Fadiah Hirza Mohammad Ariff. Joint angle production during squash forehand and backhand stroke. (215)

TECHNIQUE VARIABILITY OF PERFORMANCE ON ROTATIONAL AERIAL SKILLS IN GYMNASTICS

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Elite performance is typically associated with a low level of technique variability over repeated performances. The purpose of this study was to test the variability of technique performance of an elite level gymnast performing two fundamental skills on the balance beam, salto backward, tucked (SBT) and front aerial walkover (FAW). Results showed that the gymnast was capable of performing both skills with consistency and minimal variability. Before one extrapolates this observation to all skilled performers and performances, a larger sample of athletes and skills should be tested.

KEY WORDS: balance beam, salto backward, free aerial walkover.

INTRODUCTION: Elite performance is typically associated with a low level of technique variability over repeated performances (Müller & Sternad, 2009). In gymnastics in general, and on the balance beam in particular, where due to the constrains of the aparatus (beam width, 10 cm), the margin of error is minimal, the subject of technique variability may be of paramount importance. It was the purpose of this study to examine technique variability of performance of an elite level gymnast performing two fundamental skills on the balance beam, salto backward, tucked (SBT) and free aerial walkover (FAW).

METHODS: An internationally ranked gymnast (26 years, 1.53 m, 45kg) performed a series of SBT and FWF with adequate rest between them to eliminate fatigue as a factor affecting technical execution. The performances were videotaped with a 60 Hz camera. Eight SBT and 7 FWF were analyzed utilizing the Ariel Performance Analysis System (APAS). For the SBT, the left and right feet, ankles, knees and hips, and the left shoulder, elbow and wrist joints were digitized. For the FAW, which exhibits marked trunk hyperextension when compared to SBT, and is performed with minimal elbow joint motion, the base of the left rib-cage was also digitized whereas the elbow joint wasn't. For the SBT, temporal and kinematic data commencing with take off (TO) and ending with the landing (LA) were examined and compared. For the FAW, data analysis begun with the contact of the right foot (take off foot for this athlete) with the apparatus and ended with the first contact of the landing foot (the left for this athlete). CM flight height (% of height) were determined from the CM TO vertical velocity. The raw data was 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. For each skill, Friedman's repeated measures ANOVA (SYSTAT, Inc.) was used to examine performance technique variability among the skill's trials.

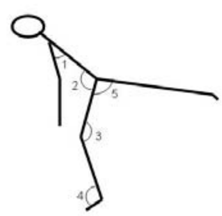

Figure 1. Definition of joint (1-4) and inter-thigh (5)

RESULTS AND DISCUSSION: Table 1 presents mean values and standard deviations for selective variables at selective positions of the FAW. The statistical analysis revealed no significant differences among the 7 trials for all the variables (p =0.909). Flight time included the time span from the frame when the CM positive velocity decreased during ascent to the frame in descent when the negative vertical velocity decreased. It should be noted, however, that the definition of TO/LA was limited to the (low) video sampling rate (60 Hz). Total time included flight time plus push-off time. TO/LA CM angles were the angles between the right horizontal axis and the line connecting the CM with the TO (right) and LA (left) feet, respectively. Figure 1 defines joint and inter-thigh angles. Average angular velocity of the arms included the time span of forceful shoulder joint extension from the first contact of the TO (right) foot with the apparatus until TO. It should be noted that although the technique of this athlete included shoulder joint motion out of the sagittal plane (abduction), that motion occurred after TO.

Table 1
Temporal and Kinematic Data for the FAW°

Variable	T3	T4	T5	T6	T7	T8	T9	Mean	SD
Total time (s)	0.65	0.667	0.683	0.683	0.683	0.667	0.683	0.67	0.01
Flight Time (s)	0.33	0.333	0.333	0.367	0.35	0.317	0.333	0.337	0.02
TO CM vel. (m/s)	2.066	2.03	1.9 82	2.089	1.949	1.983	2.101	2.028	0.06
TO CM angle (°)	74	72	73	67	67	78	71	71.7	3.90
LA CM angle (°)	79	77	79	80	80	76	77	78.3	1.60
Flight CM height (%)	7.8	8.2	12	8.5	6.8	7.8	8.9	8.5	1.65
TO ankle j. angle (°)	174	142	173	138	178	179	139	160	19.57
LA ankle j. angle (°)	117	126	124	111	126	129	132	124	7.23
TO knee j. angle (°)	183	183	176	179	181	181	183	181	2.61
LA knee j. angle (°)	154	161	158	163	157	159	160	159	2.91
TO inter-thigh angle (°)	155	144	143	139	140	150	141	145	5.86
LA inter-thigh angle (°)	116	121	116	106	115	120	121	116	5.26
TO shoulder j. angle (°)	50	55	54	58	57	50	54	54	3.11
LA shoulder j. angle (°	-142	-139	-135	-137	-136	-133	-141	-138	3.26
Ave. ang. vel. arms (°/s)	687	679	683	681	683	683	679	682	2.79
Trailing leg. LA. angle (°)	71	74	80	77	77	75	86	77	4.81

Note: Negative (shoulder j.) angles denote hyperextension. *Trailing leg. LA. angle* refers to the angle of the non-landing leg (left for this athlete) with a line parallel to the apparatus at landing.

Table 2 present results for SBT. As with the FAW, the statistical analysis revealed no significant differences among the 7 trials for all the variables (p=0.092). For the SBT, where the athlete takes off/lands from both feet—with the one in front of the other to accomadate the small width of the apparatus—TO/LA CM angles were defined as the angles between the right horizontal axis (beam) and the line connecting the CM with the middle point between the feet. In addition to the (non significant technique variability) results shown in Tables 1 and 2, Figure 2 presents samples of joint angle motion where one can observe remarkable consistency of performance for this athlete. This consistency of performance (repeatability) was observed not only on the 2 joints presented in Figure 2, but across the motion of all other joints and all measurements.

Table 2
Temporal and Kinematic Data for the SBT

Variable	T3	T4	T5	T6	T7	T8	T9	T10	Mean	SD
Flight Time (s)	0.517	0.483	0.5	0.5	0.483	0.5	0.467	0.483	0.492	0.015

TO CM velocity (m/s)	2.474	2.249	2.499	2.487	2.515	2.519	2.457	2.583	2.48	0.092
TO CM angle (°)	80	81	82	89	81	80	80	81	81.6	2.82
LA CM angle (°)	100	103	97	90	101	100	111	99	100.	5.48
Flight CM height (%)	20.4	20.3	20.8	20.7	21.1	21.2	20.1	22.2	20.9	0.009
TO ankle j. angle (°)	150	167	165	159	170	163	165	168	163	0.62
LA ankle j. angle (°)	109	110	107	114	116	116	116	114	113	5.94
TO knee j. angle (°)	137	130	132	139	132	133	132	130	133	3.35
LA knee j. angle (°)	159	165	164	161	164	161	149	158	160	3.02
TO hip j. angle (°)	181	186	186	186	190	185	187	189	186	4.8
LA hip j. angle (°)	84	88	84	86	85	85	77	82	84	2.54
TO shld. j. angle (°)	127	111	112	124	111	117	110	110	115	3.06
LA shld. j. angle (°)	10	16	12	16	15	15	14	11	14	6.32

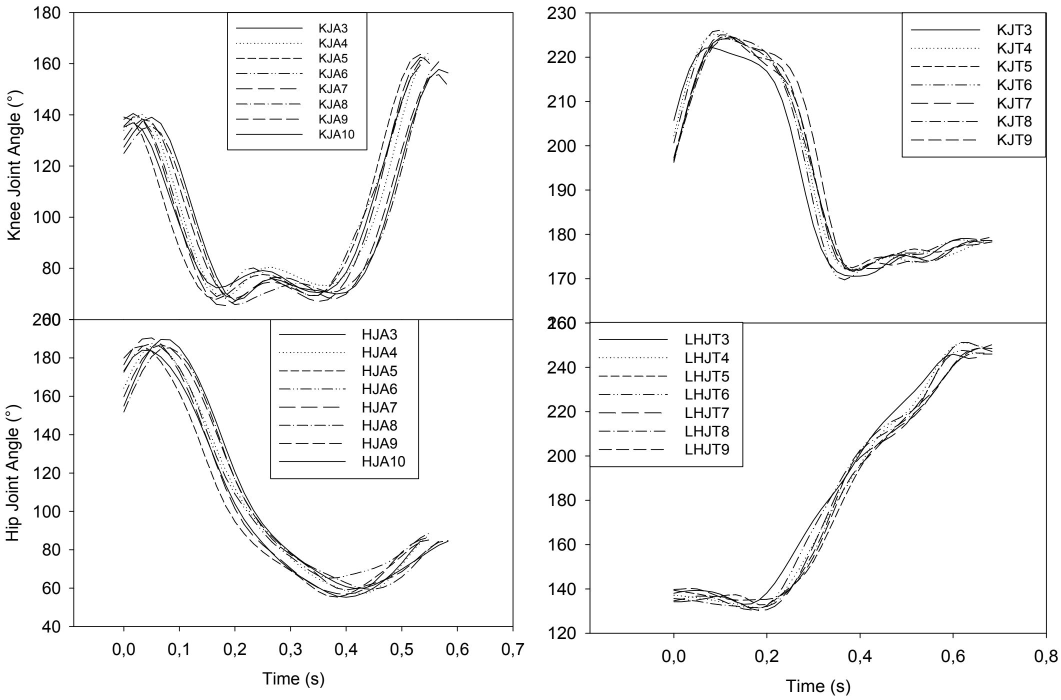

Figure 2. Knee (top) and hip (bottom joint angles (°) for SBT (left) and FAW (right)

CONCLUSION: Results showed that, on the balance beam, a highly skilled athlete is capable of performing with consistency and minimal technique variability both, forward and backward rotation skills. Before we can extrapolate this observation to all skilled performers and performances, a larger sample of athletes and skills should be tested.

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