A COMARATIVE ANALYSIS OF THE TRIPLE BACKWARD SOMERSAULT AND THE DOUBLE BACKWARD SOMERSAULT ON THE MGH BAR

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INTRODUCTION

The high bar is one of the most spectacular events of the men' s gymnastics competition. Gymnasts, in order to win, are expected to perform difficult and flawless routines culminating in a dismount. The dismount, as the skill last seen by the judges, greatly influences the scores awarded. The triple backward somersault in tuck position (TBS) and the double backward somersault in layout position (DBS) are among the highest level dismounts performed today.

Although similarities and differences between the mechanics of the TBS and the DBS dismounts would be expected, they cannot conclusively be accepted until relative data are compared. It would be beneficial for gymnasts and coaches to recognize the differences and the similarities between TBS and DBS for teaching and performing both skills perfectly. The purpose of this study, therefore, was to investigate the similarities and differences between mechanical variables of the two skills.

METHODS

Five TBS and five DBS recorded during the 1990 United States Gymnastics Federation Championships with a NAC 400 HSV camera operating at 200 Hz, were analyzed utilizing an Ariel Performance Analysis System (APAS). Two dimensional position data of 6 body points (ankle, knee, hip, shoulder, elbow, and hand) were digitally smoothed with a

cut-off frequency of 7 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. Kinematic and kinetic data were compared via paired t-tests. When appropriate, kinematic and kinetic data were normalized by height and weight.

RESULTS AND DISCUSSION

Table 1 shows kinematic results for the center of mass (CM) and temporal results. It is shown that CM position at release was similar between the two skills. The CM in one trial of TBS was above the bar though Kerwin, Yeadon & Harwood (1993) reported that, in somersault dismounts, the CM should be released below it. The release velocity of CM in DBS in this study was similar to that of double salto backward dismount reported by Takei, Nohara & Kamimura (1992). Resultant and vertical release velocities for TBS was greater than the one for DBS, while the DBS horizontal velocity was greater than in TBS. These (velocity) results could be attributed to possible differences in the beat action through the bottom of the swing (Gervais & Talley, 1993) which increases the speed of the dismount giant swing (Cheetham, 1984), as well as differences in CM release angle. Release velocity and release angle differences can, in turn, explain the greater height but less horizontal distance that the CM traveled in TBS as compared to DBS.

Total flight time of DBS and TBS were 1.200 and 1.394 seconds. The longer flight time of TBS was due to larger release velocity and CM release angle.

Table 1 Displacement and Velocity of the Center of Mass, Release and Landing Angles and Flight Time

Parameter	TBS M	TBS (SD)	DBS M	DBS (SD)	t	P
Dis R X (% of height)	40.60	(1.933)	42.20	(1.823)	0.985	0.380
Dis R Y (% of height)	- 6.50	(7.587)	-11.56	(8.683)	-1.220	0.289
Dis R R (% of height)	41.18	(3.672)	43.38	(2.359)	-1..401	0.234
Vel R X (m/sec)	0.84	(0.217)	1.29	(0.160)	-3.999	0.016
Vel R Y (m/sec)	5.98	(0.520)	4.89	(0.401)	4.790	0.009
Vel R R (m/sec)	6.04	(0.531)	5.06	(0.356)	4.417	0.012
Rel Ag (deg)	83.36	(8.079)	75.42	(11.041)	1.738	0.051
Max Ht (deg)	92.66	(16.281)	51.84	(18.521)	4.557	0.010
Ho Dis (% of height)	74.06	(9.589)	117.30	(18.897)	-3.983	0.016
Land Ht (% of height)	45.08	(5.179)	44.22	(4.940)	0.207	0.846
Land Ag (deg)	90.06	(3.805)	91.78	(5.443)	-0.440	0.683
Ft Time (sec) .	1.394	(0.064)	1.200	(0.094)	4.802	0.009

Note
Dis R X,Y,R = horizontal, vertical and resultant displacement of the CM at release (from bar) (+ means above bar)
Vel R X,Y,R =horizontal, vertical and resultant velocity of the CM at release
Rel Ag = release angle (tan-1 Dis R X/Dis R Y).
Max Ht = maximum height above bar.
Ho Dis = horizontal distance that the CM moved from bar
Land Ht= landing height of CM above floor.
Land Ag = landing angle (angle of CM to feet line with the right horizontal axis-with the floor).
Ft Time= flight time

Table 2 presents angular velocity of the trunk, angular momentum of total body in flight and percent rotation of the trunk from the moment of release to the peak of the flight.

As the data in Table 2 shows, though there were no significant differences in angular momentum of the total body between TBS and DBS, there were significant differences in all measures of angular velocity of the trunk between the two skills. The maximum trunk angular velocity of TBS in particular, was as high as 1.7 times the trunk angular velocity of the DBS. Trunk angular velocity differences, however, were offset by differences in moment of inertia which was greater in DBS as compared to TBS.

The percent of trunk rotation from release to the peak of the flight to total somersault angular rotation was 42.60% in TBS and 39.02% in DBS, which may be explained by the proportionally longer duration of the portion of TBS from release to the peak of the flight (47.3% and 34.2% for **TBS** and DBS, respectively).

Table 2. Angular Velocity of Trunk and Angular Momentum of the Body

Parameter	TBS M	TBS (SD)	DBS M	DBS (SD)	t	p
Ang Mo **(kg.m2/s)**	0.393	(0.095)	0.308	(0.045)	1.827	0.142
A **Vel** R **(deg/sec)**	365.20	**(126.27)**	**584.00**	(79.970)	-2.714	0.050
A A Vel **(deg/sec)**	695.00	**(28.531)**	**483.40**	(47,730)	7.770	0.001
M A Vel (deglsec)	1565.60	(81.670)	953.20	(69.080)	8.131	0,001
% ROT TRUNK	42.60	(1.411)	39.02	(1.886)	4.728	0.009

Note
Ang Mo = angular momentum (= absolute **value/(mass*height2)**
A **Vel** R = CM angular velocity at release **(= v/r)**
A A Vel = average angular velocity
A **Vel=** maximum angular velocity
% ROT TRUNK= percent of trunk rotation when CM was at the peak of its flight

CONCLUSIONS

Based on the result of this study it was concluded that:

1) There were no significant differences between TBS and DBS in CM displacement at release, in CM height and angle at landing, and in total body angular momentum in flight.
2) Both resultant and vertical release velocity of the CM were greater in TBS, while the horizontal release velocity in TBS was smaller than that of DBS.
3) The trunk angular velocity at release and average angular velocity of TBS were higher than those of DBS. The maximum angular velocity of TBS was as high as 1.7 times of DBS.
4) The total flight time of TBS was longer than that of DBS.
5) Both the CM release angle and CM maximum height were larger in TBS than in DBS, but the horizontal distance of DBS was larger than the one of TBS.
6) The percent of trunk rotation from release to the peak of the flight to total somersault angular rotation, was larger in TBS.

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