INTRODUCTION

Lateral ankle sprains are common sport-related injuries which often lead to ankle instability (AI) [1]. Specifically, AI has been shown to impair neuromuscular control and dynamic joint stability of the lower extremity [2]. During the landing phase, an impact force occurs and it is attenuated through the lower extremity joints [3]. These joints contribute to shock absorption via energy dissipation by work performed using eccentric muscle contraction around the joints [4]. Thus, a failure of shock attenuation can place excessive stress on joints, resulting in lower extremity injury such as ligament sprain, articular cartilage damage, and menisci lesions [5]. It is important to examine energy absorption by calculating the amount of work done by the joints to identify how AI affects the absorption strategy adopted by the ankle, knee, and hip joints during functional activity. Therefore, the purpose of this study was to examine the effect of AI on energetic patterns of the lower extremity during a forward-side jump.

METHODS

72 AI (37M, 35F: 22.2±2.3yrs, 173.9±9.5cm, 70.0±13.1kg), and 72 matched healthy control subjects (39M, 33F: 22.0±3.2yrs, 171.1±14.6cm, 71.2±20.3kg) were categorized according to the FAAM (ADL: 82.2±9.9%, Sport: 60.5±13.0%) and MAII (3.7±1.2). Subjects were tested on the dominant limb, and fifty-nine reflective markers were placed over anatomical landmarks to calculate joint powers (W/kg). Subjects performed five trials of a forward-side jump on the force plate, which was to jump forward 1 m to the center of the force plate, land with the dominant leg, and then immediately jump to the contralateral side. Joint power was measured during the landing phase of a forward-side jump which was from initial foot contact (0%) to peak knee flexion (100%). A functional linear model (p<.05) was used to evaluate differences between AI and control groups for lower-extremity joint powers. This analysis compared variables as polynomial functions rather than discrete values. Functions (power curves) were compared between groups. Pairwise comparison functions as well as 95% confidence interval (CI) bands were plotted to determine specific differences. If 95% CI bands did not cross the zero line, we considered the difference significant. Eccentric joint work (J/kg) was calculated as the area under the negative power curve for ankle, knee, and hip joints. Total lower extremity energy absorption was calculated by summing the negative joint work at each joint. Then, relative energy absorption of each joint (%) was calculated as a percentage (each joint work/total lower extremity energy absorption x 100). Independent t-tests were used to compare relative energy absorption of each joint during the landing phase of the forward-side jump between the AI and the control groups.

RESULTS AND DISCUSSION

The AI group had less ankle joint power (p<.05) during 15-25% and 50-85% of landing phase than the control group (Fig.1-A and B). Compared to the control group, less knee joint power (p<.05) was observed during 70-95% of the landing phase in AI group (Fig.1-C and D). Unlike ankle and knee joints, the AI group demonstrated greater hip joint power (p<.05) during 15-32% of the landing phase than the control group (Fig.1-E and F). A group difference was found in the relative percentage of hip joint work of total lower extremity energy absorption (AI: 12.3±7.0% vs Control: 10.1±6.4%; t_{142}=2.036, p=.044) (Fig. 2). In the current study, individuals with AI showed decreased ankle energy absorption in the early landing phase of a forward-side jump while increased hip joint energy absorption compared to the control group.
Less shock attenuation by the ankle joint may place more stress on ankle joint, resulting in ankle injuries such as ligament sprains, and articular cartilage lesions [4, 5]. Thus, this finding suggests that patients with AI focus on improving ankle muscle function to dissipate more shock during landing of functional activities. Overall, the AI group increased the hip joint contribution to the total energy absorption during the landing phase of a forward-side jump. The hip joint has the mechanical advantages of its surrounding musculature (greater cross-sectional area, longer muscle fibers, and relatively shorter tendons) to absorb more energy during landing compared to that of the knee and ankle joint [6]. Increased energy absorption by the hip joint may be an effort to compensate for decreased ankle joint power/work. Subjects with AI altered their energetic patterns, redistributing joint power/work to the hip joint to attenuate shock by dissipating ground reaction force to proximal joints (hip) during a forward-side jump. Our findings suggested that subjects with AI demonstrated altered lower extremity energetic patterns during the landing phase of a forward-side jump. The results of the current study may provide useful information in developing lower extremity muscle training programs and prevention programs for lower extremity injury.

REFERENCES