RELATIONSHIP BETWEEN THE VELOCITY OF THE CENTER OF MASS AND THE MECHANICAL WORK DONE BY THE SHOULDER AND HIP JOINTS IN PERFORMING THE BASKET TO HANDSTAND ON PARALLEL BARS

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The purpose of this research was to investigate the relationship between the velocity of the center of mass and the mechanical work done by the shoulder and hip joints in performing the basket to handstand on parallel bars. Twenty-six male elite gymnasts were videotaped at the national championships. Two-dimensional motion analysis technique and inverse dynamics approach were used for calculating the kinematic and kinetic parameters. The negative work done by the shoulder joint significantly related to the velocity of the center of mass at 270 deg. point($r=0.55$, $p<0.05$), but the positive work done by the hip joint had no significant relationship to the velocity($r=0.33$, n.s.). Therefore decreasing the negative work done by the shoulder joint was important for better execution of the basket to handstand on parallel bars.

KEY WORDS: gymnastics, parallel bars, basket, mechanical work.

INTRODUCTION: The basket to handstand type elements are important skills in men's artistic gymnastics. Takei and Dunn (1996) indicated that the vertical velocity at bar release was important for performing the basket to handstand mount. Most of researches focused on the velocity of the center of mass (e.g. Yamada et al., 2010), while few researches to investigate about the mechanical work done by the joint torque (Hiley et al., 2009). The purpose of this research was to investigate the relationship between the velocity of the center of mass and mechanical work done by the shoulder and hip joints in performing the basket to handstand on parallel bars.

METHODS: The basket to handstand type elements performed by twenty-six male elite gymnasts were videotaped (60Hz) in the sixty-fourth National Championships in Yamaguchi, Japan in 2010. Twenty-two body landmarks were digitized. The coordinates of the body landmarks were filtered with a fourth order Butterworth digital filter with cut-off frequencies ranging from 3.0 to 4.2 Hz which were determined automatically (Winter, 1990). The center of mass of the gymnast was estimated using the body segment inertia parameters of a Japanese athlete model (Ae, 1996). The joint torques of the shoulder and hip were calculated using an inverse dynamics approach. The mechanical work done by the joint torques were calculated by integrating the joint torque powers of the shoulder and hip. The joint torque power and the mechanical work were normalized by the body mass of the subject. Five specific events (0, 90, 180, 270, and 360 degrees) were decided based on a rotation angle of the center of mass around the hand for this research (Figure 1). Correlation coefficients were calculated for a test of relationships between the velocity of the center of mass and the mechanical work done by the joint torque. The level of significance was set less than 0.05.

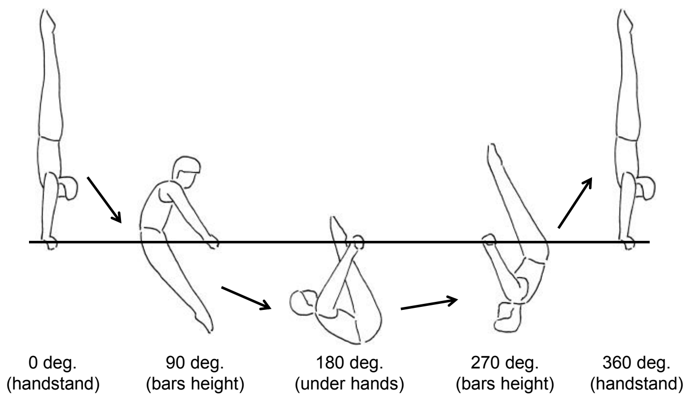

Figure 1: The basket from handstand to handstand.

RESULTS: Figure 2 provides typical changes in the joint angle, joint angular velocity, joint torque, and joint torque power of the shoulder and hip during the basket to handstand. The shoulder joint angle had two extension peaks and hip joint had one flexion peak. The joint angular velocity of the shoulder had two extension peaks and two flexion peaks and that of the hip joint had each flexion and extension peaks. The joint torque of the shoulder had flexion peak and great extension peak. The hip joint torque had small and great peaks of extension and one flexion peak. The joint torque power of the shoulder had two negative peaks and that of the hip joint had two positive peaks. While the power generated at the hip joint torque showed mostly positive, the power generated at the shoulder joint torque was mostly negative. Figure 3 shows relationships between the velocity of the center of mass at the 270 degree point and the mechanical work done by the shoulder and hip joint during 0 to 270 degrees. The mechanical work done by the shoulder joint significantly related to the velocity of the center of mass (r=0.55, p<0.05), but that of the hip joint had no significance relationship (r=0.33, n.s.).

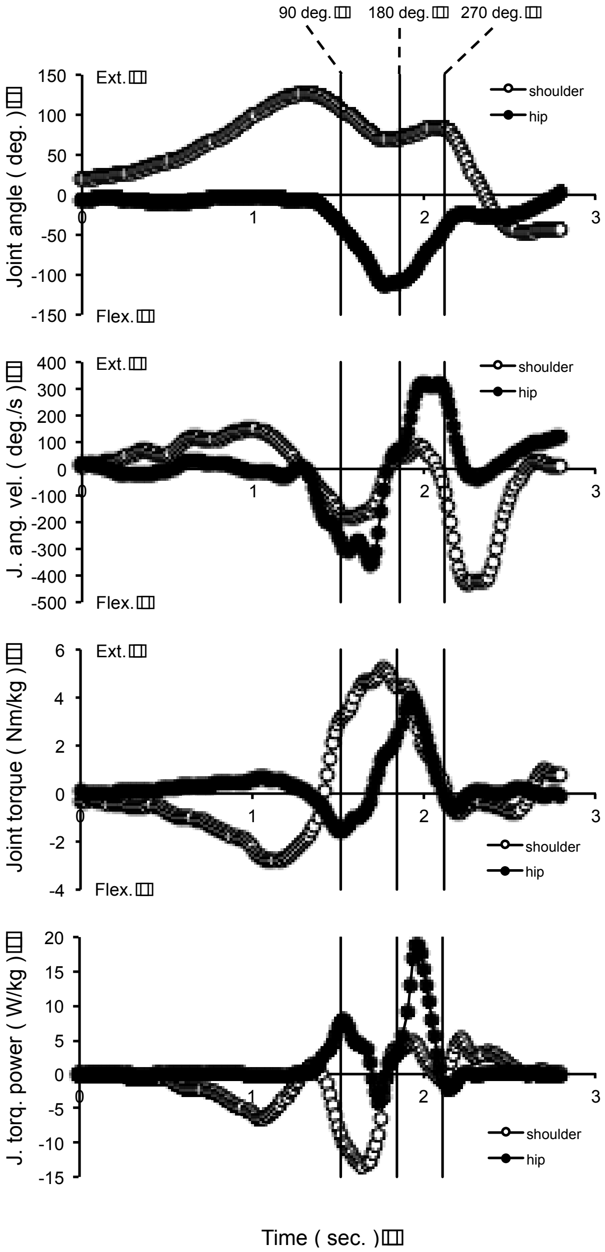

Figure 2: Joint angle, joint angular velocity, joint touque, and joint torque power of the shoulder and hip in performing the basket to handstand (typical data).

DISCUSSION: A moderate correlation between mechanical work done by the shoulder joint and the velocity of the center of mass at the 270 degree point was identified. The joint torque power of the shoulder was mostly negative; consequently, the mechanical work done by the shoulder was negative, too. On the other hand, the joint torque power of the hip joint was mostly positive, but there was no relation to the velocity of the center of mass. Therefore decreasing the negative work done by the shoulder joint was important for better execution of the basket to handstand from 0 to 270 degrees.

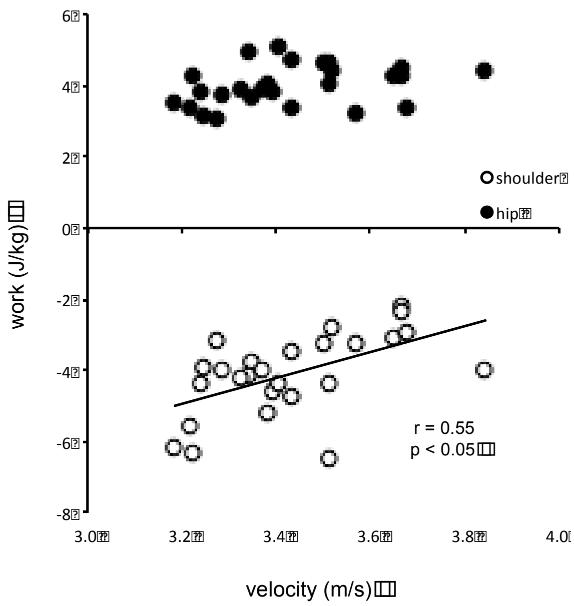

Figure 3: Relationships between the velocity of the center of mass and the mechanical work done by the shoulder and hip during 0 to 270 deg.

CONCLUSION: The joint torque power of the shoulder was mostly negative, and the hip joint mostly positive. The mechanical work done by the shoulder joint torque was related to the velocity of the center of mass and this work was negative. Therefore increasing the velocity of the center of mass at 270 degree point needed decreasing the negative work done by the shoulder joint from 0 to 270 degrees. Most of the mechanical work done by the shoulder was absorbed from 0 to 180. Thus, it will be possible to reduce the negative work by decreasing the movement of the shoulder during the downward swing.

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