ANALYSIS OF THE TRAJECTORY OF CENTER OF MASS ON DIFFERENT SQUAT POSTURES AND LOADINGS

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INTRODUCTION: Weight lifting is usually used for lower extremity training, however, it might cause muscle or joint injury due to wrong posture. The center of mass (COM) could be measured as a parameter to monitor human movement. The purpose of the current study was to investigate the trajectory of COM at different postures and loadings of barbell squats weight lifting. We hypothesized that loading on the knee joint and trajectory changes of COM during 1/3 squat were smaller than 1/2 squat.

METHOD: Twelve females participated in this study. The mean age, weight, and height of the participants were 20.08±1.18 yrs, 57.92±4.87 kg, and 163.42±3.73 cm, respectively. A motion capture system with 10 cameras (MX 13^{+}, VICON, UK) was used to monitor and record the trajectories of the reflective markers on the special anatomical positions of the whole body at the sampling speed of 250 Hz. The subject was asked to perform 1/2 (knee flexion 90˚) and 1/3 (knee flexion 60˚) barbell squats with different loadings of 0%, 25%, 50% and 75% 1RM weighting in random order. The COM during squat was calculated by the movements of the segments defined by the reflective makers using Dempster's method. Two-way ANOVA with repeated measures and LSD post hoc were used for statistics. The significant level was set as $p < .05$.

RESULTS: The maximum knee joint flexion during 1/3 and 1/2 squats were around 80˚ and 100˚, separately (Table 1). The results showed that the flexion angle during 1/3 squat was smaller than that during 1/2 squat (*p<.05*). The trajectories and the displacements of COM during 1/2 and 1/3 squats at different loadings were showed on Figure 1 and Table 2, separately. The displacement of COM during 1/3 squat was smaller than that during 1/2 squat (*p<.05*).

Table 1. Maximum Knee joint angle (Mean±SD in degree) during 1/3 and 1/2 squats with different loadings.

	0 %1RM	25%1RM	50%1RM	75%1RM
1/3 Squat*	73.81±11.33	80.20±11.45	79.99±11.09	81.14±13.78
1/2 Squat	100.06±11.87	100.41±12.97	99.89±10.50	96.35±12.15

* *p<.05*

Table 2. Displacements (Mean±SD in %BH) of the COM during 1/3 and 1/2 squats with different loadings.

	0 %1RM	25%1RM	50%1RM	75%1RM
1/3 Squat*	10.20±1.44	11.60±1.83	11.50±1.23	11.60±1.65
1/2 Squat	19.39±6.91	17.37±2.49	16.99±2.57	16.05±2.40

* *p<.05*

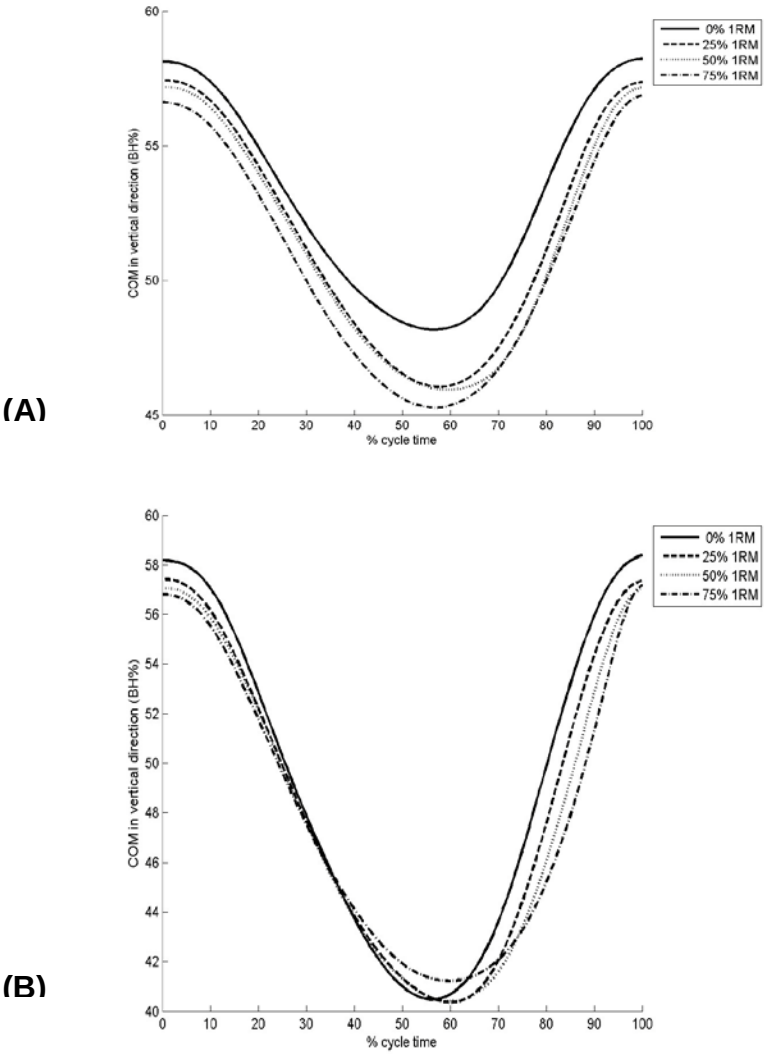

Figure 1. The trajectories of COM during 1/3 (A) and 1/2 (B) squats with different loadings.

DISCUSSION: Lower loading on the knee joint and smaller displacement of the COM were noted during 1/3 squat in the current study. It indicated that the knee joint was less flexion and bore small moment and force. The more knee flexion angle, the greater knee joint loading (Scott, 1991). It might induce the knee injury if the joint was over loading. Therefore, free weight squats should be performed at less flexion angle to lower the joint loading of force and moment. To understand the muscle activity and joint power during squat, the joint moments and electromyography should be monitored and calculated in the future.

CONCLUSION: The results indicated that the maximum knee flexion angle of 1/3 and 1/2 squats were around 80˚ and 100˚, separately. The 1/3 free weight squat was suitable for lower extremity training because it had a knee flexion angle less than 90˚ and less displacement of the COM.

REFERENCES:

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