EFFECT OF BILATERAL ASYMMETRY OF LOWER MUSCLE FORCES ON VERTICAL JUMPING HEIGHT: A SIMULATION STUDY

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INTRODUCTION

Properties and function of each bilateral component of the human body are basically symmetrical. Thus, when human movements such as jumping and walking are investigated, a bilateral symmetry is assumed. However, in reality, they are not precisely symmetrical. Additionally, little is known about the effects of bilateral asymmetry of musculoskeletal properties on various human movements. It is hard to address this question using experimental protocols because of the difficulty in controlling the asymmetry of the human body.

The purpose of this study was to investigate the effects of bilateral asymmetry of lower muscle forces on the biomechanics of a vertical jumping motion using computer simulation.

METHODS

A model of 3D human body musculoskeletal system was developed using DADS-3D (LMS International). Segment inertial parameter and muscle parameter values were derived from [1] and [2], respectively. A dynamic activation mechanism to represent the transfer lag between the neural input signal and the musculotendon force development [3] was implemented. In addition, Hill-type muscle F-V-L relations, elements to limit the joint range of motion, and ground reaction force [4] were implemented. Fifteen muscles for each leg were implemented. Properties of each muscle were bilaterally symmetrical and derived from [5] and [6].

Two types of models were developed. One model had the same construction and properties as above mentioned (Model-Bal). Another model had basically the same construction and properties as above mentioned, except for the muscle force (Model-Imbal). All muscle forces in the right leg of Model-Imbal were 5% greater than those of Model-Bal, while All muscle forces in the left leg of Model-Imbal were 5% smaller than those of Model-Bal.

Mathematical representations of the skeletal, muscle and activation dynamics were programmed in FORTRAN, then compiled with DADS-3D. Muscle activation profiles were searched using Bremermann's [7] numerical optimization method (Figure 1). The objective function was vertical jumping height.

RESULTS AND DISCUSSION

Jump movements were generated with the models above mentioned (Figure 2, 3). The jump movement of Model-Imbal was similar to that of Model-Bal. The jumping heights of Model-Bal and Model-Imbal were almost the same. However, actions of a few muscles such as m.gluteus medius were different between Model-Bal and Model-Imbal. It was revealed that the actions of those muscles are important for the coordination of jumping in Model-Imbal.

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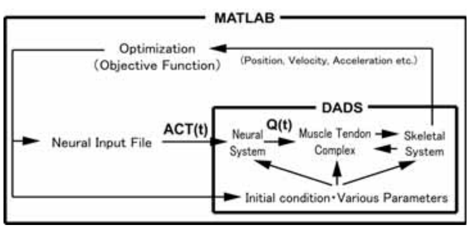

Figure1: Schematic of the simulation

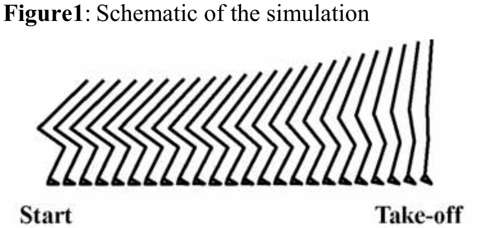

Figure 2: Stick figures of the vertical jumping of Model-Bal generated through the numerical optimization.

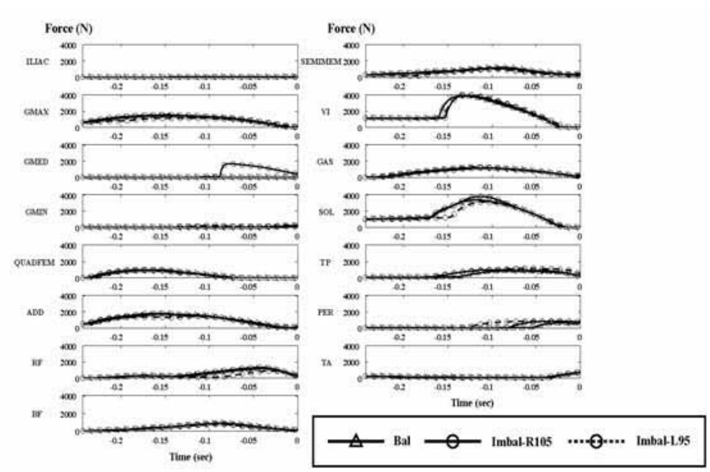

Figure 3: Time-Force relation profiles of the contractile element during jump movement. 0 sec is take-off time.