BIOMECHANICAL CONSIDERATIONS OF CMJ AND SQJ ON THE SAFETY MAT

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The purpose of this study was to detect whether differences exist concerning the kinematic parameters of jump (SQJ and CMJ) on two different surfaces (RS and SS). Nine healthy students performed two jumps on two surfaces. Two factor repeated measure (ANOVA) was used for statistical analysis (p<.05). No significant difference about GRF was found among all conditions. Fy-anterior on SS was smaller than on FM (p<.05) and Fy-posterior of CMJ was smaller than SQJ on RS (p<.05). Kinematic analysis revealed significant differences in the angle of ankle between SS and FM during starting posture (p<.05). It became clear that knee joint angular velocity is significantly faster on RS than SS (p<.05). In conclusion, by riding on SS, the significant difference seen by SQJ and CMJ of RS had disappeared.

KEY WORDS: beach volleyball, jump, CMJ, SQJ.

INTRODUCTION: Beach volleyball became one of the most major sports in the world. IOC included beach volleyball into Olympic events, in Atlanta 1996. In the beach volleyball game, it is important to jump higher to block and spike on instable sand (George et al., 2003). It is clear that jump height of CMJ is 7% more than SQJ because the countermovement produces a large amount of work over the first part of the muscle's shortening distance (Bobbert et al., 1996). Nevertheless, the pro beach-volley player would prefer SQJ to CMJ when he jumps to block (Homberg et al., 1994). Previous studies indicated that jump surface affects jump height and performance (George et al.2004; Clifford, L. 1999). So, it is important to investigate how or why the conditions of the surface influence a jump, when adjusting the jump method. The purpose of this study was to detect whether differences exist concerning the kinematic parameters of jump (SQJ: Squat jump and CMJ: Counter movement jump) on 2 land surfaces (RS: Rigid Surface and SS: Safety mat Surface).

METHODS: Nine healthy students (age=21.42.0, 167.4 ± 7.5cm, 606. ± 0278.4N, male=7, female=2) participated in this study. Informed consent was obtained from all subjects in accordance with the policy statement of the Kanazawa University Research Committee. Subjects practiced jump on the force plate (RS: Rigid Surface) and the safety mat (SS: Safety mat surface) placed on the force plate. Subjects performed 5 vertical jumps with maximum effort in both conditions. The best of 5 trails, based on the maximum vGRF, was selected for further analysis. GRF data were sampled at 1000Hz on the force plate (Kistler). Reflective markers placed on seven anatomical points (top of the head, shoulder, great trochanter, knee, ankle, heel, 5th metatarsal). Performance were captured from right side using seven capture cameras (Nac V-133, sampling rate 200HZ). Surface EMG were recorded at 200HZ using electrodes (Delsys). Statistical processing of the parameters was carried out using Two-factor repeated measure ANOVA (p<.05).

RESULTS AND DISCUSSION: The mean and standard deviation of ankle angle during push off phase were SS-CMJ 69.5±4.5 deg, SS-SQJ 70.6±4.8 deg, RS-CMJ 73.5±6.5 deg, RS-SQJ 76.1±6.0 deg (Fig. 1). Significant differences were found in SS-CMJ vs. RS-CMJ, SS-SQJ vs. RS-SQJ, RS-CMJ vs. RS-SQJ (*<.05). Inclination of ankle extension by 3.5 degrees increases jump height in two-leg vertical jumps (Clifford et al. 1999). The case of SS condition enables more extension for ankle joint at both CMJ and SQJ. Moreover, significant differences disappeared between CMJ and SQJ. This suggests that SQJ could jump as high as CMJ jump performance on SS. But we could not say why significant difference was found in vGRF parameter.

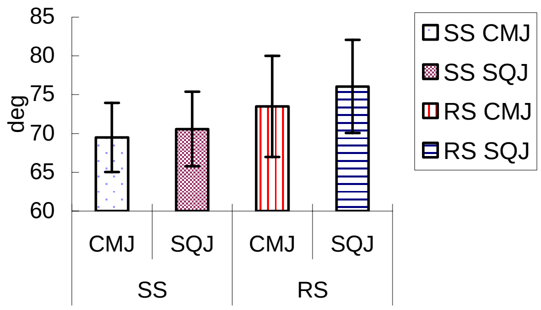

Fig. 1 Comparisons of ankle angle among SS-CMJ, SS-SQJ, RS-CMJ, and, RS-SQJ (*<.05)

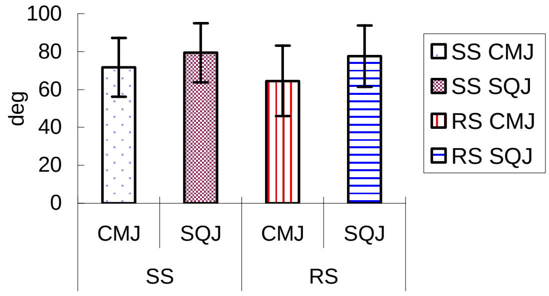

Fig. 2 Comparisons of hip angle among SS-CMJ, SS-SQJ, RS-CMJ, and RS-SQJ (*<.05)

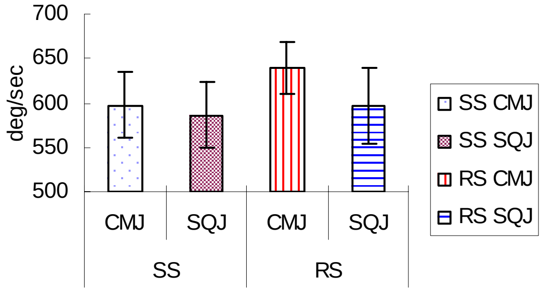

Fig. 3 Comparisons of knee extension angular velocity among SS-CMJ, SS-SQJ, RS-CMJ, and RS-SQJ (*<.05)

The mean and standard deviations of minimum angle of hip during push off phase were SS-CMJ 71.7±15.5 deg, SS-SQJ 79.4±15.6 deg, RS-CMJ 64.5±18.6 deg, SS-SQJ 77.7±16.2 deg (Fig. 2). Significant difference was found between RS-CMJ and RS-SQJ (*<.05). Considering a previous simulation study, hip angle in vertical jump influences knee joint power and torque (Toriumi 2000). No significant difference between SS-CMJ and SS-SQJ was found. It is suggested that SS made subjects instable and unable to use hip joint in CMJ. Hip angle has much effect on maximum angular velocity of knee extension. The mean and standard deviations of knee extension angular velocity during push off phase were SS-CMJ 597.3±37.1 deg/sec, SS-SQJ 586.2± 37.2 deg/sec, RS-CMJ 639.7x 28.6 deg/sec, SS-SQJ 596.7± 43.5 deg/sec (Fig. 3). Significant differences were found in SS-CMJ vs. RS-CMJ, SS-SQJ vs. RS-SQJ, and RS-CMJ vs. RS-SQJ (*<.05). SS-CMJ was slower than RS-CMJ by 40 deg/sec approximately. This change might indicate fatigue of the knees. It can be surmised that expansion of a hip joint during push off phase compensates a reduction of knee angular velocity. vGRF is one of the most important parameters to evaluate jump performance. High jump performances need larger vGRF. In this study no significant differences were found in vGRF among all conditions (SS-CMJ: 1323.8±224.2N, SS-SQJ:

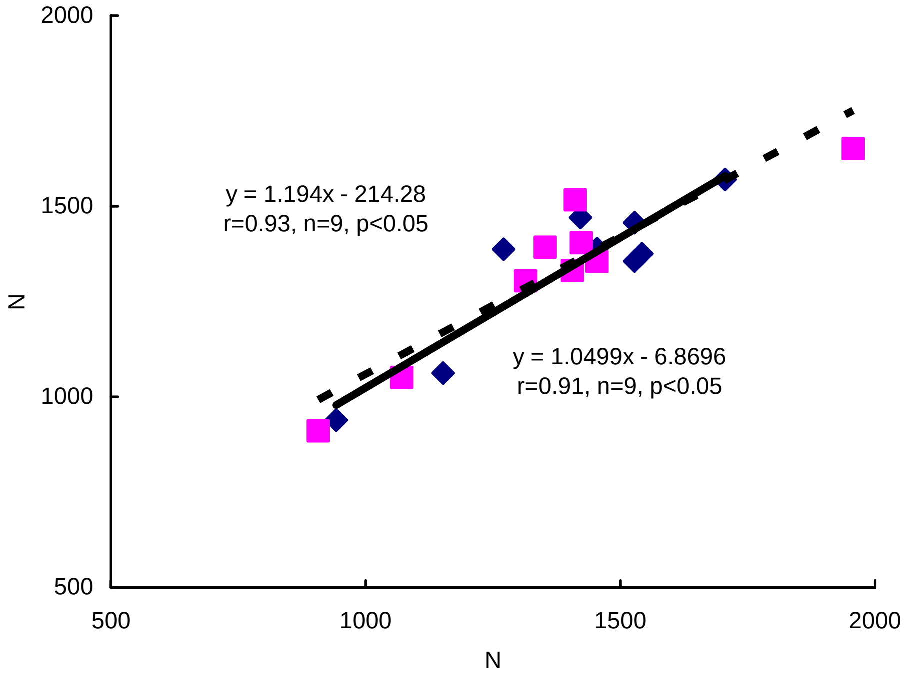

Fig. 4 Relationships of vGRF among SS-CMJ, SS-SQJ, RS-CMJ, and RS-SQJ for 9 subjects.

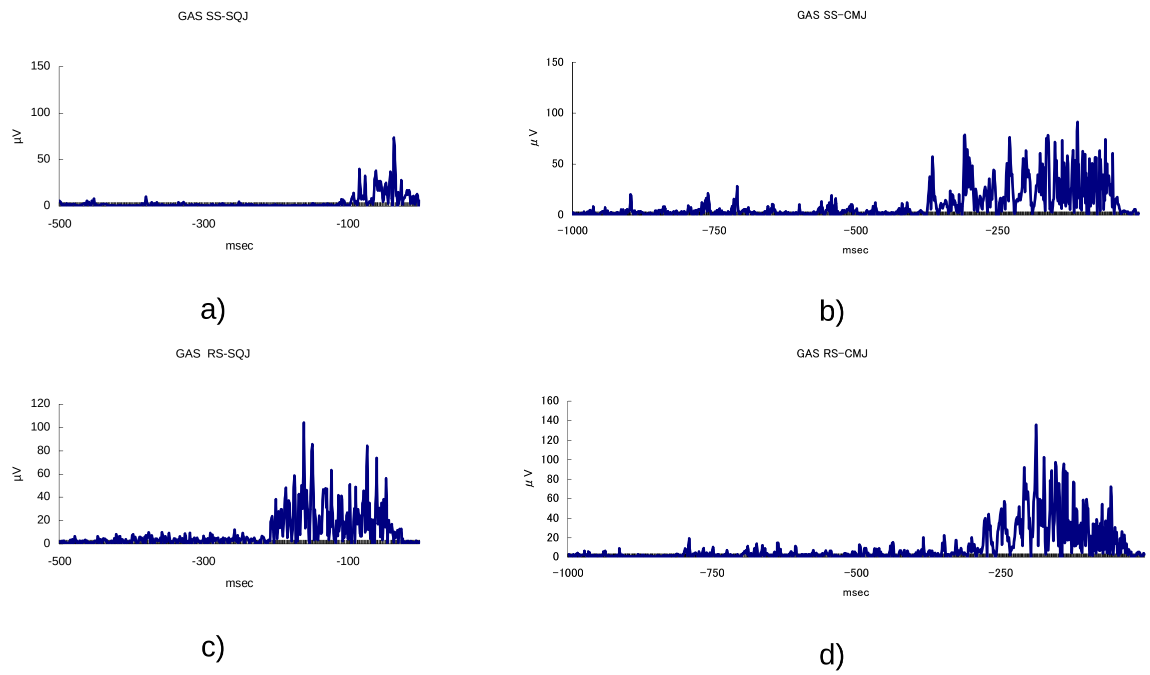

Fig.5 EMG activity of lateral head of gastrocnemius muscle during SS-SQJ(a), SS-CMJ(b), RS-SQJ(c), and RS-CMJ(d).

1336.4±288.3N / RS-CMJ: 1334.1±202.5N, RS-SQJ: 1393.7±233.8) but several kinematic changes were found during push off phase. Figure 4 shows relationships of vGRF among SS-CMJ, SS-SQJ, RS-CMJ, and RS-SQJ. It can be seen that the correlation co-efficients between the vGRF value of CMJ and SQJ were high (SS r=0.93, RS r=0.91, p<.001). Considering surface EMG (Fig. 5), SS-SQJ and SS-CMJ reached smaller values than RS-SQJ and RS-CMJ. Different surface conditions caused kinetic changes in lower extremity in jump performances.

CONCLUSION: Kinematical significant differences and kinetic change were found between SS and RS. Considering from the results, ankle extension and hip flexion at start posture were influenced from jump surface, making vGRF larger. Decrease in knee angular velocity means vGRF became smaller. In conclusion, instability of jump surface makes one change in the jumping motion. As for the block jump in beach volleyball game held on unstable ground such as sand surface, SQJ is superior to CMJ because of short time to take off but about same jump height.

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