KINEMATIC ANALYSIS OF RING-SHAPE LEAP AFTER STEPPED UP THE LEGS AND BACKWARD BALANCE IN ARTISTIC GYMNASTICS

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Through three-dimensional video analysis and comparative analysis, a study on two artistic gymnastics skills has been done. Results revealed the kinematic characteristics of these two movements. The findings provided useful reference information to coaches for improving the efficiency of scientific training.

KEYWORDS: artistic gymnastics; body movement difficulty; kinematics analysis.

INTRODUCTION: The degree of difficulty of body movement is a basic feature of artistic gymnastics and an important criterion for the technical level of the athletes. The quantity of body movements, the level of difficulty, and the types of body movement difficulties chosen are the important factors which decide the technical value of movement arrangement (Cao & Yang, 2005). There have been some studies on training and movement arrangement of artistic gymnastics (Guo, 2000; Li, 2003; Zheng, 2004). However kinematic analysis of artistic gymnastic movements has not been reported. In this study we performed a three-dimensional video analysis for two body movements with high degree of difficulties.

METHODS: Two elite teenager artistic gymnasts performed two body movements with high degree of difficulties (ring-shape leap after stepped up the legs and backward balance) were recorded with two synchronized video cameras (BASLER A6) at 100Hz (Figure 1), two repetitions for each movement. A radial frame with 24 control points was used to calibrate the space. Nineteen body marks (top of head, neck, both shoulders, elbows, wrists, fingertips, hips, knees, ankles, toes and the midpoint of hips) were manually digitized with video processing software (3D-SignalTEC V1.0c). The raw data were smoothed by a low-pass filter with cutoff-frequency of 6Hz.

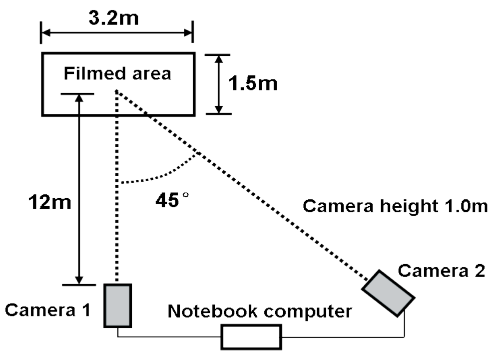

Figure 1: Measurement setup.

RESULTS: Definitions of kinematic variables are shown in Figures 2 to 5. The results are presented in Tables 1 and 2.
The results revealed the main kinematic characteristics of these two movements.

Figure 2: Ring-shape leap after stepped up the legs, in take-off phase.

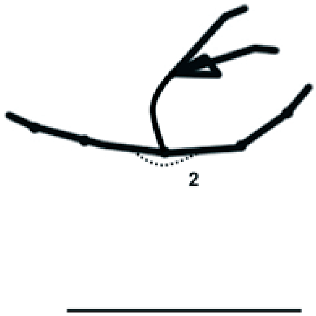

Figure 3: Ring-shape leap after stepped up the legs, in flight phase.

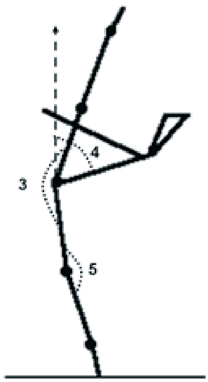

Figure 4: Backward balance.
Notes:
1, 5: knee angle
2, 3: angle of thighs
4: trunk angle

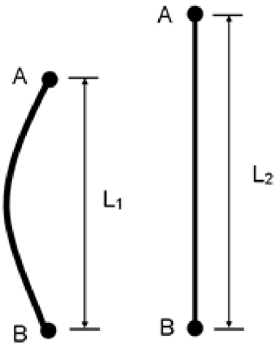

Figure 5: Torso length.

Point A. neck
Point B. the midpoint of hips
L_1: Length of trunk in bending condition
L_2: Length of trunk in normal condition
Trunk bending rate: $K=L_1/L_2$

Table 1
Kinematics data for Ring-shape leap after stepped up the legs

Variables		gymnast A	gymnast B
Angle at the maximum amortization before take off (°)	knees	147.29	149.78
	ankles	110.57	134.21
Swing velocity of hands at take off (m/s)	left	6.25	5.03
	right	21.09	10.36
Swing velocity of toes at take off（m/s）	left	23.2	10.9
	right	17.5	8.5
Max. bending rate (K) of trunk		0.60	0.74
Ankle joint angles at the max. height of flight (°)	left	167.91	163.46
	right	168.30	166.65
Knee joint angles at the max. height of flight（°）	left	173.13	171.06
	right	172.54	169.69
The max. angle between thighs during flight（°）		213.79	197.78
Duration of flight (s)		0.54	0.38

Table 2
Kinematics data for Backward balance

Variables		gymnast A	gymnast B
Average ankle angle during balance (°) (supported by left leg)	left	172.67±2.60	151.58±8.48
	right	173.54±3.03	165.69±4.95
Average knee angle during balance (°) (supported by left leg)	left	172.65±1.73	5.03
	right	169.38±1.19	10.36
Maximum angle between thighs during balance (°)		213.55	192.02
Maximum trunk angle during balance (°)		87.25	88.72
Balancing time (s)		0.28s	0.18s

DISCUSSION AND CONCLUSION: Ring-shape leap after stepped up the legs: The standard movement of jumping (Code of points for rhythmic gymnastics, 2009) is described as high flight height, graceful posture in the air and the angle of thighs being over 180 degree. Table 1 shows, in the take-off phase, that Gymnast B knees and ankles failed to bend adequately, which was caused by insufficient stretching of leg muscles. In addition, the slow pre-swing of the limbs and incorrect stopping led to insufficient flight height. The whole duration of flight only lasted 0.38 second. On the other hand, Gymnast A's pre-swing speed was comparatively fast and the duration of flight reached 0.54 second.

The angle between thighs for Gymnast B was 197.78°, yet less than Gymnast A's angle which was 213.79°. Meanwhile, the angles of knees and ankles for Gymnast B were comparatively smaller. All above-mentioned figures showed that Gymnast B's movement did not reach the standard.

The maximum bending of trunk showed that Gymnast B's trunk bending range was less than either Gymnast A's or the standard trunk bending range.

Backward balance analysis: The standard movement of balance (Code of points for rhythmic gymnastics, 2009) is described as having the angle of thighs over 180 degree, the posture is graceful, stable and kept for enough time. Table 2 shows that the angles of the knee and ankle joints of Gymnast B's supporting leg were too small, yet the swinging leg kept a comparative good posture, which suggested that Gymnast B need further training on muscular strength of her legs. On the other hand, all the angles of Gymnast A's knees and ankles approached 180°.

During the whole balancing process, the stability of Gymnast B's balancing time (0.18 second) was shorter than Gymnast A's (0.28 second) . Furthermore, the angle between her legs was insufficient and the body failed to keep straight. The data showed that Gymnast B should make an extra effort to increase the strength training, especially on the legs and trunk muscles.

In conclusion, the findings of this study provided useful reference information for coaches to improve the efficiency of scientific training.

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