QUANTIFICATION OF ENERGY ABSORBED BY THE LOWER EXTREMITY DEPENDS ON ENDPOINT OF THE IMPACT PHASE

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INTRODUCTION

Landing is a complex task essential in physical activity. The lower extremity initially absorbs kinetic energy present at contact using eccentrically controlled hip and knee flexion and ankle dorsiflexion, momentarily stabilizes the body in a knee flexed position, and finally generates energy to extend the body into upright posture or a subsequent movement. The work performed by the eccentrically active muscles is estimated as the integral of the negative phase of the ankle, knee and hip joints mechanical power-time curves [1] Several researchers have investigated the relative contribution of the leg joints to energy absorption during different landing techniques[2,3], and reported differences in relative joint contributions. However, the use of different end points to define the impact phase confounds comparison of the results. The purpose of this study was to compare the absolute and relative amounts of negative work performed at each joint using different methods to define the impact absorption phase.

METHODS

Eighteen college age females, free of lower extremity trauma, volunteered as participants. In one session, 10 trials of landing from a 38 cm stool were performed; instructions were to "land comfortably." Joint kinetics (JMF) were calculated [1] using inverse dynamics from synchronized video (120 Hz) and force platform (960 Hz) data beginning before contact to beyond maximum knee joint flexion; joint mechanical power (JMP) was calculated as JMF·ω. The JMP-time curves were integrated to calculate negative mechanical work beginning with first ground contact; three end points were used: 1) when the vertical GRF leveled out or reached a minimum [3] (EP_{grf}), 2) when the lowest C of G was reached, or max knee flexion [2] (EP_{knee}), and 3) when the negative power at the knee was equal to 20% of the maximum negative knee power (EP_{pwr}), based on the observation that subsequent kinetics are more related to stabilization than energy absorption. Total work was calculated as the sum of the ankle, knee and hip works. Impact phase duration, absolute negative work and relative % work ($Work_{joint}$ / $Work_{total}$) was calculated for each of the three defined impact phases. The 10-trial mean values were entered into a repeated measure ANOVA (α=.05), with Bonferroni adjustment to the *post hocs.*

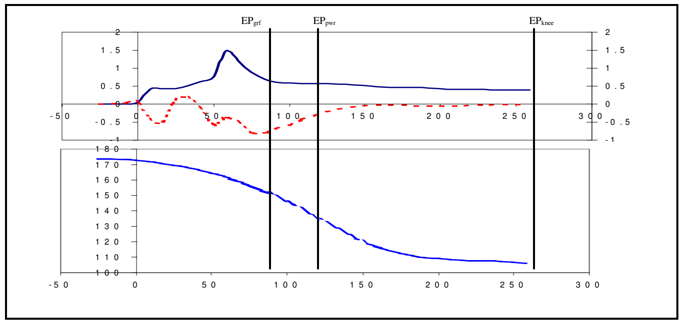

Figure 1. Typical vertical GRF (top), knee power (middle), and knee position (bottom) curves.

RESULTS AND DISCUSSION

Impact phase duration was significantly different among the techniques, shortest when defined by the GRF and longest when defined by max knee flexion (table 1). The total work and individual joint works also increased, but not significantly at the hip joint. Basically, the longer the impact phase, the greater the energy absorbed. However, for % total work, differences EP_{grf} differed from the other methods at the ankle and the knee, but not at the hip joint. EP_{pwr} and EP_{knee} did not differ for % total work at any joint. For EP_{grf}, the ankle and knee joints absorbed similar % total energy, but for both EP_{pwr} and EP_{knee} the knee absorbed significantly more energy than the ankle.

CONCLUSIONS

The method of identifying the end of the impact absorption phase affects the total and joint work calculated. The hip joint is least affected by the definition used. Most importantly, since the % contribution of joints to total energy absorption is used as a reflection of neuromuscular strategies [2,3], the comparison of the conclusions on neuromuscular adaptations must consider the different definition used in the studies.

REFERENCES

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Table 1: Descriptive statistics of the power and the duration values of the different methods

		EP_{grf}		EP_{pwr}		EP_{knee}	
		Actual (J/kg)	%	Actual (J/kg)	%	Actual (J/kg)	%
Power	**Hip**	.347 ± .129	19.3 ± 7.19	.413 ± .190	17.9 ± 7.84	.510 ± .376	19.2 ± 10.81
	Knee	.744 ± .162	41.5 ± 9.41	1.087 ± .239	47.5 ± 9.97	1.177 ± .285	47.2 ± 10.89
	Ankle	.722 ± .259	39.2 ± 11.04	.801 ± .263	34.7 ± 10.91	.835 ± .266	33.6 ± 11.52
	Total	1.81 ± .253		2.30 ± .312		2.52 ± .457	
	Duration (ms)	.084 ± .012		.135 ± .028		.217 ± .078	