COMPARISON OF METHODS USED TO DETERMINE INDUCED VERTICAL GROUND REACTION FORCE

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INTRODUCTION

Every muscle action contributes to the ground reaction force via joint reaction forces passed through the system. Calculation of these effects is of interest, as it gives insight into a muscles role during a particular movement. Direct dynamic simulations have been used determine the role of individual muscle during gait [1,5], however different methodologies have been used. Neptune et al. [5] determined an individual muscle's contribution to the ground reaction force at each instant in time by taking the difference of the actual ground reaction force and the ground reaction force caused by all forces except the muscle of interest. Anderson and Pandy [1] determined an individual muscle's contribution to the ground reaction force by applying each muscle force in isolation and determining the resulting ground reaction force. The purpose of this study was to determine the induced vertical ground reaction forces during jumping using both methods and compare the summed induced vertical ground reaction forces with the actual vertical ground reaction force.

METHODS

An optimal control, direct dynamics simulation model was used to simulate vertical jumping. The model had four rigid links (foot, shank, thigh, and a combined head, arms, and trunk), connected by frictionless hinge joints. The foot was connected to the ground by a hinge joint at the metatarsal-phalangeal joint. It had a rotational spring-damper at this joint to represent the floor-heel interaction [6]. The equations of motion were formulated as mixed differential-algebraic equations [4]. The model was actuated by six muscle models representing the major muscle groups of the lower extremity. Each muscle was represented by a Hill-type model consisting of a series elastic element and a contractile element [2]. A genetic search algorithm [3] was used to select sequences of muscle model neural excitations for each of the muscles so that the total potential and kinetic energy of the center of mass was maximized at the instant the foot lost contact with the ground.

Induced vertical ground reaction forces were calculated using the methodology of Neptune et al., [5] (Method 1) and Anderson and Pandy [1] (Method 2). The induced ground reactions force for each muscle were summed and compared to the actual ground reaction force.

RESULTS AND DISCUSSION

The procedures for determining induced vertical ground reaction force produced similar results. When the individual, induced vertical ground reactions forces were summed, the total was similar to the actual vertical ground reaction force for both methods examined (Figure 1).

Method 2 produced a larger total vertical ground reaction force than method 1, with method 1 being closer to the actual values. This difference was fairly consistently spread across all of the muscles. The reasons for this difference are not completely clear, however method 1 allows for the possibility that a muscles contribution to the ground reaction force can change based upon the activity of other muscles.

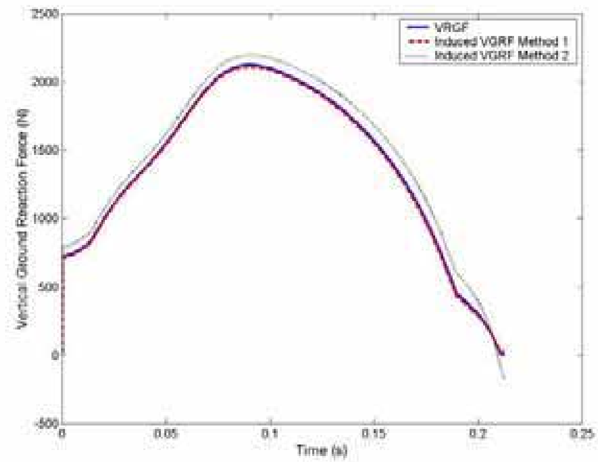

Figure 1: Total induced vertical ground reaction force for each method compared to actual vertical ground reaction force (VGRF).

CONCLUSIONS

Calculation of induced ground reaction forces can provide insight into a muscles role during a particular movement. Determining a muscles induced ground reaction force by subtracting the ground reaction force caused by all other forces from the total ground reaction force at each instant in time produces results closer to the actual ground reaction force than does applying each muscle force in isolation and determining the resulting ground reaction force.

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