INVESTIGATION OF THE BIOMECHANICS OF HUMAN MOTION USING COMPUTER SIMULATION

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Abstract

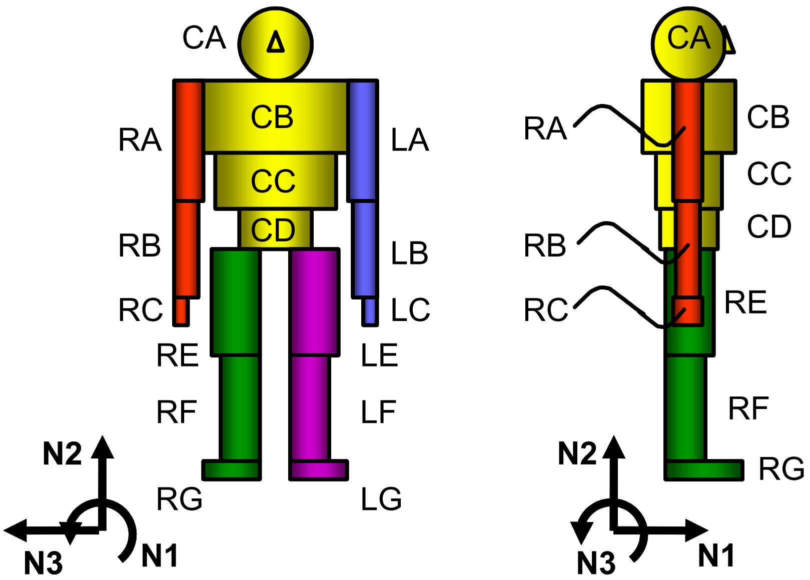
This abstract introduces the research results of our group during this year. We have our research focus on computer simulation of the human neuromusculoskeletal system. As a total, we have published 11 research articles related to this focus since 2005. This abstract contains the outlines of three of those research articles. More research results will be presented on the day of the symposium.

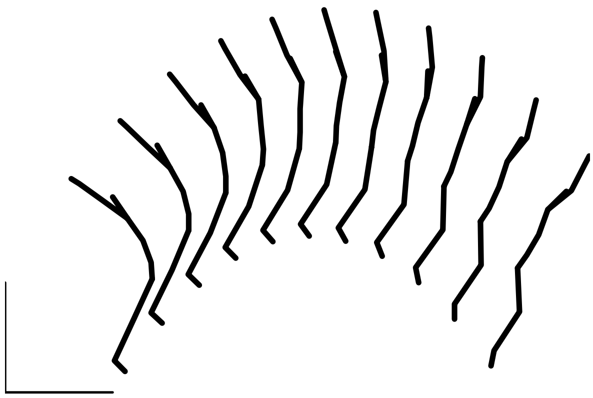
1. Influence of vision and static stretch of the calf muscles on postural sway during quiet standing (*Human Movement Science*, in press)

The purpose of this study was to evaluate the effects of vision and static stretching of the ankle joint (calf muscles) on postural sway during quiet standing. We tested two conditions: pre-stretch and post-stretch. Under the pre-stretch condition, the subjects stood on a force platform for 30 seconds while recording the sway of the center of pressure of the ground reaction force. We calculated the following posturographic parameters to represent postural sway after data collection: the sweep area, total excursion, standard deviation, maximal mediolateral range and maximal anteroposterior range. When stretching the ankle joint (post-stretch condition), the subjects used a commercial stretching tool to statically dorsiflex the ankle joint. The subjects stood on this tool quietly for 3 minutes. After that, they immediately moved onto the force plate and the postural sway was recorded. Eyes-open and eyes-closed conditions were tested in both pre-stretch and post-stretch conditions. As a

result, we found that postural sway increased with stretch under the eyes-closed condition. Each of the five posturographic parameters showed a statistically significant change. However, under the eyes-open conditions, there were only small increases in postural sway after stretch. Only one of the five parameters showed a statistically significant change. These findings suggested that stretching of the calf muscles has an effect to increase postural sway, although vision can compensate for this effect.

2. A three-dimensional linked segment model of the human whole body (*International Journal of Sports and Health Science*, 2005)

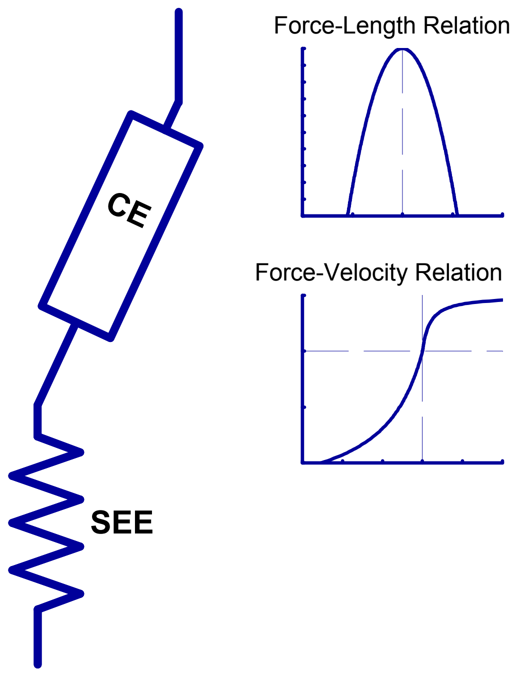


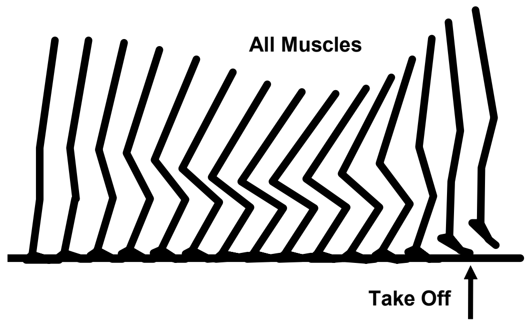


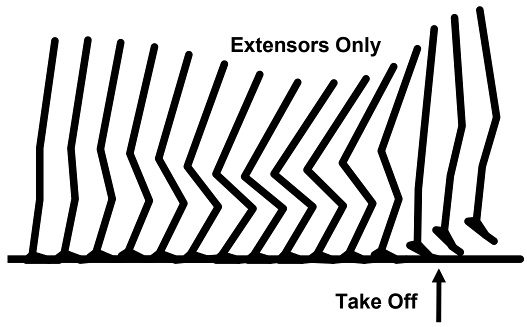
We developed a computer simulation model of the human whole body skeletal system, and reported the program of the model in this paper. We built the computer program for processing with a commercial simulation package AUTOLEV (OnLine Dynamics, Sunnyvale, CA, USA). The model contained sixteen rigid body segments, i.e., head, chest, mid-trunk, lower-trunk, right and left upper arms, right and left lower arms, right and left hands, right and left upper legs, right and left lower legs, and right and left feet. These segments were connected through the neck, chest, stomach, shoulder, elbow, wrist, hip, knee, and ankle joints. The total DOF of this model was 35. The passive properties of the lower limb joints were also implemented. As an example, we simulated a "hanging" motion and a "jumping-like" motion. Readers can either simply copy the computer program reported in this paper, or change it, to run a simulation.

3. **Contribution of non-extensor muscles of the leg to maximal-effort countermovement jumping (*BioMedical Engineering OnLine*, 2005)**

The purpose of this study was to evaluate the influences of non-extensor muscles (i.e., the muscles whose primary function is not leg extension) of the leg on the kinematics and kinetics of human maximal-effort countermovement jumping. Although it is hard to address this question using experimental methods, the technique of computer simulation can be a powerful tool. We constructed a skeletal model with 9 rigid body segments and 20 degrees of freedom. Two sets of muscle models were attached to the skeleton: all major muscles in the leg ("All Muscles" model) and major extensor muscles in the leg (i.e., muscles whose primary function is leg extension; "Extensors Only" model). A series of step functions with a step duration of 50 ms represented the neural activation inputs to these muscles. Simulations started from an upright standing posture. A random-search numerical optimization searched for the optimal patterns of the activation input with an objective of maximizing the height reached by the body's center of mass after jumping up. The simulated kinematics was almost two-dimensional, suggesting the validity of two-dimensional analysis when evaluating the net mechanical outputs of joints using inverse dynamics. The "All Muscles" model achieved a greater jumping height than the "Extensors Only" model. For the "All Muscles" model, the work output performed by non-extensor muscles was 47.0 J, which was 13% of the total amount (359.9 J). The quantitative distribution of work outputs from the muscles was markedly different between these two models. These results implied that the role of non-extensor muscles in countermovement jumping is not negligible.







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