BIOMECHANICAL ADAPTATIONS OF THE LOWER LIMBS DURING DROP-LANDING FROM DIFFERENT HEIGHTS IN HEALTHY YOUNG ADULTS

1Chih-Chung Hu, 2,Yen-Hung Liu, 3Ling-I Wang, 4Chau-Lung Chen, 5Jeng-Hsiu Lai, 6Tung-Wu Lu

1Department of Mechanical Engineering, Ming-Chi University of Technology, Taiwan,
2Institute of Biomedical Engineering, National Taiwan University, Taiwan,
3Department of Physical Therapy, Tzu-Hui Institute of Technology, Taiwan,
4Department of Physical Education and Kinesiology, National Dong-Hwa University, Taiwan,
5Department of Physical Education and Health, Taipei Physical Education College, Taiwan

SUMMARY
Lateral ankle sprain, one of the most acute sport injuries, often occurs during drop-landing on uneven surfaces. Previous studies were limited to investigate the kinematics or kinetics of the lower limbs during drop-landing. The aim of this study was to investigate the biomechanical adaptation of the lower limbs during drop-landing from different heights. Twelve young healthy adults were recruited in the current study. Each of them performed drop-landing from three different heights (37cm, 67cm and 97cm). The joint kinematics, kinetics and leg stiffness of the lower extremities were calculated from the measured data. The results showed that young healthy adults modulated their leg stiffness, joint angles and moments to meet the increasing demands of drop-landing from different heights. The finding of this height-dependent mechanical modulation may provide insight into the motor control strategy of the lower limbs, which may be helpful for clinic decision-making and injury prevention.

INTRODUCTION
Ankle sprain, frequently occurring on jumping-related sports, is one of the acute sports injury [1, 2, 3]. Among these ankle sprain cases, 85% were diagnosed as lateral ankle sprain and easily re-sprain and suffer residual ankle symptoms [4]. Many clinical studies had been concluded that lateral ankle sprain injury was occurring the huge stress on plantarflexed and inverted ankle joint while drop landing [2, 3]. However, the mechanism of ankle sprain occurrence is still controversial. Previous studies investigating the pattern of drop landing were limited in 2-D analysis [3].

The spring-mass model and leg stiffness is used to simulate and study the dynamics of walking, running, and up/down stairs [4]. However, there is few study has investigated the leg stiffness during drop landing at different heights. The aim of this study was to investigate the leg stiffness, as well as the associated joint kinematics and joint kinetics, in young adults during drop-landing from different heights. It was hoped that the results could provide insight into the motor control strategy and adaptation of the lower limbs, which may be helpful for clinic decision-making and injury prevention.

METHODS

Twelve young healthy adults (Age: 21.3 ± 1.2 y/o; Height: 169.80 ± 3.13 cm; Body weight: 65.9 ± 7.81 kg) were recruited and asked to perform drop-landing from platforms at three selected heights (0.37 m, 0.67 m & 0.97 m) (Fig.1). Two forceplates (AMTI, USA) were used to collect the ground reaction force (GRF) and three-dimensional (3D) joint kinematics and joint kinetics data were measured using 7-camera motion analysis system (VICON 512, Oxford Metrics, UK) simultaneously.

The joint angles and moments were calculated using inverse dynamics analysis and expressed in landing phase, i.e. from the moment of the first contact on force plate to the instance when the subject regained his balanced on the force plate. The leg stiffness, defined as the change in the value of the resultant GRF owing to a change in the resultant leg length.

RESULTS
The results of this study showed that the peak hip extensor moments and knee extensor moments were increased significantly with increasing height (p < 0.05; Fig.2) during landing phase.

The peak ankle plantarflexor moments of the ankle joint were decreased significantly with increased heights (p<0.05; Fig.3). The external rotator moment of the ankle joint at 97cm-height was significantly greater than the moments jumping from lower heights during landing phase (p<0.05; Fig.4).
DISCUSSION

The current study investigated the adaptation of the lower extremities during drop landing at three different heights in young healthy adults. Subjects modulated their joint angles, moments and leg stiffness to adapt the different heights. The unchanged leg stiffness was shown at 37cm and 67cm-height platforms, which indicated that these two heights seemed unharmful for the subjects before landing. But the impact force did increase at 67cm after landing, which also forced subjects to increase joint flexion angles and muscle contraction to undergo larger impact force [5-7].

Drop landing from the 97cm-height platform might be really a threat to subjects. Therefore, reduced leg stiffness was used to face the largest impact [4] and increased hip and knee flexion angles were used to absorb the impact force. The muscle contraction forces of all three joints were also increased to make body remain un-buckled at landing phase.

The plantarflexor and external rotator moments of ankle joint increased while jumping from 97cm-height platform, suggesting that ankle joint was bearing huge internal rotation moment leading to foot inversion. Therefore, the subjects would easily sprain their ankle while drop-landing from height more than 67cm even the adaptation of lower limb had been taken during landing phase.

CONCLUSIONS

The preliminary results indicate that young healthy adults would modulate the leg stiffness, joint angles and joint moments as the biomechanical strategy while drop-landing from different heights. The ankle joint moment was still increased rapidly while drop-landing from the 97cm-height platform. Therefore, drop-landing form such height might have to be prohibited for individuals with history of ankle sprain.

REFERENCES