INTRODUCTION

Joint moments obtained from gait analysis are commonly used to characterize normal and pathologic gait. However, it is well known that factors such as height and weight influence these joint moments. As a result, various joint moment normalization techniques have been devised to help account for these anthropometric differences. Two of the more common methods include normalizing the joint moment by body weight times height (BWHT) or by body mass (BM). The purpose of the present study was to determine in a cross-sectional study which joint normalization method (body weight times height or body mass alone) most reduced the effects of height and weight on hip, knee, and ankle joint moments in a group of normal subjects.

METHODS

A group of 158 normal subjects (74 females, 84 males) were retrospectively collected from the gait laboratory database. Subjects were included if they had no previous history of musculoskeletal involvement and had a right and left side walking trial between 0.9-1.4 m/s. Average age, weight, and height were 33.9 ± 13.6 yrs, 73.3 ±15.0 kgs, and 1.73 ± 0.09m respectively.

Gait analysis was performed using an optoelectronic system with a passive marker system (CFTC) and a multi-component force plate (Bertec). Inverse dynamics were used to calculate the three dimensional local external moments (all moments reported from this point forward are external joint moments). Out of the possible 18 joint moments, the 10 most clinically relevant moments were chosen which included hip flexion, extension, abduction, adduction, internal rotation, external rotation; knee flexion, extension, adduction; ankle dorsiflexion. The average speed for representative walking trials was 1.18 ± 0.1 m/s.

Stepwise multiple regression procedures were used on three different data sets. These data sets included the raw joint moments, joint moments normalized by BWHT, and joint moments normalized by BM. The analyses determined which independent variables (height or weight or speed) were most highly correlated with dependent variables (joint moments). The criteria for entering a variable was p=0.05 and for eliminating a variable after having been entered p=0.01. A 0.05 significance level was used for all statistical analyses. For the analyses, the most effective normalization would have the lowest r² value.

RESULTS AND DISCUSSION

Both normalization methods significantly reduced the variance in the moments ascribed to height and weight. However, the
efficiency of the normalization methods was not equivalent for each moment examined.

As expected, the raw data analysis demonstrated that weight and height had a significant impact on explaining the variance in the ten joint moments. Weight entered the equation for 9 out of 10 moments before speed and had a range of \( \text{adj } r^2 = 0.16 - 0.82 \). Weight had its largest effects on the hip adduction moment (adj \( r^2 = 0.60 \)), knee extension moment (adj \( r^2 = 0.47 \)), and the ankle dorsiflexion moment (adj \( r^2 = 0.82 \)). Height entered the equation for 6 out of 10 moments, but was always the second or third variable (after weight and/or speed), with a change in the adj \( r^2 \) of 0.01 to 0.07. The largest effect was for the knee flexion moment.

For the moments normalized by BWHT, weight entered the equation for 4 moments, always after speed, with a change in the adj \( r^2 \) of 0.02 to 0.06. But out of these, only the hip extension moment accounted for >5% of the variance. Height only entered the equation for one moment, hip adduction, but was the first variable in with an adj \( r^2 = 0.13 \).

For the moments normalized by BM, weight entered the equation for only one moment, hip extension, with a change in the adj \( r^2 = 0.02 \). Height accounted for some degree of variance in 4 moments. In two cases, height was the first variable entered and had the largest effect on the ankle dorsiflexion moment (adj \( r^2 = 0.22 \)).

**SUMMARY**

The two joint normalization techniques investigated in this study were both successful in reducing the effects of height and weight on joint moments. However, their effectiveness varied with the joint and moment being evaluated. Therefore some caution should be used when interpreting joint moments that have been normalized since height and weight may still be contributing to the variance in the data.

**REFERENCES**


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