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Comparison of 3D joint moments using local and global inverse dynamics approaches among three different age groups

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Abstract

A complete understanding of joint moment is important to locomotion research. The purpose of the study was to compare stance phase lower extremity joint moments, calculated by a three-dimensional (3D) inverse dynamics model and expressed in global and local coordinate systems, to examine the influence of different coordinate systems on joint moment profiles. Additionally, aging influences on joint moments were examined. Thirty healthy (10 young, 10 middle-aged and 10 old) participants were involved in the current study. Kinematic and kinetic data were collected using standard gait study protocol. Results suggested that globally expressed joint moments were significantly different than those expressed locally. Furthermore, significant moment differences were found between young and old age groups. The older adults produced less evertor muscle moments at the ankle joint. However, aging effect was not significant for majority of the joint moment comparisons. It is concluded that coordinate system need to be carefully chosen, and specified in 3D joint moment analysis, while significant error introduced by using 2D analysis need to be considered.

Keywords: Age; Coordinate system; 3D; Inverse dynamic

1. Introduction

A complete understanding of joint moment is important in the general study of human locomotion. Sagittal plane joint moments estimated by using two-dimensional (2D) inverse dynamics analysis has been a popular and useful tool in understanding the mechanisms of human gait [1–3]. This is a simplified procedure, which requires only one camera to capture human movement, a few marker position data to define joint centers and center of mass (COM) locations, and a fixed coordinate system to interpret the results.

Recently, three-dimensional (3D) inverse dynamics analyses of sagittal plane joint moments have been presented [4–5]. Alkjaer et al. [4] compared the ankle, knee and hip joint moments in sagittal plane utilizing two- and three-dimensional models during normal walking and concluded that the simpler 2D approach seems appropriate for gait analysis because little differences were found in the overall joint moment patterns between the 2D and 3D models. Nevertheless, the sagittal view provides only part of the information. This is especially true at the hip joint where hip abductor moments play an important role in maintaining trunk balance in the frontal plane [6].

Several studies were also conducted to reveal joint moments in three planes (sagittal, frontal and transverse) using 3D inverse dynamics approach [7–10]. While inter-subject variability has been examined in these studies, no age group differences in three dimensional analyses were addressed, which led to the necessity of comparing 3D joint moments among different age groups in the current study. Furthermore, lower extremity joint moments were found to be an important variable explaining age-related musculoskeletal deterioration. It is also believed that 3D joint moment analysis will further aid in answering the fundamental questions associated with age-related slip-induced fall accidents.

To describe human motion in space, appropriate coordinate systems have to be adopted in 3D inverse dynamics analysis. Various coordinate systems categorized

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