DIFFERENT POWER AND MUSCULAR ACTIVITIES OF THE LOWER LIMBS IN THE REBOUND JUMP

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The purpose of this study is to clarify the differences in myoelectric activities and power exerting the lower limbs of the performance that is jumping height is high and low people in the rebound jump. The subjects was 23 male students belong to track and field (age : 20.8 ± 0.9 years, height : 179.6 ± 6.1 cm, and body mass : 82.3 ± 17.0 kg). The subjects performed five-repeated rebound jump (5RJ), based on the jumping height of the result, divided into jumping high-high group (GOOD) and the low group (POOR), it was compared with the lower limbs joint power and myoelectric activity. As a result, it was clearly that differences in the performance of GOOD and POOR has become the appropriate preliminary motion that was preactivation of the lower limbs muscles in the before foot contact and due to the quick action in take off of the first half.

KEY WORDS: jump height, counter movement, muscle preactivation.

INTRODUCTION: In the performance of a human movement that requires great force exerted in a short time, it is known that the counter movement is performed before the primary motion. Ito et al. (1987) investigated the rebound effect in calf muscle on the basis of this mechanism, as a result, it was revealed that even with a small activity level of the muscle, can exhibit high performance by using the counter movement, this effect is due to stretch-shortening cycle (SSC) movements in calf muscle. For kinetics factors of jumping movement by using such a counter movement, considered to be validated on that take into account the differences in the performance, become one of the fundamental data for understanding the mechanical mechanism to jump higher. Therefore purpose of this study is to clarify the differences in muscular activities and power exerting the lower limbs of the performance that is jumping height is high and low people in the rebound jump.

METHODS: A total of 23 male students with a track and field background (age : 20.8 ± 0.9 years, height : 179.6 ± 6.1 cm, and body mass : 82.3 ± 17.0 kg) participated in this study after writing informed consents in accordance with the College of Humanities and Sciences, Nihon University ethics committee. The subjects performed five-repeated rebound jumps (5RJ). The arms were set at the hip to prevent counter effects due to swinging of arms. The 5RJ motions were recorded using a high-speed camera GC-P100 (JVC KENWOOD, 300 Hz). From the read 7 points (the position coordinates of the toe, ball of the thumb, heel, malleolus point, knee joint midpoint, greater trochanter and calibration) and four calibration markers, a motion analysis system Frame-DIAS V (DKH, 100 Hz) was used to calculate the angular velocity of the hip, knee joints, and ankle (the coordinate dates were smoothed using a Butterworth digital filter at 2-9 Hz, as a result of residual analysis for each point). In addition, the mass, center of mass location, and moments of inertia of the body segments were estimated from the body segment parameters of Ae et al. (1992). Joint torque was calculated using an inverse dynamics approach using a four segment ring body model (trunk, thigh, shank and foot). The inner product of the joint angular velocity and joint torque was the joint torque power (torque power). From the ground reaction force recorded using a force platform (Kistler, 1k Hz), the air time (Ta) and contact time (Tc) were required to be calculated to further calculate the jumping height (Hjump= 9.81•Ta2/8), the mean (f-mean) and maximum (f-max) of the vertical component, impulse, and maximum time (Tfmax-Ts) of appearance of the ground reaction force. The electromyogram (EMG) of gluteus maximus (GM), biceps femoris (BF), rectus femoris (RF), vastus lateralis (VL), gastrocnemius (Gas), and tibialis anterior (TA) were recorded after A/D conversion, along with the synchronization of video and ground reaction force data, by using an LED-type synchronizer (DKH). The each of EMG were that full-wave rectification through Butterworth high-pass filter of 10Hz, were smoothed by the 10Hz low pass filter. Statistical treatment was performed with t-tests for all calculation data. The level of statistical significance was set at 5%.

RESULTS: The mean for all participants for jump height was 34.71 ± 7.03cm. In this study, which uses jump height as an indicator of performance, students categorized into high jump and low jump height groups by using the GP analysis (good-poor analysis). The average value +0.5 group of more than the standard deviation of the jump height is defined as GOOD, the average value of -0.5 standard deviation below the group of jump height was defined as POOR. As a result, the jump height of GOOD (n = 9) is 41.98 ± 3.50 cm, and that of POOR (n = 7) was 26.35 ± 2.65 cm. Table 1 shows the performance results of GOOD and POOR in 5RJ. Results of t-test, significantly different Hjump ($p < 0.001$) and Tfmax-Ts ($p < 0.01$) were obtained.

Table1: Jump performances in 5RJ.

	GOOD(n=9)	POOR(n=7)	significant
Hjump (cm)	41.98 ± 3.50	26.35 ± 2.65	***
T-contact (sec)	0.20 ± 0.03	0.22 ± 0.05	
Impulse (Ns)	513.73 ± 85.23	596.30 ± 147.14	
F-mean (N)	2584.29 ± 299.20	2664.42 ± 160.16	
F-max (N)	4048.94 ± 449.37	3958.68 ± 400.07	
Tfmax-Ts (sec)	0.07 ± 0.01	0.10 ± 0.02	**

mean±s.d. ***: p<0.001 **: p<0.01

Figure 1 shows the normalized data of joint angular velocity, torque, and torque power of the ankle joint, knee joint, and hip joint in 5RJ. Those changes patterns, both were similar. In the joint angular velocity, a significant difference recognized for the ankle joint from 86% to 91%, for the knee joint from 64% to 96%, and for the hip joint from 82% to 97% ($p < 0.05$). In torque, a significant difference was recognized, for the ankle joint at 10%, from 17% to 21%, and from 41% to 70%, for the knee joint from 20% to 36%, from 44% to 63%, and at 70%, and for the hip joint from 25% to 29%, and from 48% to 54% ($p < 0.05$). In torque power, a significant difference was recognized for the ankle joint from 9% to 10%, from 15% to 25%, from 28% to 35%, and from 47% to 81%, for the knee joint from 18% to 39% and from 56 % to 74%, for the hip joint from 25% to 28%, from 61% to 62%, and from 93% to 94% ($p < 0.05$). Next, for a case study, the EMG of the lower limbs in 5RJ, selects the closest subject jump height to the average value in each of the groups of GOOD and POOR, each of subject Y (GOOD), and A (POOR) definition did.

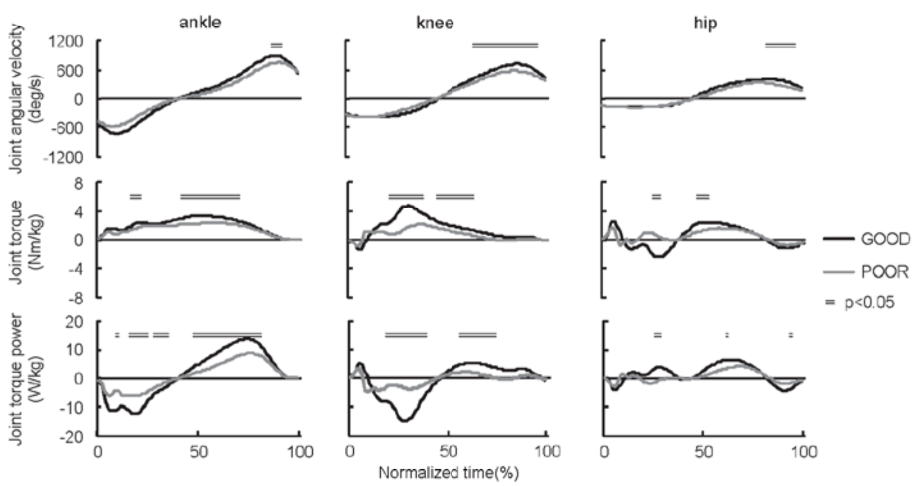

Figure1: Normalized lower limb joints each part of the joint angular velocity, torque and torque power.

Figure 2 shows the vertical component of the ground reaction force and the EMG of both subjects. On comparison of the EMG of both subjects, a difference in the amplitude of GM, RF, and Gas was observed. In addition, muscle electric discharge was observed in Gas and TA before foot contact in subject Y.

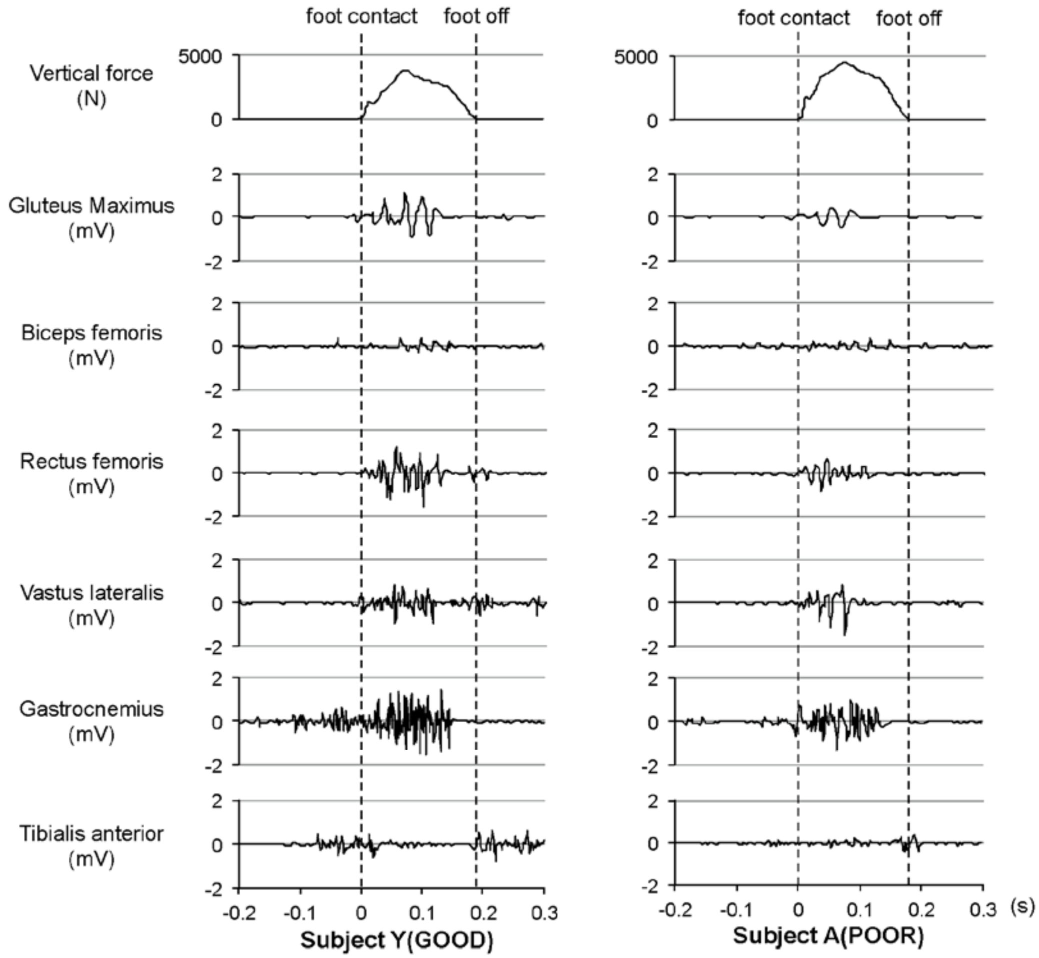

Figure2: Vertical component of ground reaction force and the EMG of subjects Y and subject A.

DISCUSSION: From the results in Table 1, GOOD is seen to have performed work effectively in a short time operation of the first half in the support phase as compared to POOR. Thus, consider the differences in the force exerted on the lower limb joints of GOOD and POOR. As seen in Figure 1, it can be seen that in the hip joint, GOOD is a short period, however a large positive power than the POOR; in the knee joint, GOOD has a large negative power in the first half of the support phase and a positive power in the second half of the support phase as compared to POOR. Bobbert et al. (1996), have reported that the hip joint torque just after the crosscut of reaction is increased by the use of the counter movement, the amount of hip joint work is increased by its effect, which leads to an increase in the jump height. In addition, Zushi and Takamatsu (1996) suggests that, in order to exert a large knee extension force from the instant to the foot contact in a rebound jump, the landing operation of bending the knee joint in an instant to the ground just before. Given the results obtained in this study and these reports, the difference in performances of GOOD and POOR are thought to be because of bending the knee joint to the ground just before, and because of quick takeoff techniques such as the flexion and extension movement of the hip joint after landing. In the ankle joint, it can be seen that GOOD has a large negative power in the first half of the support phase, and a large positive power from middle to foot off as compared to POOR (Fig. 1). The ankle exhibits a negative power by an eccentric muscle contraction in the first half of takeoff to absorb the impact (Bobbert et al., 1987a, b). However, a large negative power found in the first half of the support phase represents that the impact force of the landing is large. Yamazaki et al. (1980) have pointed out that it is important to the preactivation of the lower limb muscles to respond immediately to a large load at the time of landing. So, then consider the muscular activity of the lower limb muscles of GOOD and POOR. It can be seen that GM, RF and Gas of the amplitude of Subject Y are larger than those of Subject A. The magnitude of the amplitude for from the magnitude of the output of the muscle, Subject Y was obtained high jump height to exert more power in the lower limb than Subject A. Here, focus on the muscular activity of Gas. In Subject Y, the muscular activity from before foot contact was seen; however, it was not observed in Subject A. Melvill jones et al. (1971) suggest that the muscular activity of Gas in the eccentric contraction is advance pre-programming based on temporal and spatial predictions for the landing, and stretch reflex associated with it effectively works in the subsequent kick. In addition, Ito et al. (1987) has stated that it is induced stretch reflex by to stretch the active muscle, increasing muscle stiffness. Kojima et al. (1983) mentioned that increase of the stretch reflex because of an increase in extension speed affects the use of elastic energy. From these facts, Subject Y performs the appropriate preliminary operation, the preactivation of triceps of the calf and temporal and spatial predictions before foot contact and inferred that elastic energy was efficiently used by performing a quick motion. With such a mechanism, it is considered that Subject Y jumped higher and exerted a large power in the lower limbs

CONCLUSION: The purpose of this study was to investigate the differences of power exertion of the lower limbs in the rebound jump from the kinetics viewpoint. Based on the average value of the jump height of the rebound jump, the power and muscle activity in the lower limbs of the people performing high and low jumps during rebound jump were compared, and they were categorized into GOOD (for high jumps) and POOR (for low jumps) groups. The differences in performances of GOOD and POOR were revealed to be due to appropriate preliminary motion, which is the preactivation of the muscles of the lower limbs prior to foot contact and the quick motion in the first half of support phase.

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