CHANGES OF SPRING–LIKE LEG BEHAVIOR ACCORDING TO DIFFERENT TOUCH DOWN VELOCITIES IN DROP LONG JUMPS

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INTRODUCTION

Shortening and lengthening of the leg is a characteristic of hopping on the spot. On the other hand, jumping with the aim of moving forward consists of shortening-lengthening and rotation of the leg. The contribution of these two components may change according to the vertical and horizontal velocity of the center of mass (COM) and attack angle at the instance of touchdown. Moreover leg stiffness during the contact phase is affected by both the velocity and angle. A spring mass model was developed that represents the mechanical behavior of the integrated muscle-tendon system. The purpose of this study was to investigate the differences in spring-like leg behaviors of hopping on the spot and hopping following drop long jumps (Fig.1) with different touchdown velocities.

METHODS

Nine college jumpers participated in this study. Subjects performed hopping on the spot (HJ) and hopping following a drop long jump (DLJ). Subjects were required to vary their running speed on the box (2m long, 0.3m high) to achieve landing distances of 1m, 2m and 3m onto a force platform (Fig.1). Vertical and horizontal GRF signals from the force platform were sampled at 1080Hz. 3D motions of the body were recorded at 120 Hz using a VICON motion analysis system (VICON612 Oxford United Kingdom). Selected 2D parameters were then placed into the model. Spring-like leg behaviors during the contact phase of HJ and DLJ were evaluated using the spring mass model (McMahon et al., 1990; Arampatzis et al., 1999 ; Farley et al., 1998) (Fig. 1). As the velocity of the COM is derived from leg rotation and shortening-lengthening, these were calculated by geometrics related to changes of rotating angle and the length L (Jacobs et al., 1992).

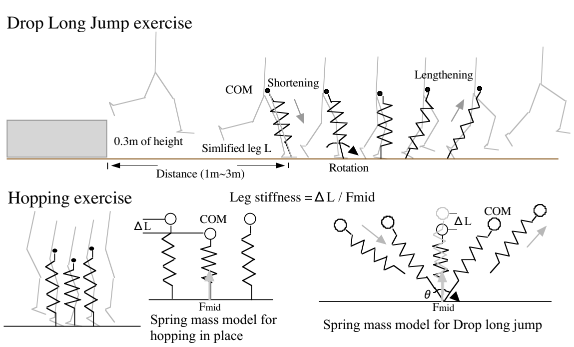

Fig. 1 Spring mass models for hopping in place and drop long jumping

RESULTS AND DISCUSSION

Velocity of the COM and the attack angle at the instance of touch down and during early stance, as the jump distance increased, is related to greater compression of the leg L (ΔL) and larger vertical and horizontal GRF. However, leg stiffness decreased and contact time shortened over this period (Fig.2). The model showed an approximate linear relationship between vertical GRF and ΔL in the HJ but was non linear in each DLJ (Fig.3). Correlation coefficients between leg stiffness of HJ and each DLJ were not significant. These results suggest different spring-like leg behaviors in both HJ and DLJ. Horizontal and vertical velocity of the leg rotation markedly increased during contact phase as the jump distance increased. On the other hand, the influence of the leg shortening-lengthening on horizontal and vertical velocity increased with compression during the early stance but did not change during the recoiling motion latter in the stance phase (Fig.4). We concluded that the leg spring becomes compliant and does not recoil because of limitations of the muscle-tendon elasticity with a high impact GRF, while the rotary motion of the leg spring acts strongly as horizontal velocity increases in forward jumping following a faster approach.

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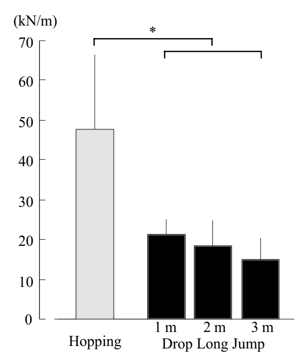

Fig. 2 Leg stiffness of hopping in place and drop long jumpings according to different distance.

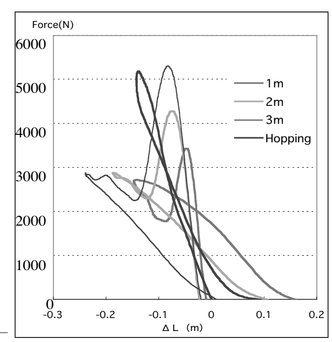

Fig. 3 Vertical ground reaction force versus lenght of shortening-lengthening in place and drop long jumpings according to different distance.

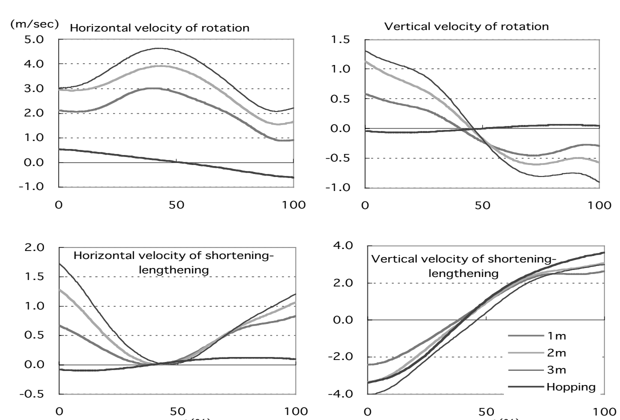

Fig. 4 Vertical and horizontal velocity of the leg rotation and shortening-lengthening components according to defferent distances.