The effects of normalization on ground reaction forces and joint moments during gait in elderly subjects

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Introduction

Normalization is often use in biomechanics in order eliminate the effect of different body dimensions on the study variables. However, studies have been showing different results regarding the effectiveness of the normalization process [1-2]. The aim of this study was to verify if two normalization processes were able to eliminate the relation between body dimension parameters and kinetic variables during gait in the elderly.

Methods

The sample included 27 community-dwelling older adults with 60 or more years (age 71.4±5.4y, body mass 69.6±11.9kg, trochanteric height (TH) 0.87±0.04m).

Kinematic and kinetic data were collected using 8 infrared cameras (Qualisys) working at a frequency of 200Hz and 2 Kistler force plates. The CAST marker set was used [3]. Participants walked at their comfortable pace.

Three trials from each subject were processed in Visual 3D software (C-Motion, Inc). A 10 Hz 4th order Butterworth filter was applied. An 8 segments model (feet, shanks, thighs, pelvis and trunk) was built and optimized [4]. Standard inverse dynamics was performed to compute lower limb joint moments.

Ground reaction force peaks (medial, posterior, anterior and 2 vertical peaks) were normalized to body weight (BW) and ankle and knee joint moments' peaks (sagittal plane) were normalized to body mass (BM) and to BW*TH. Spearman correlation coefficient was determined using IBM SPSS Statistics (version 25) in order to verify the correlation between body parameters and the kinetic variables. The coefficient of variation (CV) was computed to check if the normalization process would reduce the variability between subjects.

Results

As expected, all the non-normalized ground reaction force peaks were correlated with BW (rho≥0.5). The normalization process eliminated all the verified correlations, with the exception of the vertical ground reaction force second peak (rho=-0.51, $p<0.01$), and reduced the CV.

Both normalization processes eliminated the correlation between ankle plantarflexor joint moment peak with BW and TH. However, BWL the normalization seemed to have a poorer effect in the CV. No correlations were found between the knee joint moment and the body parameters.

Discussion

In general, this study shows that the normalization process helps to eliminate the effect of body parameters on kinetic variables. However, contrarily to what was expected, its effectiveness was not the same across variables and BM normalization was superior to BW*TH normalization for ankle plantaflexor joint moment.

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