

**PREACTIVITY DURING ROTATIONAL JUMP LANDING****Daisuke Bai<sup>1,2</sup>, Takahiko Fukumoto<sup>2</sup>****<sup>1</sup>Department of Rehabilitation, Heisei Memorial Hospital, Nara, Japan****<sup>2</sup>Department of Physical Therapy, Faculty of Health Science, Kio University, Nara, Japan**

The purpose of this study was to identify the the timing of the muscle preactivities of the hamstrings and quadriceps during landing from 180 and 360 degrees rotational jump. The subjects (n=10) participated in this study. The tasks were 180 and 360 degrees rotational jump. The electromyography (EMG) data was collected from the left leg muscles of all the individuals: the vastus medialis (VM), the rectus femoris (RF), the vastus lateralis (VL), the semimembranosus (SM) and biceps femoris (BF). In VL, 360 degrees was significantly faster than 180 degrees ( $p < 0.01$ ). In the case of 180 degrees landing, the timing of preactivity of the hamstrings resulted in significantly earlier than the quadriceps ( $p < 0.01$ ). As for 360 degrees landing, the timing of preactivity of SM resulted in significantly earlier than VM ( $P < 0.05$ ). These results proved that rotational jump was necessary as a part of prevention programs.

**KEY WORDS:** rotational jump, preactivity, anterior cruciate ligament (ACL) injury.

**INTRODUCTION:** Previous studies about knee joints which report the timing of muscle activities during jump landing such as a drop jump, squat jump and vertical jump. Preactivity (muscle activity) before landing leads to an appropriate knee position against valgus loading. Lately, it has been suggested that preactivity helps the limitations of neuromuscular controls. It is reported that neuromuscular controls contribute to the dynamic restraint mechanism. Therefore, appropriate alignment maintenance during jump landing appears pertinent to the reduction of ACL injury.

Cowling, Steele and McNair (2003) reported that the timing of muscle activities before landing of the hamstrings turned out to be significantly earlier than the quadriceps. It can be suggested that increased preactivity of the hamstrings helps to reduce an anterior tibial drawer and knee flexion moment during landing. This timing may be supported by neural programming during planned or expected activity. Many studies have reported vertical jump landing or drop jump landing but few studies have reported rotational jump landing. Previous researchers have reported lots of ACL injury prevention training programs which included 180 degrees and 360 degrees rotational jump landing. Nagano and Fukubayashi (2011) reported that the preactivity of the hamstrings was significantly increased after the jump and balance training. The results show a decrease in the number of ACL injury. However there are no reports to analyze rotational jump landing. Thus, the effectiveness of rotational jump landing on ACL injury prevention is still questionable.

The purpose of this study is to investigate the timing of the muscle preactivity of the hamstrings and quadriceps during 180 and 360 degrees rotational jump landing.

**METHODS:** The subjects were ten healthy females (mean age;  $23.5 \pm 2.5$  years, weight;  $50.3 \pm 3.8$  kg, height;  $158.5 \pm 4.8$  cm). Informed consent was obtained in writing from all subjects before the study. The subjects were told to jump one right-handed rotation. The tasks were 180 and 360 degrees rotational jumps. The subjects were instructed to fold their arms across their chest, to land as natural as possible with both feet on the landing platform keeping the landing posture for about 2 seconds. The electromyography (EMG) data was collected from the left leg muscles of all the individuals: the vastus medialis (VM), the rectus femoris (RF), the vastus lateralis (VL), the semimembranosus (SM) and biceps femoris (BF). The ground electrode was placed on the skin over the right styloid process of ulna. The skin over the right styloid process of ulna and these muscles were shaved and washed with

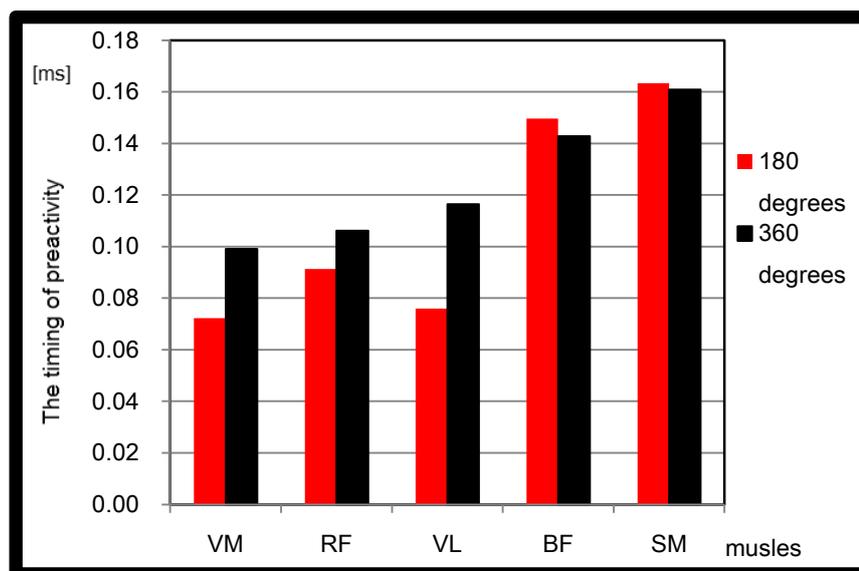
alcohol. The EMG data was recorded at 1000Hz by a surface EMG system (SX230; Biometrics Ltd. UK). The EMG data was filtered through a low-pass Butterworth digital filter at a cutoff frequency of 50Hz. The timing of initial contraction was based on four standard deviations above baseline, which was recorded during the quiet period before the rotational jump. For these tasks, the ground reaction forces generated during rotational jumps landing were recorded by using a force platform (MA8000; ANIMA Corp. Japan) which was synchronized to the EMG system. This data was measured at the time of initial foot-ground contact (IC). The sampling frequency of the force platform was 125 Hz. We recorded the area and mean amplitude for 200 milliseconds before IC for statistical analysis. Paired *t* tests were used to compare differences between 180 degrees landing and 360 degrees. A one-way analysis of variance (ANOVA) was used to determine if there was a difference among the timing of each muscle during each contraction. Tukey post hoc analysis was used to identify the contractions timing differences among the five muscles. All statistical comparisons were performed with the level of significance set at  $p < 0.05$ .

**RESULTS:** In VL, 360 degrees was significantly faster than 180 degrees. In others, there are no significant differences.

**Table 1**  
**The timing of preactivity during 180 degrees landing and 360 degrees landing.**

Muscles	180 degrees	360 degrees
VM	0.07 ± 0.03	0.10 ± 0.07
RF	0.09 ± 0.03	0.11 ± 0.05
VL	0.08 ± 0.03	0.12 ± 0.05
BF	0.15 ± 0.03	0.14 ± 0.03
SM	0.16 ± 0.03	0.16 ± 0.02

In the case of the 180 degree landing, the timing of preactivity of the hamstrings resulted in significantly earlier than the quadriceps ( $p < 0.01$ ). As for the 360 degree landing, the timing of preactivity of SM resulted in significantly earlier than VM ( $p < 0.05$ ). The results of 180 degrees and 360 degrees landing are presented in figure 1.



**Figure 1: The timing of preactivity during 180 degrees landing and 360 degrees landing.**

**DISCUSSION:** The purpose of this study was to investigate the muscle preactivity timing of the hamstrings and the quadriceps during 180 and 360 degrees rotational jump landing. The feature of this study is rotational jump landing. Rotational jump movement was included in the

prevent program but there are no reports to analyze about rotational jump landing. 180 and 360 degrees rotational jump movement is more difficult than a drop jump, squat jump and vertical jump. And it is not possible to predict landing posture. We compared the differences between the landing of 180 degrees and 360 degrees. In VL, 360 degrees was significantly faster than 180 degrees. In others, there are no significant differences. 360 degrees rotational jump movement is more difficult than 180 degrees. However, in quadriceps, 360 degrees tended to be earlier than the 180 degrees landing. On the other hand, in the hamstrings, 360 degrees tended to be later than the 180 degrees. Previous studies reported that the difficult task caused the delay in hamstrings muscle activity.

In the case of the 180 degrees landing, the timing of the preactivity of the hamstrings is earlier than the quadriceps. As for the 360 degrees landing, the timing of preactivity of SM resulted significantly earlier than VM. SM leads to internal rotation and flexion at the knee, which possibly caused the significant difference between medial muscles during 360 rotational jump landing. There were not any significant differences between each muscle except medial muscles during 360 degrees rotational jump landing. However, the hamstrings contraction and coactivation of the hamstrings and the quadriceps are designed to protect the knee joint not only against excessive anterior drawer but also against knee abduction and valgus load. The result of 360 degrees rotational jump may limit the potential for coactivation of the muscles to protect ligaments. So there is no significant difference between the hamstrings and quadriceps during 360 degrees rotational landing.

There are difference results between the 180 degrees rotational jump landing and the 360 degrees landing. However, in the case of 180 and 360 degrees landing, the timing of preactivity of the hamstrings resulted significantly earlier than the quadriceps. Even if the rotational stress joins knee joint, there is no significant difference between BF and SM and between VL, RF and VM. The activities of VM and SM lead to internal rotation against the femur as for the tibia and VL and BF lead to external rotation. This result suggests that the rotational stress is reduced by the activities of BF and SM at the same time. Cowling, Steele and McNair (2003) reported that the timing of muscle activities before landing of the hamstrings turned out to be significantly earlier than the quadriceps during leaping from subjects' non-dominant leg and landing on dominant limb in single limb stance. Our results are similar to previous studies. It is well-known that hamstrings muscle activities lead to the greater knee flexion and posterior movement of tibia and decrease knee valgus loads. There is a higher risk of ACL injury in females compared to male during landings on the ground from a jump. This is because female perform athletic maneuvers with decreased knee flexion and hip flexion, increased quadriceps activation and increased knee valgus angles. This biomechanical pattern is thought to increase the risk of ACL injury. However our result suggested that greater knee flexion is necessary to decrease ACL stress by this posture.

Neuromuscular training studies which are to prevent ACL injury have been conducted previously in an attempt to reduce ACL injury risk. 180 and 360 rotational jump movements were included in the prevent program. Nagano and Fukubayashi (2011) reported that the preactivity of the hamstrings was significantly increased after the jump and balance training. Jennifer, Tamara, Suzanne and Jackie (2008) reported that the muscle timing of female athletes and male athletes were significantly earlier than female non-athletes. Training correct posture and repeating same exercises caused to increase muscle activities. The hamstring muscles forces protect ACL. The hamstring muscle preactivity is thought to be beneficial for stabilizing a knee during landing. However there are no reports to analyze rotational jump landing. Our results supported the theory that rotational jump was necessary as a part of prevention programs. We need to train athletes.

There are some limitations in this study. This study only looked at the muscle preactivity in response to rotational landing. We ought to measure sagittal and frontal moment of the knee joint. The connection between muscle activity and the moment of the knee joint should be examined in the future. Secondly there are only ten subjects. In future we should increase the number of subjects.

**CONCLUSION:** This task was 180 and 360 degrees rotational jump. The muscle activities of hamstrings and quadriceps showed the same results that were reported for landings from vertical jump or drop jump. The time of muscle preactivity of hamstrings is earlier than the quadriceps during rotational jump landing. This result of generating earlier preactivity times of the antagonistic quadriceps muscles is suggested to lead greater knee flexion and more inferior knee valgus. Increased muscle activities before IC is important for stabilization. There are two limitations. We didn't examine the kinematics of the knee joint, hip joint or ankle joint. In addition, there are only ten subjects. We will report the relationship between the timing of the preactivity and knee angles during rotational jump increase the number of subjects in future.

In conclusion, these results prove that rotational jumps are necessary as part of prevention programs. And prevention training programs should focus on acquiring a landing technique with adequate knee flexion and avoiding knee valgus.

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