DIFFERENCES IN ONSET TIMING OF MUSCLE ACTIVITIES DURING TWO TYPES OF JUMP LANDINGS

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The purpose of this study was to determine the differences in onset timing of muscle activities between single leg landings and double leg landings. Healthy male college students participated in this study. All subjects performed two types of jump landings, single leg and double leg. The muscle activation during jump landings was measured using electromyography. Muscle activity onset occurred earlier during the single leg landing than during double leg landing, however, there were no significant differences between the onset of the quadriceps femoris muscles' activities and that of the hamstring muscles' activities. Results showed that the earlier muscle activation during motions such as the single leg landing may contribute to decreasing the impact to the joint.

KEY WORDS: onset, muscle activity, jump landing, ACL injury.

INTRODUCTION: Anterior cruciate ligament (ACL) injury is the most frequent knee joint sports-related injury and is often observed during jump-landing movement. The muscle activities during jump landings have been investigated by many researchers, and differences between quadriceps and hamstring muscle activation during landing motion have been reported. It is generally said that muscle activation of the quadriceps is greater than that of the hamstring muscles before landing, which is one of the risk factors of ACL injury. Demont & Lephart (2004) reported that muscle activation started during movement before joint impact, so it is possible to start muscle activation earlier to decrease the impact. Although the onset timing of muscle activities during jump landings is often unknown, there are a few reports on it. The purpose of this study was to clarify the differences in onset timing of muscle activities between single leg and double leg jump landings.

METHODS: Ten healthy male college students with no history of knee injury or neurological disorders participated in this study (age 21.7 ±1.1 years; height 174.5 ±5.6 cm; weight 72.3 ±7.2 kg). Prior to participating, each subject provided informed written consent according to the university institutional review board policy.
All subjects performed a single leg and double leg landing from a 40cm height box to the floor. The onset timing of the muscles was measured using electromyography (EMG). EMG data were collected from the vastus medialis (VM), vastus lateralis (VL), semimembranosus (SM), and biceps femoris (BF). The onset timing was visually identified as the first point, the EMG amplitude of 100 ms after the start of landing movement that exceeded the mean baseline and 3 standard deviations. The definition of baseline was set as the EMG amplitude of 100 ms after the toe-off from the box to the foot contact on the floor (Figure 1). The duration from the toe-off to the foot contact was standardized as 100%.

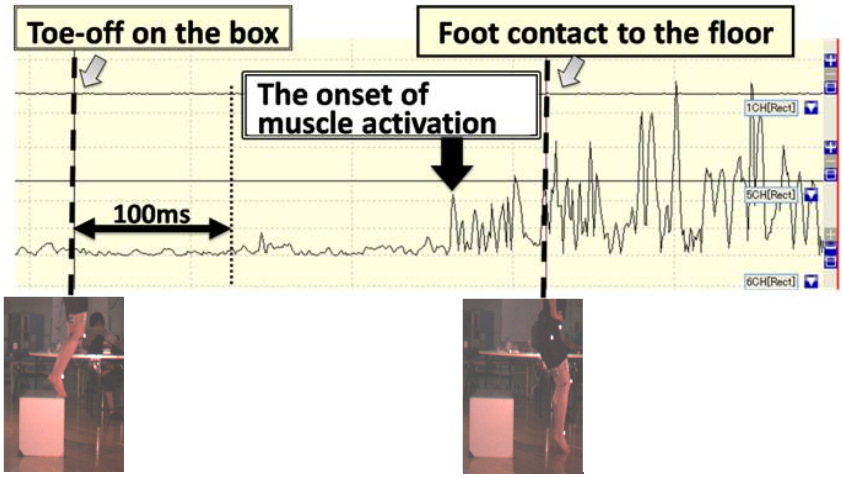

Figure 1: Measuring the onset of muscle activities during landing from the 40 cm height box.

One-way ANOVA with the post-hoc Scheffe's -`F`- test was used to clarify the differences in the onset timing of each muscles type. Paired t-tests were used to determine if differences existed single leg and double leg landings. Both statistical significances were set at 0.05.

RESULTS: The initial contact occurred 352.8 ±49.2 ms after the toe-off from the box with a single leg and 365.5 ±28.2 ms with a double leg. The onset of the VM activity during the single leg landing was 77.8 ±13.7%, that of the VL activity was 70.6 ±15.5%, that of SM activity was 75.4 ±6.7% and that of BF activity was 73.9 ±6.4% (Figure 2). The onset of the VM activity during the double leg landing was 87.1 ±12.8%, that of VL was 85.4 ±14.3%, that of SM was 79.6 ±7.6% and that of BF was 80.6 ±6.8% (Figure 3)

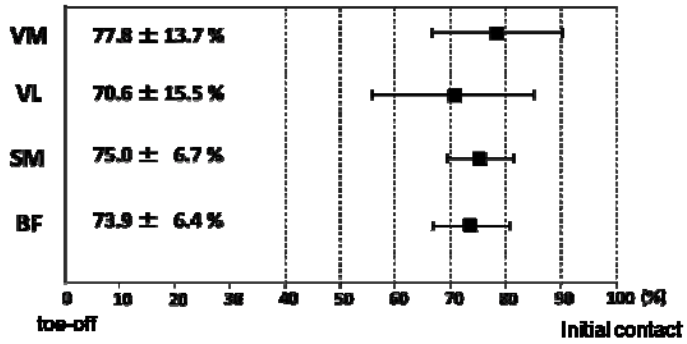

Figure 2: The onset timing of muscles during single leg landing.

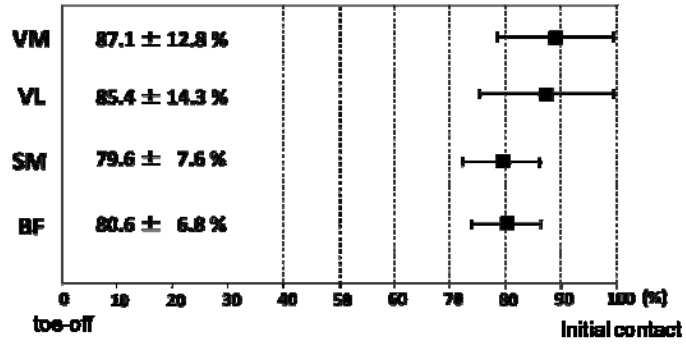

Figure 3: The onset timing of muscles during double legs landing.

There were no significant differences between the onset timing of the 4 muscles during each task. The onset timing of the muscles during the single leg landing was significantly faster than that during the double leg landing ($p<0.05$, Table 1).

Table 1: There were significant differences between each muscle during single leg landing and double legs lading.

		%			
VM	Double legs	87.1	±	12.8	* (9.7 %)
	Single leg	77.8	±	13.7	
VL	Double legs	85.4	±	14.3	* (14.8 %)
	Single leg	70.6	±	15.5	
SM	Double legs	79.6	±	7.6	* (4.6 %)
	Single leg	75.0	±	6.7	
BF	Double legs	80.6	±	6.8	* (6.7 %)
	Single leg	73.9	±	6.4	

DISCUSSION: ACL injuries are said to occur within 100 ms after jump landings (e.g. Schmitz, Kulas, Perrin, Riemann & Shultz, 2007). In addition, Demont (2004) reported that the onset timing of muscles contribute to stabilizing joints and preventing injury during movement. For these reasons, it is necessary to start muscle activity before the foot contact with the floor to prevent ACL injury. Because greater impact is added to the knee joint at the time of the single leg landing than at double leg landing, it may be beneficial to start muscle activity early to prepare for the knee impact. One study suggested that contraction of the quadriceps femoris muscles increases tension to the ACL and that contraction of the hamstring muscles protects ACL from the additional tension (Solomonow, Baratta, Zhou, Shoji, Bose, Beck & D'Ambrosia, 1987). This study showed no significant difference between the onset timing of the quadriceps femoris muscles (VM and VL) and that of the hamstring muscles (SM and BF), however, 5-8% of hamstring muscles' activities started earlier than the quadriceps femoris muscles' activities in the double leg landing movement. Significant differences may become clearer between the quadriceps femoris and the hamstring muscles once the number of objects is increased. The onset timings of muscle activities during the single leg landing were 10-15% earlier with the quadriceps femoris muscles and 5% earlier with the hamstring muscles than those during the double leg landing movement. The earlier onset of the quadriceps femoris muscles' activation than that of the hamstring muscles during the jump landing was one of the risk factors of ACL injury since contraction of the quadriceps femoris muscles may create additional tension for the ACL.

CONCLUSION: This study clarified the differences in the onset timing of muscle activities between a single leg landing and a double leg landing. Although there were no significant differences between muscles during the single leg and double leg landings, the onset muscle activities during the single leg landing were significantly earlier than those during the double leg landing. The earlier hamstring activity observed during the jump landing may contribute to protecting the ACL from injury.

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