MULTIJOINT CONTROL STRATEGIES USED TO GENERATE IMPULSE DURING GOAL DIRECTED MOVEMENTS

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INTRODUCTION

Complex tasks performed by humans are comprised of a series of phases with multiple objectives. Given the complexity of human movement, simultaneously satisfying objectives at both the total body and local levels during each phase of the movement involves some type of hierarchical control structure. While we can not directly determine the structure of the control system, we can advance our understanding of the hierarchical relationships between functional components by determining differences in control between tasks performed under various conditions. Previous research regarding horizontal jumping suggests regulation impulse during forward directed jumps is controlled in part by tipping the total body center of mass (TBCM) forward relative to the feet (Ridderikhoff et al., 1999). In this study, we test the hypothesis that skilled performers regulate angular impulse generation during the take-off phase of a backward jumping task by tipping the total body center of mass (TBCM) backward relative to the feet.

METHODS

Nine skilled athletes (n=9) performed backward directed jumps with (Back somersault BS) and without rotation (Back Jump BJ) from a force plate onto a landing pit. Reaction forces (600 Hz, Kistler) and sagittal plane kinematics (60 fps) were simultaneously collected during the take-off phase. Each coordinate of the body landmarks (deLeva, 1996) were digitized, filtered using a fourth order Butterworth Filter (Saito & Yokoi, 1982) with cut-off frequencies determined using a method based on Jackson (1979). Kinematic and reaction force data were synchronized at the time of last foot contact with the force plate. Joint kinetics were determined using Newtonian mechanics. Linear and angular impulse during the take-off phase were calculated by integrating the horizontal (A/P) and vertical components of the reaction force and reaction force moment about the mediolateral axis passing through the TBCM, respectively.

RESULTS AND DISCUSSION

Angular impulse generation was controlled by both the TBCM relative to the feet and the direction of the reaction force. Between task differences in trunk-leg coordination were observed between the joint flexion phase (JF) preceding the jump and the joint extension phase (JE) prior to take-off from the plate. Between task differences in horizontal and angular impulse generation were observed during both the JE and JF phases (Figure 1). These between task differences were attributed to modifications in trunk-leg coordination (Figure 2) and direction of the reaction force generated during the JE phase. The difference in shank and thigh orientation relative to the reaction force during both the JE and JF phases contributed to between task differences in joint kinetics (Figure 3). During the joint flexion phase of the BS task, the orientation of the leg (hip-ankle) was tipped in the posterior direction to greater degree than during the BJ task (Figure 2). Greater leg angles during the JF phase were associated with a greater horizontal component of the reaction force. During the JE phase, however, the posterior directed reaction force during the BJ task, generated in part to counteract the backward angular impulse generated during the JF phase, was generated with a more vertical leg orientation. These results suggest multijoint control strategies used to generate impulse during goal directed movements are task and phase specific.

REFERENCES


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Figure 1. Between-task differences in The reaction forces (A) and the reaction force moment about the TBCM (B) during the take-off phase. Angular impulse generated during the joint flexion phase (JF) of the BJ was countered during the joint extension phase (JE).

Figure 2. Between-task differences in trunk-leg control. A more backward leg and trunk position was observed during the take-off phase of the back somersault (BS) as compared to the back jump (BJ).

Figure 3. Between-task differences in NJMs due to differences in shank and thigh segment orientation relative to