A THREE-DIMENSIONAL KINETIC ANALYSIS OF THE PELVIS AND THE HIP JOINT FOR MALE RACEWALKERS

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Introduction

The pelvic rotation is one of the most distinctive techniques of race walking. However, there was little information on the pelvic rotation because only few investigations have been done three-dimensional analysis of race walking. The purpose of this study was to investigate three-dimensional kinetics of the pelvis and the recovery leg for male race walkers during the official race.

Methods

Twenty-one male race walkers participating in an official race of 10000m were videotaped at 60 fields/s with two VTR cameras. VTR images of the top eight walkers obtained at the 3360m mark were digitized over one walking cycle. Three-dimensional coordinates of the body segment endpoints were obtained by using a DLT technique. A 15-link-segment model was applied to calculate linear and angular kinematics of joints, the centers of mass, and the body segments, and further used to estimate joint forces and torques. The location of the centers of mass, masses and the moments of inertia of the body segments of the subjects were estimated from the body segment parameters of Ae (1992). Torque and force at the recovery hip joint were calculated by an inverse dynamics, which solved equations of motion from the endpoint of the recovery leg. Torque and force at the trunk joint were calculated from endpoints of the upper body.

Results and Discussion

Figure 1 shows changes in averaged angular velocity of the pelvis ( $\omega_p$), torque exerted by the muscles of the recovery hip joint (T$_{rh}$), and torque exerted by the muscles of the trunk (T$_t$) about the vertical axis during the right leg recovery phase. The torque of the support hip joint could not be calculated in the present study because of the lack of ground reaction force data. The positive $\omega_p$ increased after toe-off and decreased in the first half of the recovery phase. The negative $\omega_p$ increased before heel-on, which might decelerate the horizontal velocity of the recovery hip joint and result in the decreases in the step length and the rotation of the pelvis in transversal plane (Cairns et al. 1986). However, the deceleration of the recovery hip joint would help the recovery leg to swing backward and to decrease the impact of the foot contact. The T$_{rh}$ changed from the negative to the positive in the first half of the recovery phase and maintained in the second half of the recovery phase. T$_t$ was out of phase with T$_{rh}$ during the whole recovery phase and the magnitude of T$_t$ was larger than that of T$_{rh}$. T$_t$ was supposed to rotate the pelvis because $\omega_p$ increased when T$_t$ was positive and $\omega_p$ decreased in negative T$_t$. T$_{rh}$ might act to restrict the pelvis rotation because the direction of T$_{rh}$ was opposite to $\omega_p$ and T$_t$ at the beginning and the end of recovery phase.
Figure 2 shows changes in flexion-extension and adduction-abduction torques of the recovery hip joint in the moving coordinate system fixed to the recovery thigh. The flexion torque was generated at the beginning of the recovery phase and changed to the extension torque in the middle of the recovery phase. The extension torque increased during the second half of the recovery phase and reached the peak before heel-on. The adduction torque was generated in the whole recovery phase. The extension and adduction torques of the hip joint contribute to swing the recovery leg backward in the second half of the recovery phase, although the extension and adduction torque exerted in the end of recovery phase could limit the deceleration of the recovery hip joint.

Reference

Figure 1 Changes in angular velocity in averaged angular velocity of the pelvis and torque exerted by the muscles of the recovery hip joint and trunk about the vertical axis during the recovery phase.

Figure 2 Changes in flexion-extension torque and adduction-abduction torque at the recovery hip joint.