

## EACH BODY SEGMENT FUNCTION DURING THE SUPPORT PHASE OF THE DROP JUMP

Kiyohide Aoyama, Yohei Shimokouti, Nihon University, Tokyo, Japan,  
Kazuyuki Ogiso, Toba National College of Maritime, Mie, Japan,  
Mitsugi Ogata, Toshifumi Yasui, University of Tsukuba, Japan

**KEY WORDS:** body segments function, relative momenta, accelerative force

**INTRODUCTION:** The drop jump is used to develop explosive muscle power in sports training. There have been some studies of takeoff motion in the drop jump to explain the mechanism through the analysis from the viewpoint of joints moments and the power of the model of the link-segment or the musculo-skeletal system. Physical movements are generated as combinations of those of each body segment. Therefore, it is important to clarify the role and function of each body segment in the movements. The purpose of this study was to investigate each body segment function in the takeoff motion of the drop jump.

**METHOD:** Ten male athletes performed a drop jump with a height of 40cm. They were instructed to use arm action. Their take-off motions were filmed at 200Hz with a high speed camera. Two dimensional coordinates were obtained by digitizing the motion with a sampling frequency of 200Hz. The data was filtered with a Butterworth digital filter (Winter, 1979) at 8.5Hz. These data were used to calculate the relative momentum of the body segments using method of Ae et al. (1985). The equations of the relative momentum were (1) to (6).

$$\begin{aligned}GM_{ar} &= m_{ar} V_{ar}/s & (1) \\GM_t &= m_{ar} V_s/h + m_t V_t/h & (2) \\GM_{th} &= (m_{ar} + m_t) V_h/k + m_{th} V_{th}/k & (3) \\GM_{sh} &= (m_{ar} + m_t + m_{th}) V_k/a + m_{sh} V_{sh}/a & (4) \\GM_f &= (m_{ar} + m_t + m_{th}) V_a + m_f V_f & (5) \\GM_{tl} &= GM_{th} + GM_{sh} + GM_f & (6)\end{aligned}$$

where GM = relative momentum,  $m_i$  = segment mass,  $V_{i/j}$  = velocity of segment  $i$  relative to joint  $j$ , ar = arm, t = trunk, th = thigh, sh = shank, f = foot, tl = takeoff leg, s = shoulder, h = hip, k = knee, and a = ankle.

The mean impulses of each body segment were calculated from the changes in relative momentum. Accelerative forces were calculated by numerical differentiation of relative momentum. BSP of Chandler et al. (1975) were used to estimate the segmental center of gravity and mass center of the whole body. In this study the whole take-off phase is divided, at the moment when the mass center of body hits its lowest point, into two parts respectively referred to as the early half (downward phase) and the later half (push-off phase).

### RESULTS AND DISCUSSION:

Each body segment function during the takeoff phase

Figure 1 shows the mean impulses of the body segments. Positive mean impulses show that the relative momentum of that body segment is increased vertically upward against the adjacent lower joint (or against the ground in the case of the ankle). In the early half of the take-off phase, the arms and trunk showed negative mean impulses. The take-off legs showed a large positive mean. In the later half, all the body segments showed positive mean impulses. Similar to the early half, take-off legs showed the largest mean impulses of all the body segments. It was clear that the take-off legs showed the largest contribution to vertical velocity in the take-off motion.

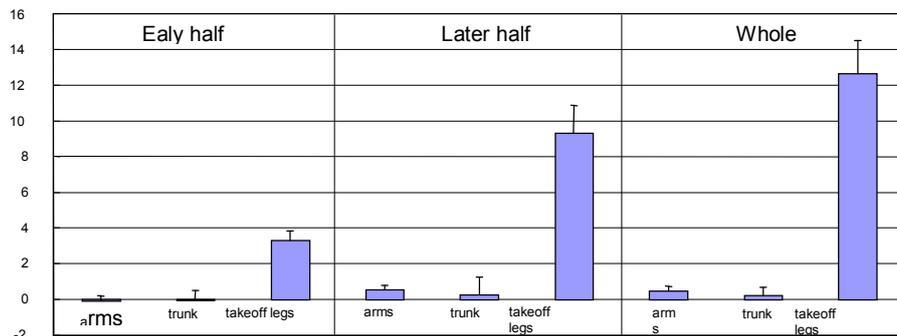


Fig.1 The mean impulses of the body segments

Figure 2 shows the mean impulses of the lower limb segments. The thighs and the shanks showed negative mean impulses in the early half of the take-off phase. The feet showed large positive mean impulses. The feet gave the largest contribution to vertical velocity of the lower limb segments. The ankle joint flexor muscles generated large negative power in the early half of the take-off phase. The feet supported the body, which is with the energy. The large impulses of the feet were generated not only by ankle joint flexor power (Bobbert, et al., 1987), but also by the great power generated by the knee extensors and transferred to the ankle joints through the double-joint muscles (A.J. Van Soest et al., 1985).

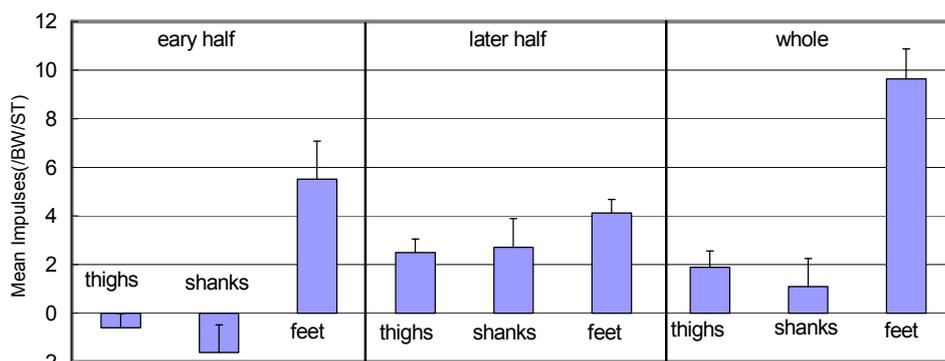
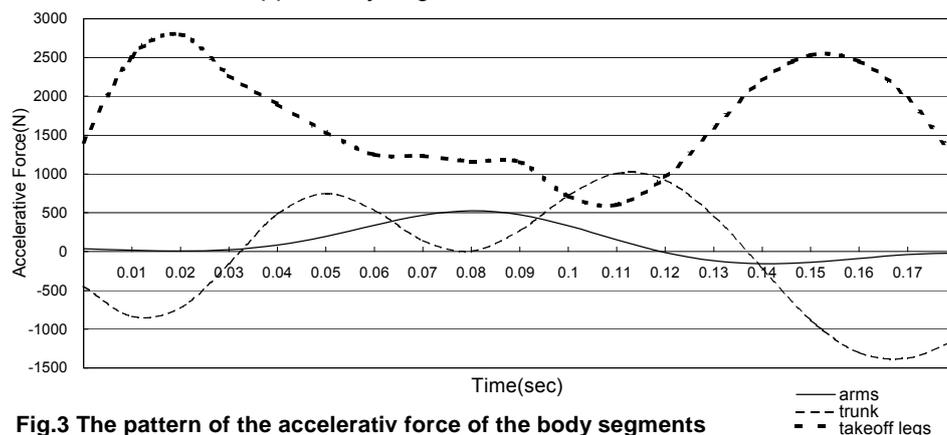


Fig.2 The mean impulses of the lower limb segments

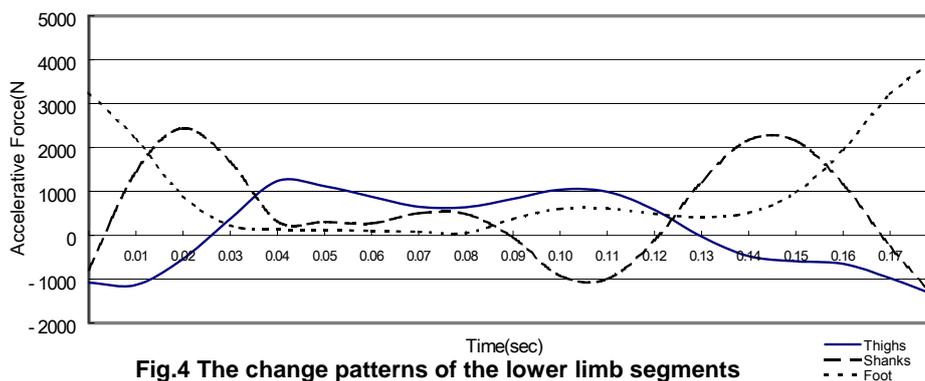
Change Pattern of function from the view point of the accelerative forces  
 Figure 3 shows the change pattern of the accelerative force of the body segments. The positive accelerative force means the accelerative force of that body segment

is increased vertically upward against the adjacent lower joint (or against the ground in the case of the feet). The arms showed a positive accelerative force from the early half to around the midpoint of the take-off phase. The trunk showed a negative accelerative force immediately after the touchdown, then gave a two-peaked pattern of positive force in the middle of the phase, and the negative force in the phase immediately before the take-off. The take-off legs showed larger accelerative force than other parts. In the change of the accelerative force in a time series, the peak figure is seen in the lower body segments in the early half of the take-off, while in the upper body segments in the later half.



**Fig.3 The pattern of the accelerativ force of the body segments**

Figure 4 shows the change patterns of the accelerative forces of the lower limb segments. The thighs showed the negative accelerative force immediately after the touchdown, then gave a two-peaked pattern of positive force in the middle of the phase, and then a negative force. The thighs showed the same pattern as the trunk, because of its large mass. The shanks gave both positive and negative force alternately during the take-off. The feet showed positive accelerative force throughout the overall take-off phase, having the larger ones immediately after the touchdown and before the take-off.



**Fig.4 The change patterns of the lower limb segments**

**CONCLUSION:** The take-off legs contributed to upward velocity in the take-off phase. In particular, the feet showed the largest contribution of all the body

segments. The feet supported the body in the early half, and then all the parts were charged with the role of accelerating the body upward in the later half of the phase. According to the changes of the accelerative force of each body segment, the function of accelerating the body upward is placed on the lower parts in the early half of the take-off, and on the upper parts in the later half. Therefore, each body segment does not work at the same time in order to accelerate the body upward.

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