude	1150 (930)