INTRODUCTION

Many researchers have studied rhythmical hopping movement to analyse the well-documented muscle function, the stretch-shortening cycle during landing phase. However, for enforced faster frequency hopping than optimal frequency the mechanical behavior of the muscle and the mechanisms controlling joint stiffness have been not very well understood. The purpose of this study was to investigate the stiffness regulation in the ankle joint and muscle activity due to keep hopping frequency rhythmically.

METHODS

Eleven male healthy volunteers (age 23.5 ± 1.1, height 1.73 ± 0.06 m, weight 62.6 ± 6.6 kg) participated. Each test leg was chosen as the subject’s take-off leg at long jumping (three right legs, eight left legs). Prior to participation, subjects signed an informed consent.

Subjects performed two-legged rhythmical hopping with subject’s arms akimbo at the different frequencies on the two force platforms (Kistler type 9287BA&9281CA; Kistler Instruments, Switzerland) in bare feet. The six hopping frequencies (1.5, 1.8, 2.1, 2.4, 2.7, 3.0 Hz) were indicated by audible clicks and subjects were instructed to hop corresponding to the target frequency with a maximal effort. Each hopping was performed at random and was recorded for four seconds after we identified that a subject could perform orderly hopping.

Vertical and horizontal ground reaction forces (GRF) were measured for both two legs with force platforms. Electromyography (EMG) was recorded using bipolar pre-amplified surface electrodes (HEI BB-04; Harada Hyper Precision Inc., Japan) that were placed over the bellies of the rectus femoris (RF), vastus lateralis (VL), gastrocnemius medialis (GA) and soleus (SOL) of test leg. Skin surface index (SSI) that could indicate muscle behavior indirectly and non-invasively during movement using our novel technique (Maruyama et al. 2002) was measured on the belly of GA of test leg. GRF, EMG and SSI were collected non-invasively during movement using our novel technique (Maruyama et al. 2002) was measured on the belly of GA of test leg. GRF, EMG and SSI were collected with a sampling frequency of 1 kHz. Joint markers were placed on toe, the distal head of the fifth metatarsal bone, heel, lateral malleolus, lateral epicondyle of the femur, great trochanter and spina iliaca anterior superior of test leg. The lateral side 2-D image of test leg was captured with a high-speed video camera (FASTCAM-PCI; Photoron LTD, Japan) at 250 kHz. All data were synchronized using a clock pulse generator (PH-1413SP; DKH Co., LTD, Japan) to introduce a trigger signal to the computer.

The negative phase of landing in jumping within each hopping was analyzed. Leg stiffness was calculated as a change in GRF of the test leg divided by the change in vertical displacement of the great trochanter’s marker. The joint stiffness was calculated as a change in the joint moment divided by the change in joint angle (Kuitunen et al. 2002). Muscle-tendon-complex of GA (GA-MTC) stiffness was calculated as the change in muscle force divided by the change in GA-MTC length.

RESULTS AND DISCUSSION

Jumping height was significantly decreased by increasing the hopping frequency and was a natural consequence of dwindling flight time. Leg stiffness was significantly increased by increasing the hopping frequency. The relationship between leg stiffness and ankle joint stiffness was a significant linear correlation as show in Figure 1 and it was same result as Farley et al (1999). This finding suggested that during hopping leg stiffness was adjusted by modulating ankle joint stiffness.

The relationship between ankle joint stiffness and GA-MTC stiffness was a significant linear correlation. EMG pre-activation level was not different at hopping frequencies. GA-MTC was significantly lengthened pre landing by increasing the hopping frequency, whereas the change in GA-MTC length during negative phase was significantly decreased by increasing the hopping frequency. The change in SSI during a jumping was significantly decreased by increasing the hopping frequency.

SUMMARY

According to the results of this present, it was suggested that during hopping ankle joint stiffness was controlled by modulating stretching level of GA-MTC length.

REFERENCES