TECHNIQUE ANALYSIS OF THE BACK TOSS ON THE PARALLEL BARS PERFORMED BY ELITE GYMNASTS

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INTRODUCTION

The back toss (BT), a skill frequently performed by gymnasts on the parallel bars, involves a release-regrasp swing type of motion from one handstand to another. Mastering the skill, a task requiring considerable amount of practice, is beneficial not only for points awarded to gymnasts by the judges for the BT itself, but also for its contribution towards the perfect execution of other parallel bars skills including the most current dismounts. It would be beneficial for gymnasts and coaches to recognize the variables for which judges are looking, as well as technique differences between skillfully and poorly executed BTs. The purpose of this study was, therefore, to: 1) identify the skill variables best correlating with the scores given to the BTs by qualifying judges, and 2) to identify the differences in technique between the most and least skillful BTs.

METHODS

Seventeen BTs, recorded during the 1990 United States Gymnastics Federation Championships with a NAC 400 HSV camera operating at 200 Hz, were analyzed utilizing the Ariel Performance Analysis System (APAS). Two dimensional position data of 4 (for BTs without knee. or elbow joint flexion) to 6 (BTs with elbow and/or knee joint flexion) body points were digitally smoothed with a cut-off frequency of 6 Hz before being submitted to further analysis. Dempster' s (1955) data as presented by Plagenhoef (1971) was utilized to predict the segmental and total body anthropometric parameters necessary to solve the mechanical equations. The analyzed BTs were rated by two internationally qualified judges on a scale from 1 (worst) to 10 (best). To determine the best predictors of a good score, product moment correlations between kinematic variables and the average judges' scores were computed. To examine the differences between kinematic variables of the best (n=8; average score: 8.125) and worst (n=9; average score: 4.444) BTs, paired t tests were used.

RESULTS AND DISCUSSION

Table 1 presents the correlations between computed kinematic variables and the average judges' scores. According to the data and in order of importance, the best predictors of a good BT are: 1) the shoulder joint angle at the time gymnasts re-grasp the bar; 2) the total time that the gymnasts are airborne; 3) the horizontal velocity of the center of mass (CM) at push off; 4) the hip joint angle at push off; 5) the CM maximum height above bars (absolute and normalized); 6) the time from the smallest hip joint angle to zero degrees of shoulder joint angle (that is, until gymnasts pass through a support position); and 7) the smallest hip joint flexion angle.

Table 1 (N=17): Correlations Between Mechanical Variables and Judges' Scores

Variable	Mean	SD	r	P
MAXY (m)	1.068	0.093	0.520	.032
MAXYPER (%)	62.207	5.440	0.532	.028
SJARL (degrees)	68.693	14.977	0.475	.054
THETARL (degrees)	64.677	6.564	0.029	.912
THETARG (degrees)	79.307	5.499	0.205	.431
TTAIR (seconds)	0.407	0.051	0.554	.021
TOSJARL (sec)	0.184	0.031	0.343	.178
TSHJAOSJA (sec)	0.028	0.032	0.432	.083
HJARL (degrees)	196.699	12.197	0.540	.025
I-IJARG (degrees)	210.828	10.173	-0.298	.245
SMHJA (degrees)	131.928	6.447	0.486	.048
EIJROM (degrees)	66.784	9.908	0.321	.208
LHJA (degrees)	219.557	8.551	-0.248	.336
SJARG (degrees)	170.769	29.646	0.739	.001
YVELRL (m/sec)	2.949	0.387	0.352	.166
YVELRG (m/sec)	-0.956	0.516	-0.114	.666
XVELRL (m/sec)	-0.956	0.206	0.550	.022

MAXY:	Center of mass (CM) maximum height above bars.
MAXYPER:	CM maximum height above bars as per cent of height.
SJARL:	Shoulder joint angle at push off.
TIIETARL:	Angle of wrist to CM line (from bars) at push off.
THETARG:	Angle of wrist to CM line (from bars) at re-grasp.
TTAIR:	Time the gymnast is airborn.
TOSJARL:	Time from zero degrees of shoulder joint angle to push off.
TSHJA0SJA:	Time from smallest hip joint angle to zero degrees at shoulder joint.
I-IJARL:	Hip joint angle at push off.
HJARG:	Hip joint angle at re-grasp.
SMHJA:	Smallest hip joint angle.
HJROM:	Hip joint range of motion.
LHJA:	Largest hip joint angle.
SJARG:	Shoulder joint angle at re-grasp.
YVELRL:	CM vertical velocity at release.
YVELRG:	CM vertical velocity ar re-grasp.
XVELRL:	CM horizontal velocity at release.

Table 2 presents the t-test scores between computed kinematic variables of the groups of BTs receiving the highest (mean score = 8.125) and lowest (mean score = 4.444) scores. According to the data, the hip joint angle at push off (hip joint hyperextension) is the most most significant difference between high and low scored BTs. Additional significant or substantial factors differentiating high and low scored BTs are: 1) the shoulder joint angle at the time gymnasts re-grasp the bar (should be more than 180 degrees): 2) the time from the smallest hip joint angle to zero degrees of shoulder joint angle (gymnasts should begin hip joint piking early on in the downward

swing); 3) the horizontal velocity of the CM at push off (gymnasts should move in a forward direction at push off instead of moving backwards); 4) the time from zero degrees of shoulder joint angle to the instant of push off (gymnasts should wait as much as possible before they push off); 5) the shoulder joint angle at push off (gymnasts should hyperextend); and 6) the hip joint range of motion (should be of considerable magnitude).

Table 2 Comparison Between Mechanical Variables (M and SD) of High (N=8) and Low (N=9) Scored Back Tosses.

Variable	High Score		Low Score		t	P
MAXY (m)	1.106	0.070	1.034	0.102	1.372	.212
MAXYPER (%)	64.170	3.335	60.462	6.495	1.53	.172
SJARL (degrees) +	-74.683	9.845	-63.368	17.205	2.172	.066
THETARL (degrees)	63.603	4.068	65.632	8.337	-0.279	.788
THETARG (degrees)	80.723	6.262	78.047	4.731	1.714	.130
TTAIR (sec)	0.429	0.022	0.388	0.063	1.491	.180
TOSJARL (sec)	0.194	0.028	0.174	0.033	2.236	.060
TSHJAOSJA (sec)	0.042	0.033	0.016	0.026	2.384	.040
HJARL (degrees)	201.585	5.244	192.355	15.112	2.713	.030
HJARG (degrees)	206.533	9.289	214.645	9.830	-2.075	.077
SMHJA (degrees)	134.298	4.272	129.821	7.520	1.164	.283
HJROM (degrees)	69.092	6.413	64.732	12.260	2.090	.075
LHJA (degrees)	217.047	7.456	221.788	9.258	-1.324	.227
SJARG (degrees)	188.769	8.812	154.768	32.829	2.670	.032
WELRL (m/sec)	3.053	0.253	2.858	0.473	0.754	.475
WELRG (m/sec)	-0.960	0.186	-0.952	0.235	-0.283	.785
XVELRL (m/sec) *	0.285	0.343	-0.259	0.502	2.264	.058

+ Shoulder joint hyperextension
* - Indicates velocity opposite to the direction of motion

CONCLUSION

The results indicate that the best predictor of a good BT is the shoulder joint angle at the time gymnasts re-grasp the bar. Additionally, the total time the gymnasts are airborne, the horizontal velocity of the CM at push off, the hip joint angle at push off, the CM maximum height above bars, the time from the smallest hip joint angle to zero degrees of shoulder joint angle, and the smallest hip joint angle are also good predictors of a good BT. The hip joint angle at push off, the shoulder joint angle at the time gymnasts re-grasp the bar, the time from the smallest hip joint angle to zero degrees of shoulder joint angle, and the horizontal velocity of the CM at push off are the most significant factors differentiating high and low scored BTs. Additional discriminating factors differentiating the best and worst BTs are the time from zero degrees of shoulder joint angle to push off, the shoulder joint hyperextension at push off and the hip joint range of motion.

REFERENCES

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