COMPARISON OF PULL AND CATCH PHASES DURING CLEAN EXERCISESE

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The purpose of this study was to identify differences in kinetic characteristics between the performed the PC at 30%, 60%, and 90% of one repetition maximum. Kinetic data were collected from recorded data by using a Vicon motion system and force platforms. In the comparison between the pull and catch phases, the kinetic characteristics of the catch phase were as follows: 1) The peak ground reaction force did not significantly differ according to load. 2) Ankle and knee kinetics showed large values. 3) The force and power in the ankle and knee did not significantly differ between the light load (30%) and heavy load (90%). Therefore, the importance of using PC in training not only for the pull movement but also for the catch movement.

KEY WORDS: resistance training, barbell exercises, power clean, three-dimensional.

INTRODUCTION: In many sports, power clean (PC) is used to improve dynamic performance in the lower extremity and trunk muscles. PC involves lifting the barbell from the floor to the shoulders in a quick motion, and then performing a catch of the bar at shoulder level. During the pull phase, the lifter quickly lifts the stationary barbell (Comfort et al., 2011). Then, during the catch phase, the lifter receives the descending load of the barbell before standing with the heavy load. Therefore, it may be hypothesized that the greater muscular force and power occur in the catch phase than the pull phase. However, in biomechanical studies of PC, only the pull phase has been studied (Kipp et al., 2011). No studies have been conducted on the catch phase. Furthermore, although the posture in the catch phase is described in instructional textbooks (Rippetoe et al., 2011), studies on this are scarce. Therefore, the catch phase during PC may also have an effect on training. In order to examine this hypothesis of greater loading in the catch of PC, the present study investigated ground reaction force (GRF) and joint kinetics. The purpose of this study was to identify the characteristics of the catch movement of this power training method based on differences in GRF and joint kinetics between the pull and catch phases in PC.

METHODS: Eleven male track and field athletes (age, 23.0 ± 3.3 years; height, 172.2 ± 4.2 cm; body mass, 65.6 ± 4.8 kg) participated. All subjects is regularly used the PC in their training. Written informed consent was obtained from all of the subjects prior to participation. All the study procedures were approved by the ethics committee for the Institute of Health and Sports Sciences, University of Tsukuba, Japan.
After the warm-up, the subjects performed the PC at 30%, 60%, and 90% of one repetition maximum (1 RM). The subjects were verbally instructed to move as quickly as possible during the pull phase and actively perform the catch movement.
The three-dimensional coordinates of 49 retroreflective markers fixed on the body and barbell were collected by using the Vicon motion system (Vicon Motion Systems, Ltd.) with 10 cameras operating at 250 Hz. GRF was obtained by using the Kistler force platform at 1000 Hz, and two force platforms were used to obtain the right and left leg data.
Inverse dynamics were performed on a three rigid link segment model to obtain the joint torque and torque power of the right leg. The coordinate systems used to calculate the joint torque and joint angle were the same as those described by Kariyama and Zushi (2013). The joint torque was calculated around the plantarflexion–dorsiflexion axes in the ankle joint,

and around the extension–flexion rotation axes in the knee and hip joints. In this study, the kinetic variable was not normalized to body mass, as PC performance does not depend on body weight, unlike other exercises (e.g., jumping).
Data were divided into the pull phase (i.e., from the time of barbell displacement of more than 3% from the floor to the time of foot contact with the platform) and catch phase (i.e., from the time of foot contact with the platform to the time of vertical acceleration of the barbell drop at less than 0 m/s after the catch movement).
A repeated-measures two-way analysis of variance (ANOVA) was used to determine differences between the pull and catch movements according to each dependent variable (3 loads × 2 conditions). Statistical significance was set at $p < 0.05$. When significant F-values were found, the Holm's Bonferroni method for controlling type 1 error to determine the significant difference. For joint torque power, absolute values were compared because torque power showed both positive and negative values in the pull and catch phases.

RESULTS: Figure 1 shows the typical serial changes in vertical GRF, joint torque, and joint torque power in the lower extremities during the pull and catch phases at 60% of 1 RM. In the comparison of vertical GRF between the pull and catch phases, the peak vertical GRF was greater during the catch phase than during the pull phase. In the catch phase, the peak vertical GRF, joint torque, and torque power showed spike patterns after foot contact with the platform. Figure 2 shows a comparison of peak vertical GRF between the pull and catch phases at 30%, 60%, and 90% of 1 RM. A significant interaction was observed between load and phase. Peak vertical GRF was significantly greater during the catch than during the pull phase at 30% of 1 RM, and peak vertical GRF was significantly lower during the catch than during the pull phase at 90% of 1 RM. The peak vertical GRF during the pull phase significantly increased with the increase in load. No significant difference was found in peak vertical GRF during the catch phase when the load was increased. Figure 3 shows a comparison of peak joint torque and peak joint torque power in the lower extremities between the pull and catch phases at 30%, 60%, and 90% of 1 RM. Joint torque and joint torque power in the knee joints, as well as joint torque in the ankle joint, showed a significant interaction between load and phase. Joint torque in the ankle and knee joints was significantly greater during the catch phase than during the pull phase. Joint torque power was compared in absolute values because it showed negative values during the catch phase. In the comparison of the absolute values of joint torque power, joint torque power in the hip joint was significantly greater during the pull phase than during the catch phase, and that in the ankle and knee joints was significantly greater during the catch phase than during the pull phase. We found significant differences in joint torque and knee joint torque power during the pull phase and in ankle joint torque power during the catch phase according to increasing load. However, no significant difference was found in knee kinetics during the catch phase.

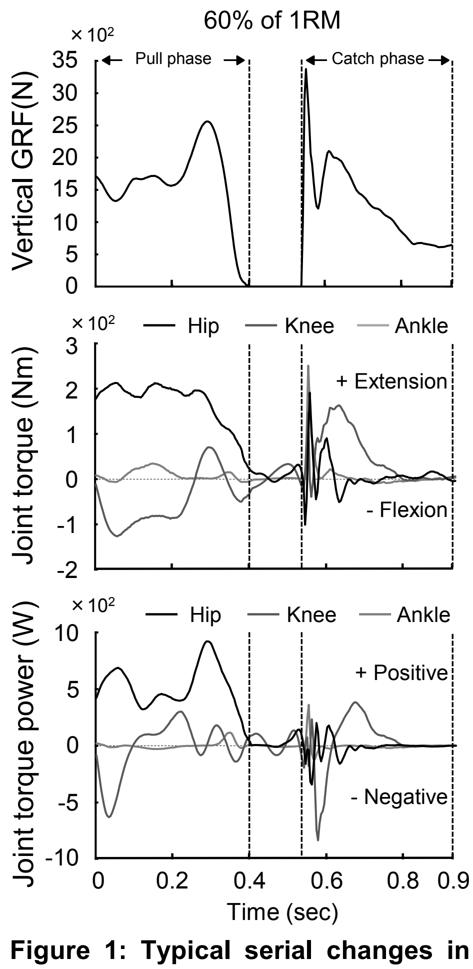

Figure 1: Typical serial changes in vertical GRF, joint torque, and joint torque power in the lower extremities during the PC at 60% of 1 RM.

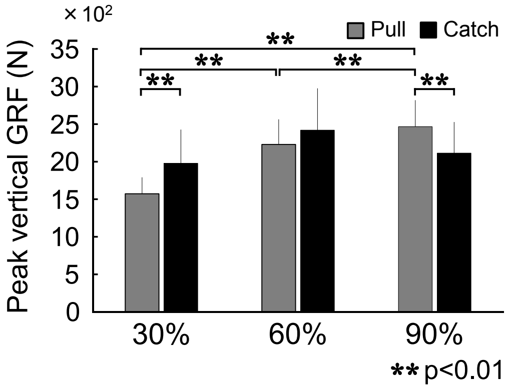

Figure 2: Comparison of peak vertical GRF between the pull and catch phases at 30%, 60%, and 90% of 1 RM.

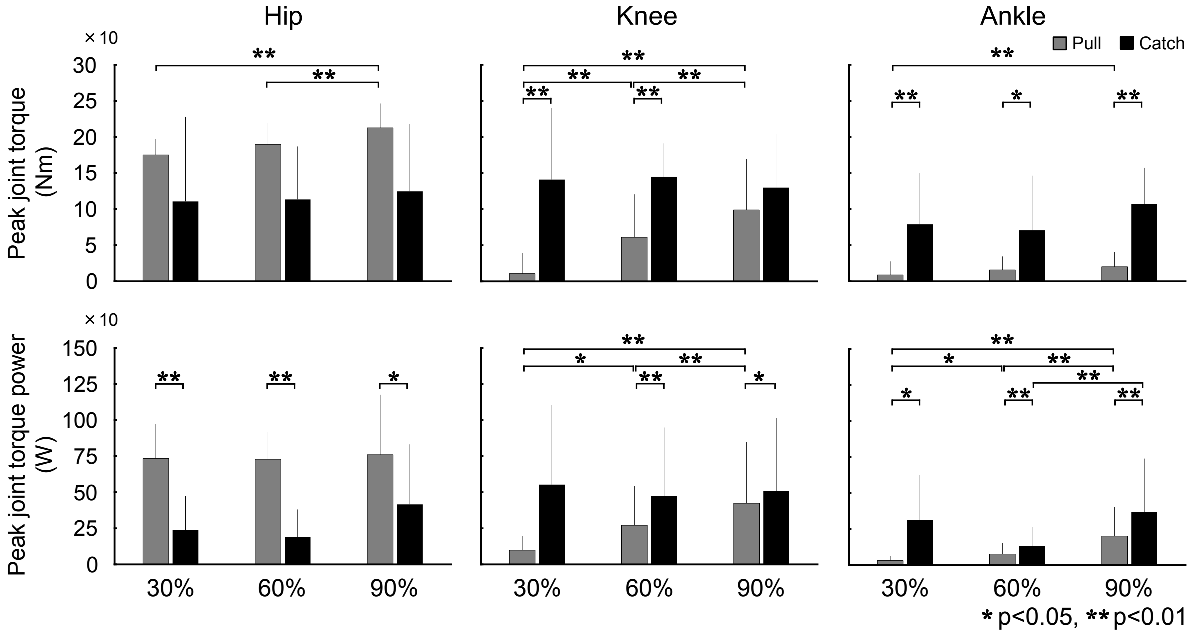

Figure 3: Comparison of joint torque and torque power in the lower extremities between the pull and catch phases at 30%, 60%, and 90% of 1 RM.

DISCUSSION: During the pull phase, the peak vertical GRF increased with the increase in load (Figure 2). This result is similar to that of a previous study that used the same loads (Cormie et al., 2012). However, no significant difference was found in peak GRF during the catch phase when the load was increased. In the comparison between the variables, the peak vertical GRF was significantly greater during the catch phase than during the pull phase at 30% of 1 RM, but was significantly lower during the catch phase than during the pull phase at 90% of 1 RM. Therefore, in the catch phase compared to the pull phase, vertical GRF was similar across light (30% of 1 RM) and heavy loads (90% of 1 RM). In addition, a large vertical GRF can be developed at light loads in the catch phase.

For joint kinetics (Figure 3), the peak joint torque in the ankle, knee and hip significantly increased during the pull phase with the increase in load. Further, although no significant difference in joint torque and joint torque power was found in almost all joints with the load increase during the catch phase, the ankle and knee joint kinetics during the catch phase were significantly greater than during the pull phase. By contrast, the hip joint kinetics were lower during the catch phase than during the pull phase. Although angular velocity is not

shown in Figure 1, force development at the lower extremity was deemed mainly achieved by eccentric muscle contraction during the catch phase. On the other hand, force development was mainly achieved by concentric muscle contraction during the pull phase (Enoka, 1988). Contraction type at the agonist lower extremity was different between the pull and catch phases. However, the comparison of the magnitude of joint kinetics between the pull and catch phases showed that large loads affected the hip extensor muscles during the pull phase and the knee extensor and ankle plantar flexor muscles during the catch phase.
The almost ankle and knee joint kinetics during the catch phase did not significant difference between loads. Furthermore, the knee joint kinetics showed a significant interaction between load and phase. Therefore, in the catch phase compared to the pull phase, the force and power that developed in the ankle, and especially in the knee, were similar across light (30% of 1 RM) and heavy loads (90% of 1 RM). However, vertical GRF, joint torque and joint torque power in the catch phase showed large standard deviations when the comparison of vertical GRF joint kinetics between the pull and catch phases (Figures 2 and 3). Accordingly, we suggest that the large discrepancy between subjects was caused by the lack of instruction about the catch phase. When using the catch movement as part of power training, coaching that focuses on the catch movement is important. In the future, in order to address these points, research emphasizing the movement and posture during the catch movement should be conducted.

CONCLUSION: In our comparison between the pull and catch phases, we found the following kinetic characteristics of the catch phase: 1) The peak vertical GRF did not significantly differ according to load; 2) Regarding joint torque and torque power in the catch phase, the hip joint showed low values, while the ankle and knee joints showed high values; and 3) The force and power in the ankle and knee did not significantly differ between the light (30%) and heavy loads (90%), and hip joint kinetics showed a significant interaction between load and phase. Based on these results, a large load affects the hip extensor muscles during the pull phase, and the knee extensor and ankle plantar flexion muscles during the catch phase. Furthermore, during the catch phase compared to the pull phase, the force and power that developed in the ankle and especially the knee were similar across the light and heavy loads. Therefore, the importance of using PC in training not only for the pull but also for the catch movement.

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