Kinetic Characteristics of the Orientation and Rear Legs in Volleyball Spike Jump

Mizuki Makino[1], Takanori Nakahara[2], Kentaro Nagakubo[2], Yuka Ando[3], Kenji Tauchi[2]
[1]Department of Sport Science and Research, Japan Institute of Sports Sciences, Tokyo, Japan
[2]School of Health and Sport Sciences, Chukyo University, Aichi, Japan
[3]Graduate School of Health and Sport Sciences, Chukyo University, Aichi, Japan
Email: m.mzk1011@gmail.com

Summary

In volleyball, spike jump (SPJ) involves asymmetric movements between the orientation (OL) and rear legs (RL). However, the kinetic characteristics of each leg have not been elucidated. We investigated the kinetic characteristics of the OL and RL in SPJ. Eighteen female volleyball players performed the SPJ. Data were collected using eight cameras and two force plates. Peak power was used to compare the OL and RL, and to test the relationship with horizontal and vertical impulses. We found that the peak positive power was higher in OL than in RL. At the ankle joint of OL, the relationship between positive peak power and vertical impulse, and the relationship between negative peak power and horizontal impulse were both significant.

Introduction

In SPJ, training that considers the differences in mechanical function between the OL and RL effectively improves jump height [1]. To achieve higher jump height, both the deceleration of horizontal center-of-mass (CoM) velocity and acceleration of vertical CoM velocity are crucial [2]. We investigated the joint power exerted by the OL and RL from two aspects: 1) the difference between both legs and 2) the relationship with the horizontal and vertical impulses of the corresponding leg.

Methods

Eighteen collegiate female volleyball players participated (age: 19.7±0.7yrs, height; 1.69±0.08m, weight: 66.2±7.0kg). Participants performed the SPJ with run-up. Data were collected using eight high-speed cameras and two force plates at 250Hz and 1000Hz, respectively. A skeletal model of the participant was constructed using an AI system. The joint torque power and horizontal and vertical impulses in the OL and RL were calculated. Differences in the peak positive and negative power between OL and RL were checked using paired t-test or Wilcoxon signed-rank test. Relationship between the peak positive power and vertical impulse of the corresponding leg, and the peak negative power and horizontal impulse of the corresponding leg were checked using Pearson's or Spearman's correlation coefficient.

Results and Discussion

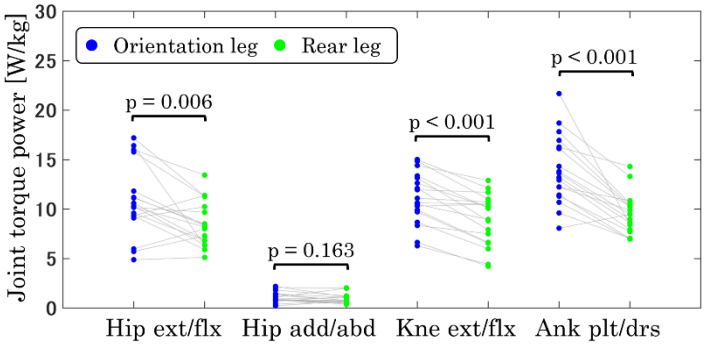

Figure 1: Differences in peak power between both legs

One of the main findings of this study was that the peak positive power of the hip, knee, and ankle joints of the OL was higher than those of the RL. This result indicates that the positive power demands of OL is higher than those of the RL. In addition, in OL, the vertical impulse was related to the peak positive power of knee extension and ankle plantar flexion, while the horizontal impulse was related to the peak negative power of hip abduction and ankle plantar flexion. Based on these results, the CoM horizontal velocity deceleration and CoM vertical velocity acceleration are associated with different joint power. However, the ankle joint of OL alone is associated with both a deceleration of CoM horizontal velocity and an acceleration of CoM vertical velocity.

Conclusions

We found that peak positive power was higher in the OL than in the RL. In particular, the positive and negative power of the ankle joint of OL significantly correlated with vertical and horizontal impulses of the corresponding leg, respectively.

References

[1] Fuchs PX. et al. (2020). *Int J Sports Physiol Perform*, *15*(7): 1019-1025.
[2] Ikeda Y. et al. (2018). *J Strength Cond Res*, *32*(1): 267-273.

Table 1: Correlation coefficient between the peak positive power and vertical impulse of the corresponding leg, and the peak negative power and horizontal impulse of the corresponding leg in the orientation (blue) and rear (green) legs

	Orientation leg				Rear leg			
	Hip ext/flx	Hip add/abd	Kne ext/flx	Ank plt/drs	Hip ext/flx	Hip add/abd	Kne ext/flx	Ank plt/drs
Positive	0.230	−0.265	0.662**	0.498*	0.625***	−0.064	−0.223	0.472*
Negative	0.219	0.732***	−0.188	0.661**	0.591**	0.493*	−0.009	0.300

*: p<0.05, **: p<0.01, ***: p<0.001