REGULATION OF REACTION FORCE DIRECTION AND ANGULAR IMPULSE DURING JUMPING TASKS VIA REDISTRIBUTION OF KNEE AND HIP NET JOINT MOMENTS

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INTRODUCTION

Previous study of goal-directed whole body movements requiring the generation of reaction forces during interaction with the environment indicates that the nervous system organizes the human body using a structure that enables the performer to satisfy a variety of task objectives with minimal modification in control [1, 2]. In this study, we hypothesized that the redistribution of the knee and hip net joint moments (NJM) serves as a mechanism for altering the direction of the reaction force and magnitude of the angular impulse generated during the take-off phase of jumping-related tasks. We expected that relative magnitude of knee and hip NJMs would be regulated via reciprocal activation of bi-articular muscles crossing the knee and hip as previously observed during seated tasks [1]. We tested this hypothesis by comparing reaction forces, center of mass trajectories, lower extremity joint kinetics, muscle activation patterns of seven lower extremity muscles during the performance of forward (reverse, R) and backward (back, B) translating jumps performed with (BS, RS) and without rotation (BT,RT) about the somersaulting axis of the body and by determining the sensitivity of trunk and leg motion to redistributions of knee and hip NJMs using an experimentally validated dynamic model[3, 4].

METHODS

Seven national level divers performed each task from a force plate onto a foam landing pit in accordance with the Institutional Review Board. Reaction forces (2000 Hz, Kistler, Amhurst, MA), sagittal plane kinematics (200Hz, NAC C^{2}S), and muscle activation patterns (2000 Hz, Konigsberg, Pasadena, CA) were collected simultaneously[2]. Body landmarks (deLeva, 1996) were digitized (Motus, Peak Performance, Inc.) and filtered using a fifth-order spline (Woltring, 1986).

A dynamic model was used to determine the sensitivity of leg and trunk motion to alternations in the relative magnitude of the knee and hip NJMs [3, 4].

RESULTS and DISCUSSION

The leg angle during the push phase and the redistribution of NJMs via reciprocal bi-articular muscle activation affected reaction force direction and angular impulse generation. The direction of the reaction force was affected by the orientation of the hip relative to the center of pressure (leg angle) during the tip phase and muscle activation patterns during the push phase. The relative magnitudes of knee and hip NJMs were affected by the orientation of the reaction force relative to the lower extremity segments resulting from reciprocal activation of the biarticular muscles (hamstrings and rectus femoris). No significant differences in NJMs or biarticular muscle activation patterns were observed between the BS and RS tasks and the BT and RT tasks (Figure 1A). The redistribution of knee and hip NJMs were shown to affect both leg and trunk angles during the push phase (Figure 1B) and affected the magnitude of the moment arm between the reaction force and center of mass. These results suggest multiple and diverse task objectives can be satisfied with minimal modifications in control.

REFERENCES

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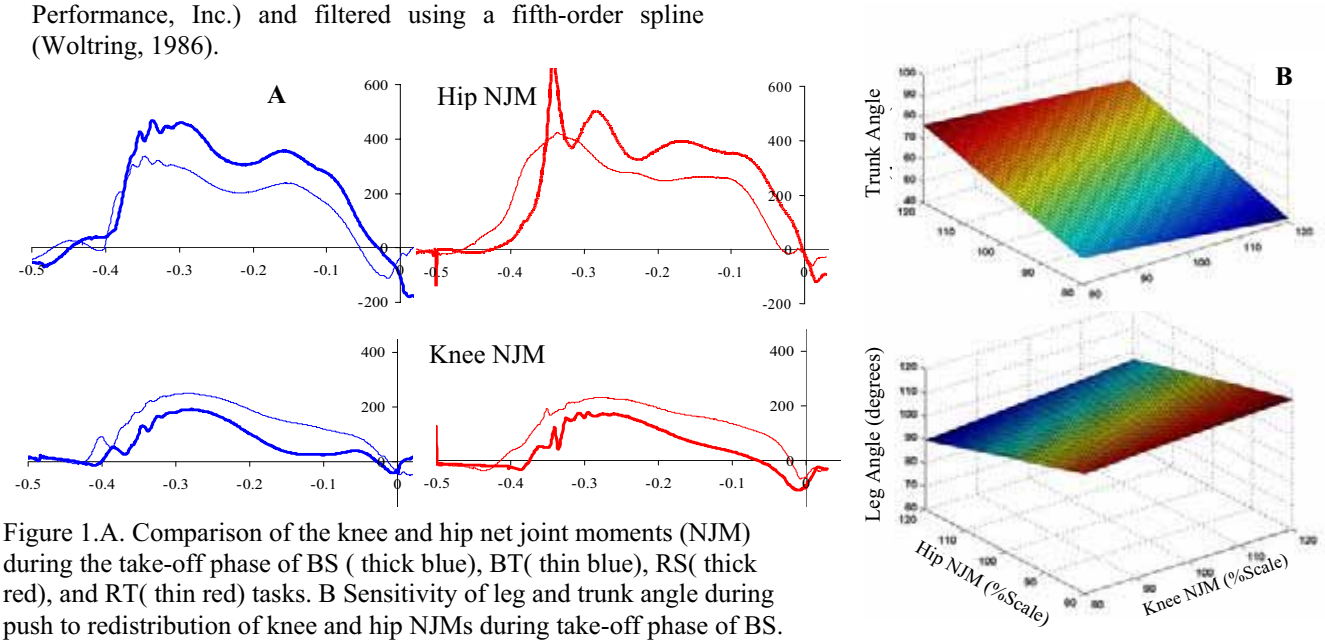

Figure 1.A. Comparison of the knee and hip net joint moments (NJM) during the take-off phase of BS (thick blue), BT(thin blue), RS(thick red), and RT(thin red) tasks. B Sensitivity of leg and trunk angle during push to redistribution of knee and hip NJMs during take-off phase of BS.