INTRODUCTION

In high jump, the jumping height of high jump is largely dependent on the vertical impulse during the takeoff phase, which related to the joint torque generated by the muscles of the takeoff leg. Therefore, it is important to understand the generation of the joint torques and the function of the takeoff leg joints for the improvement in the performance of high jump. However, there is little study on three dimensional joint torque of the takeoff leg in the Fosbury flop.

The purpose of this study was to investigate three dimensional torque and the function of the takeoff leg joints in the Fosbury flop style.

METHODS

The takeoff motion of ten male high jumpers (personal best ranging from 2.31 m to 1.80 m) who used the Fosbury flop style was videotaped with two phase-locked high-speed cameras (250 Hz). Ground reaction forces (GRF) during the takeoff phase were collected with two force platforms (Kistler AG, 500 or 1000Hz). Three dimensional coordinates of 25 points of the segment endpoints were obtained with a DLT technique and smoothed with a Butterworth digital filter of optimum cutoff frequency (2.5~22.5 Hz) chosen by a residual technique. Joint torques of the takeoff leg (JT) and joint torque powers (JTP) were calculated by an inverse dynamic approach: abduction/adduction (abd/add), extension/flexion (ext/flex), and external/internal (ext/int) rotation torques for the hip and knee joints, and spination/pronation (spi/pro), plantar/dorsi flexion (pla/dor), and external/internal rotation (ext/int) torques for the ankle joint. JT and JTP were normalized by the time of the takeoff phase, and divided by the subject’s body mass.

RESULTS AND DISCUSSION

The JT of ext/flex and abd/add of hip and knee, and pla/dor flexion of ankle were larger than other torques of the relevant joints. However, the knee joint cannot abduct and adduct because of its anatomical constraint. Therefore, we focused our discussion on four JT's: abd/add of the hip, ext/flex of the knee, and pla/dor flexion of the ankle. Figure 1 shows changes in JT's and JTPs of abd/add and ext/flex at the hip, ext/flex at the knee, and pla/dor flexion at the ankle.

The hip abduction JT was the largest in all the JT's. However, the JTP by the hip abd/add muscles was very small in the first half of the takeoff phase. The JTP by the hip ext/flex muscles was smaller in the first half of the takeoff phase than that of other joints. Despite the large JT's, these small hip JTP's resulted from angular velocities of abd/add and ext/flex in the first half of the takeoff phase.

This implies that the function of the muscles about the hip joint is to stabilize the hip joint of the takeoff leg and the trunk. The extension torque and the large abduction torque of the hip joint suggest that the development of abduction muscles about the hip is extremely important for high jumpers of the Fosbury flop style.

The knee extension JT was dominant in most part of the takeoff phase. The JTP exerted by the knee extensors was negative in the first half of the takeoff phase. The JT of the knee extension and the negative JTP exerted by the knee extensors imply that the function of the knee extensors is to generate the vertical GRF and to absorb mechanical energy in the first half of takeoff phase.

The ankle plantar flexion JT was as large as that of the knee extension. The JTP exerted by ankle plantar flexion muscles was negative in the first half and positive in the second half of the takeoff phase. Therefore, the function of ankle plantar flexion muscles is to generate vertical GRF during the takeoff phase, and to absorb mechanical energy at the first half and generate it in the second half of the takeoff phase.

Figure 1  JT's and JTPs abd/add and ext/flex of the hip, ext/flex of the knee, and pla/dor flexion of the ankle.