INDIVIDUAL JOINT MOMENT STRATEGIES UTILIZED DURING THE SUPPORT PHASE OF RUNNING

K. J. Simpson
Biomechanics Laboratory
University of Georgia
Athens, GA 30605

Introduction

Typically ground reaction force parameters have been used to determine individual kinetic strategies for accommodating impact and loading forces incurred during running. Joint moments are also useful indicators of the amount of physical stress placed on the neuromuscular system (Winter, 1983). General patterns of joint moments (MJ) during the support period can be identified, although considerable pattern variability is evident between the subjects and between the different studies (Winter, 1983; Mann, 1980; Elftman, 1940). The patterns and magnitudes appear to be influenced by skill level (Mann, 1980) and running speed (Winter, 1983; Mann, 1980). Inter-subject variability is joint dependent. Winter (1983) reported increased inter-subject JM variability from the ankle to the hip joint. Differences among subjects and studies could be due partially to the individual strategies used for accommodating impact forces and for generating propulsive forces. Therefore, the purpose of the study was to identify inter-subject differences among the lower extremity joint moments to gain a better understanding of the adaptation strategies utilized during the support period.

Methodology

Four skilled male runners volunteered as subjects. The experimental setup consisted of a Lo-Cam (100 Hz) and a video (60 Hz) camera, a force platform (552 Hz) interfaced with a computer, and an infared timing system to monitor running speed (4.60 +/- .28 m/s). Appropriate anthropometric data were obtained using a modified Hanavan model (Miller, 1975). Eight trials were evaluated. Kinematic and kinetic data were normalized in time by generating 101 estimates. Ankle, knee and hip JM were calculated using a standard Newtonian model. Values were normalized to body weight and height for comparison purposes. Peak JM parameter values were evaluated for two subjects. In addition, between-subject and two individual subject ensemble curve values were generated (Mann, 1980).

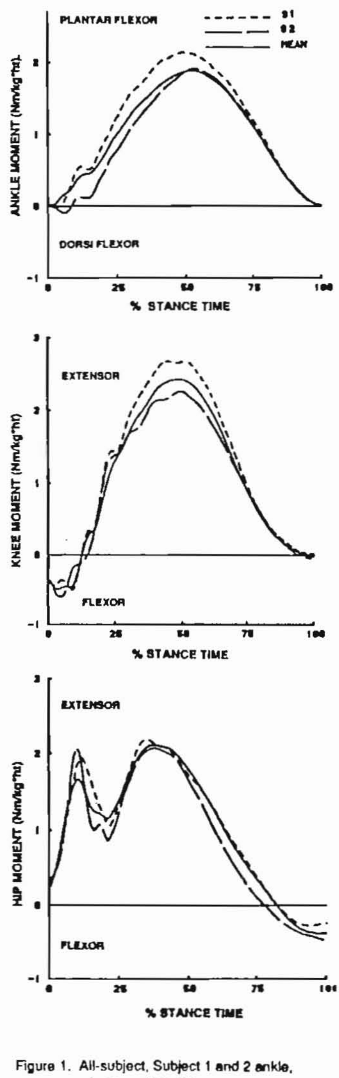

Figure 1. All-subject, Subject 1 and 2 ankle, knee and hip JM curves.

Results and Discussion

Both subjects exhibited similar moment patterns about all of the joints (Figure 1) The evident variations between the subjects are not apparent in the all-subject ensemble curve. Although plantar flexor ankle JM predominated during the entire support period, Subject 2 (S2) displayed a brief dorsiflexor Jm during the initial impact phase. Elftman (1940) also reported an initial dorsiflexor JM. Other researchers (Winter, 1983 and Mann, 1980), however have observed only plantar flexor dominance. Subject 1 (S1) demonstrated a peak plantar flexor JM occurring within the first 50% of the support period. Some individual fluctuations of the knee JM during the loading phase are evident. The fluctuations could be related to collision effects or to critical ground reaction force or JM events. The pattern of hip JM for both subjects was very similar in contrast to the findings of Winter (1983). Differences in running speeds utilized and the small number of subjects used in the present preliminary study could have contributed to the observed differences.

Differences in magnitude between the two subjects are also evident. S1 displayed greater (4.2 - 50.8%) peak joint moment values for the parameters shown in Table 1.

Table 1. Means and standard deviations of maximum JM values for two subjects and mean absolute differences (MAD) and % differences between S1 and S2.

	Max. Values Subject			
Parameter	1	2	MAD	% Diff.
Ankle Plantar Flexor	2.016 (0.124)	1.608 (0.193)	0.408	25.4
Knee Flexor	0.729 (0.179)	0.549 (0.065)	0.180	33.0
Knee Extensor	2.098 (0.226)	2.760 (0.263)	0.662	31.6
First Maximum Hip Extensor	2.106 (0.204)	1.397 (0.172)	0.709	50.8
Second Maximum Hip Extensor	2.248 (0.185)	2.158 (0.203)	0.090	4.2
Hip Flexor	0.389 (0.153)	0.439 (0.065)	-0.050	-12.9

Standard deviations are in parentheses. Units: Moments = N·m/kg • ht

The first maximum hip extensor Jm demonstrated the greatest difference of Jm values (MAD = .709 N m/kg * ht). This variability could represent impact accommodation and propulsive strategies that have injury and performance implications. The first maximum extensor moment generated at footstrike is related to hamstring injury (Mann, 1980). Greater JM magnitudes during foot strike, therefore represent increased injury potential.

Conclusions

Similar patterns of moments for all joints were demonstrated by two of the subjects. Use of all-subject ensemble curves, therefore can be used to understand the basic JM patterns. Inter-subject variations of the Jm patterns and magnitude differences of peak JM parameters suggest that individual adaptations exist. Further investigations of these individual adaptations will improve the understanding of injury mechanisms and performance techniques.

References

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