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Studying the Distinctive Biomechanical Indicators for Comparative Three Levels ofPerformance of Salto Backward Biked on Balance Beam

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The current research aims at identifying the distinctive indicators of the comparative biomechanical efficiency for the Salto backward biked on balance beam during three levels of performance. The researcher used the experimental approach (one-group deign) through follow-up measurements. Sample (3 junior female gymnastics performers – 11- 12 old year phase) was purposefully chosen from the Military Institution Sports Club in Alexandria – Egypt. They were all beginners in learning the Salto backward biked skills. The researchers concluded the following distinctive biomechanical indicators to differentiated among the three three levels of performance (preliminary conformity – good conformity – master): Maximum fade out distinctive indicators are upper arm- forearm angle, horizontal acceleration, horizontal strength and resultant strength. Feet-off the beam distinctive indicators are foot-leg angle and resultant momentum. Flight and circling distinctive indicators are upper arm-trunk angle, thigh-leg angle, horizontal acceleration and resultant momentum. Feet-touching-the beam distinctive indicators are foot-leg angle and horizontal momentum. Stability and balance distinctive indicators are thigh-trunk angle, vertical momentum and resultant acceleration. Researchers also concluded the duration of performance for final phase and a predictive equations indicating the performance level of the Salto backward biked on the balance beam during three levels of performance

***Key words:** biomechanical efficiency – distinctive indicators three levels ofperformance – Salto backward biked – gymnastics.*

Introduction:

Sports movements are studied and evaluated through three basic aspects: biomechanical, physiological and psychological. The biomechanical aspect is one of the most important aspects as it is widely used in most research and scientific references (1).

Biomechanical study of sports movements is an objective means of evaluating improving and modifying technical performance as it uses objective means of evaluation. As a field of science, biomechanics aims at understanding technical performance using various scientificsystems and procedures to improve and develop it, along with directing the learning and training processes to achieve elite performance levels(2).

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If we can identify one of kinematics or kinetic characteristics that its improvement is closely related to a similar improvement in technical performance of athletes, from the beginners level to elite performers, this characteristic is called a distinctive indicator. Distinctive indicators of the technical performance efficiency are those indicators distinguishing the improvements in mastering the technical performance of several levels of athletes. Thus, these indicators vary in value depending on the improvements in mastering the technical performance as they appear in distinctive values in the performance of various athletic levels (3).

Performance on the balance beam is characterized with speed and dynamism, increasing the importance of performing in a continuous and flow manner, along with a higher degree of stability. Any trembling or wrong landing may lead to deducting difficulty elements and subtracting tenth of points. This type of performance is characterized with being dangerous and very difficult in initiating and flowing the movement, in addition to the possibility of falling off the beam. In short, it represents a hard challenge to the performer (4, 5, 6).

Performing the motor statement on the balance beam should include five acrobatic elements, with or without hand support, and a flight phase. It is also required to perform forward, backward and sideward acrobatic elements along with aero-circles in all its three forms (straight – curved – crouched) as this provides a specific significance for shape and direction. The backward curved aero-circle (Salto backward biked) on the balance beam has a difficulty value of (c) class according to difficulty table. This movement is really important as it is performed either individually or in connection to other preceding or succeeding skills to provide the performer with the linking value (7, 8).

Through monitoring motor statements of performers, it was noted that most performers do not succeed in achieving, mastering or being stable on the balance beam. The researchers think that this is due to the lack of sufficient information during learning and training.

Sports skills, performances and actions all pass through specific phases (preliminary conformity – good conformity – mastering). Each one of these phases has its distinctive characteristics. Changes happening to the performer through motor learning phases are used as indicators to identify the differences among these phases (9, 10). This led the researchers to study these distinctive indicators to identify objective standards and measurements for performance improvement through three levels of performance.These standards and measurements are useful in improving the learning and training processes un gymnastics to achieve the desired athletic levels.

Aims:

The current research aims at identifying the distinctive indicators of the comparative biomechanical for the Salto backward biked on balance beam three levels of performance through:

1- Identifying the most important biomechanical indicators for the Salto backward biked on balance beam.

2- Designing a educational – training program for the Salto backward biked on balance beam to get junior female gymnastic performers to the mastery phase.

3- Identifying the distinctive indicators of the comparative biomechanical for the Salto backward biked on balance beam three levels of performance .

Hypotheses:

The researchers hypothesized that:

1. There is some variance in the biomechanical indicators for the Salto backward biked on balance beam.
2. The recommended educational – training program has positive effects on improving the distinctive indicators of the comparative biomechanical for the Salto backward biked on balance beam during three levels of performance **Methods:**

Approach:

The researcher used the experimental approach (one-group deign) through follow-up measurements.

Sample:

Sample (3 junior female gymnastics performers – 11- 12 old year) was purposefully chosen from the Military Institution Sports Club in Alexandria – Egypt. They were all beginners in learning the Salto backward biked skills.

Table (1)
Sample description

Variables	Measurement	Mean	SD±	Median	Squewness
Age	Year	11.7	0.13	11.66	-1.04
Height	Cm	140.11	4.49	140.00	-0.23
Weight	Kg	34.89	3.70	35.00	0.267

Table (1) indicates that squewness is between (3±). This indicates that the sample is free from radical distributions.

Application:

Application of the recommended program, along with photographing and measuring were done inside the gymnastics hall of the Military Institution Sports Club in Alexandria – Egypt from 5-6-2010 to 5-8-2010.

Evaluation form: Appendix (1)

The researchers designed an evaluation form for the Salto backward biked on balance beam three levels of performance according to the following technical points or moments:

1. Maximum fade out moment (through maximum knee bending).
2. Legs- off –the beam moment (vertical push with feet to leave the beam).
3. Flight and circling (in the air).
4. Feet touching the beam (beginning of landing on the beam)
5. Stability and balance moment (end of movement and stability on both feet). (11, 12, 13, 14)

The form was presented to experts to dedicate points to each part of the skill, along with nominal points for each phase of. three levels of performance Figure (1) shows the technical performance of the skill.

Fig.1 Technical performance of the Salto backward biked on balance beam

Stability and balance **Feet touching the beam** **Flight and circling** **Legs- off –the beam** **Maximum fade out**

Preliminary conformity phase

Stability and balance **Feet touching the beam** **Flight and circling** **Legs- off –the beam** **Maximum fade out**

Good conformity phase

Stability and balance **Feet touching the beam** **Flight and circling** **Legs- off –the beam** **Maximum fade out**

Mastery phase

Identification of biomechanical variables:

Through literature review, the following biomechanical variables are identified as most important for the technical performance of the Salto backward biked skill: leg-foot angle – thigh-leg angle – trunk-thigh angle – upper arm-trunk angle – upper arm-forearm angle – horizontal speed of the body center of gravity – vertical speed of the body center of gravity - horizontal acceleration of the body center of gravity – vertical acceleration of the body center of gravity – resultant acceleration of the body center of gravity – horizontal momentum – vertical momentum – resultant momentum – horizontal strength – vertical strength – resultant strength – altitude of the center of gravity – horizontal distance – performance duration. (11, 13, 15, 16)

The recommended training program: Appendix (2)

After literature review, the researchers identified the specific exercises used in

Appendix (3) the recommended program. (11, 15, 16, 17, 18). Table (2) shows the time distribution of the program.

Table (2)
Time distribution of the recommended program

Three levels of performance	Weeks	Training Units	Unit Duration	Date
Preliminary conformity	3	12	50 min	5-6/23-6-2010
First follow-up measurement				24-6-2010
Good conformity	2	8	50 min	26-6/7-7-2010
Second follow-up measurement				8-7-2010
Mastery	4	16	50 min	10-7/4-8-2010
Third follow-up measurement				5-8-2010

Follow-up measurements through three levels of performanceprogram:

1. Performers were video-taped and the recorded (CD) was presented to four judges, registered in the Egyptian Federation of Gymnastics, to evaluate the technical performance of each performer in preliminary conformity (2.5 to 4 points), good conformity (4.5 to 7 points) and mastery (7.5 to10 points) according to the evaluation form.
2. Performance of each performer was analyzed to identify the biomechanical variables of the Salto backward biked skill on balance beam.

Statistical treatment:

The researchers used the following statistical treatments: mean – standard deviation (SD) – median – squewness – multiple regression analysis – variance analyses – Shefee test. Significance was identified on 0.05 for discussion

Results:

Table (3)
Multiple Regression equation for choosing performance indicators of the body angles during maximum fade out

Point = 72.218 – 0.485 x (upper arm-trunk angle) R = 0.977 R^2 = 0.954

Table (4)

Variance analysis among the three performances in the upper arm – trunk angle during maximum fade out

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
upper arm – trunk angle (shoulder angle)	Intra-performances	2	143.34	71.67	71.67*
	Inter-performances	6	6	1	
	Total	8	149.34		

F value on P≤0.05 = 5.14

Table (5)

Shefee test for identifying distinctive indicators

Three Levels of Performance	Mean	Preliminary Conformity	Good Conformity	Mastery
Preliminary conformity	142.4	---	-5.9 *	-9.7 *
Good conformity	136.5		---	-3.8 *
Mastery	132.7			---

Table (6)

Multiple Regression equation for choosing performance indicators of the body angles during feet-off-the beam moment

Point = 63.577+0.92x(foot-leg angle)-1.109 x (upper arm-trunk angle)

$R = 0.977$ $R^2 = 0.955$

Table (7)

Variance analysis among the three performances in the body angles during feet-off-the beam moment

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Foot-leg angle	Intra-performances	2	271.04	135.520	135.52*
	Inter-performances	6	6.00	1	
	Total	8	277.040		
upper arm – trunk angle	Intra-performances	2	71.12	35.56	35.56*
	Inter-performances	6	6	1	
	Total	8	77.12		

F value on P≤0.05 = 5.14

Table (8)

Shefee test for identifying distinctive indicators

Variables	Mean	Preliminary Conformity	Good Conformity	Mastery
Foot-leg angle	106.1	---	8.8*	13.2*
	114.9		---	4.4*
	119.3			---
Upper arm-trunk angle	142.5	---	5.000*	6.6*
	147.5		---	1.6
	149.1			---

Table (9)

Multiple Regression equation for choosing performance indicators of the body angles during flight and circling phase

Point = 12.642+0.180x(upper arm-trunk angle)-0.115 x (thigh-leg angle)

R = 0.972 R^2 = 0.944

Table (10)

Variance analysis among the three performances in the body angles during flight and circling phase

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Upper arm – trunk angle	Intra-performances	2	293.329	146.664	146.664*
	Inter-performances	6	6.00	1	
	Total	8	299.329		
Thigh-leg angle	Intra-performances	2	687.62	343.81	343.81*
	Inter-performances	6	6.00	1	
	Total	8	693.62		

F value on P≤0.05 = 5.14

Table (11)

Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary conformity	Good conformity	Mastery
Upper arm-trunk angle	Preliminary conformity	63.29	---	9.68 *	13.58*
	Good conformity	72.97		---	3.9 *
	Mastery	76.87			---
Thigh-leg angle	Preliminary conformity	180.4	---	-4.9 *	-20.5 *
	Good conformity	175.5		---	-15.6 *
	Mastery	159.9			---

Table (12)

Multiple Regression equation for choosing performance indicators of the body angles during feet touching the beam moment

Point = 18.555-0.125 x (foot-leg angle)

R = 0.971 R^2 = 0.942

Table (13)

Variance analysis among the three performances in the foot-leg angle during feet touching the beam moment

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
foot-leg angle	Intra-performances	2	2192.124	1096.062	359.694*
	Inter-performances	6	18.283	3.047	
	Total	8	2210.408		

F value on P≤0.05 = 5.14

Table (14)
Shefee test for identifying distinctive indicators

Variable	Three Levels of Performance	Mean	Preliminary Conformity	Good Conformity	Mastery
foot-leg angle	Preliminary conformity	120.6	---	-14.3 *	-37.853*
	Good conformity	106.3		---	-23.55 *
	Mastery	82.747			---

Table (15)
Multiple Regression equation for choosing performance indicators of the body angles during stability and balance moment

Point = 2.670+0.030 x (thigh-trunk angle) R = 0.904 R^2 = 0.817

Table (16)
Variance analysis among the three performances in the foot-leg angle during stability and balance moment

Variable	Source	Freedom degrees	Sum of squares	Mean of squares	F
thigh-trunk angle	Intra-performances	1	8916.615	8916.615	3566.646*
	Inter-performances	4	10.00	2.5	
	Total	5	8926.615		

F value on P≤0.05 = 5.14

Table (17)
Shefee test for identifying distinctive indicators

Variable	Three Levels of Performance	Mean	Preliminary Conformity	Good Conformity	Mastery
thigh-trunk angle	Preliminary conformity	---	---		
	Good conformity	100.2		---	
	Mastery	177.3			---

Table (18)
Multiple Regression equation for choosing performance indicators of the body center of gravity during maximum fade out moment

Point = 9.882-2.135x(horizontal acceleration)-0.115 x (resultant speed) R = 0.980 R^2 = 0.961 Point = 18.027-0.103x(horizontal strength)-0.115 x (resultant strength) R = 0.977 R^2 = 0.954

Table (19)

Variance analysis among the three performances in the body center of gravity during maximum fade out moment

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Horizontal acceleration	Intra-performances	2	7.249	3.625	483.276*
	Inter-performances	6	0.045	0.0075	
	Total	8	7.294		
Resultant speed	Intra-performances	2	0.291	0.146	30.11*
	Inter-performances	6	0.0290	0.0048	
	Total	8	0.320		
Horizontal strength	Intra-performances	2	7889.077	3944.539	39445.387*
	Inter-performances	6	0.600	0.100	
	Total	8	7889.677		
Resultant strength	Intra-performances	2	2146.88	1073.44	1073.44*
	Inter-performances	6	6.00	1.00	
	Total	8	2152.88		

F value on P≤0.05 = 5.14

Table (20)

Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary Conformity	Good Conformity	Mastery
Horizontal acceleration	Preliminary conformity	-0.455	---	-0.461*	-2.092*
	Good conformity	-0.916		---	-1.631*
	Mastery	-2.547			---
Resultant speed	Preliminary conformity	2.048	---	-0.422*	-0.101
	Good conformity	1.626		---	0.321*
	Mastery	1.947			---
Horizontal strength	Preliminary conformity	-15.03	---	-15.23*	-61.02*
	Good conformity	30.26		---	-53.79*
	Mastery	-84.05			---
Resultant strength	Preliminary conformity	187	---	-10.8*	26*
	Good conformity	176.2		---	36.8*
	Mastery	213			---

Table (21)

Multiple Regression equation for choosing performance indicators of the body center of gravity during feet-off-the beam moment

Point = 17.896-5.373 x (resultant speed)

$R = 0.818 \quad R^2 = 0.670$

Point = 11.374-2.558x(vertical momentum) + 2.236 x (resultant momentum)

$R = 0.975 \quad R^2 = 0.951$

Table (22)
Variance analysis among the three performances in the body center of gravity during feet-off-the beam moment

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Resultant speed	Intra-performances	2	0.796	0.398	39.78*
	Inter-performances	6	0.0600	0.0100	
	Total	8	0.856		
Vertical momentum	Intra-performances	2	667.197	333.598	333.598*
	Inter-performances	6	6	1	
	Total	8	673.197		
Resultant momentum	Intra-performances	2	757.261	378.63	378.63*
	Inter-performances	6	6	1	
	Total	8	763.261		

F value on P≤0.05 = 5.14

Table (23)
Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary Conformity	Good Conformity	Mastery
Resultant speed	Preliminary conformity	2.487	---	0.019	-0.621
	Good conformity	2.506		---	-.064
	Mastery	1.866			---
Vertical momentum	Preliminary conformity	63.17	---	2.46	-16.91*
	Good conformity	65.63		---	-19.37*
	Mastery	46.26			---
Resultant momentum	Preliminary conformity	78.77	---	3.92*	-17.2*
	Good conformity	82.69		---	-21.12*
	Mastery	61.57			---

Table (24)
Multiple Regression equation for choosing performance indicators of the body center of gravity during flight and circling phase

Point = 28.114-5.815 x (horizontal acceleration)
$R = 0.961$ $R^2 = 0.924$
Point = 5.455+0.328 x (resultant momentum)
$R = 0.964$ $R^2 = 0.930$

Table (25)

Variance analysis among the three performances in the body center of gravity during flight and circling phase

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Horizontal acceleration	Intra-performances	2	0.987	0.494	144.917*
	Inter-performances	6	0.02044	0.0034	
	Total	8	1.008		
Resultant momentum	Intra-performances	2	319.756	159.878	22948.981*
	Inter-performances	6	0.0418	10.006967	
	Total	8	319.798		

F value on P≤0.05 = 5.14

Table (26)

Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary Conformity	Good Conformity	Mastery
Horizontal acceleration	Preliminary conformity	4.311	---	-0.526*	-0.798*
	Good conformity	3.785		---	-0.272*
	Mastery	3.513			---
Resultant momentum	Preliminary conformity	27.03	---	5.77*	14.5*
	Good conformity	32.8		---	8.73*
	Mastery	41.53			---

Table (27)

Multiple Regression equation for choosing performance indicators of the body center of gravity during feet touching the beam phase

Point = 6.886+0.932 x (horizontal acceleration)

$R = 0.915$ $R^2 = 0.836$

Point = 53.597+1.743 x (horizontal momentum)

$R = 0.942$ $R^2 = 0.888$

Table (28)

Variance analysis among the three performances in the body center of gravity during feet touching the beam phase

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Horizontal acceleration	Intra-performances	1	9.42	9.42	942.005*
	Inter-performances	4	0.0400	0.0100	
	Total	5	9.46		
Horizontal momentum	Intra-performances	2	17.79	8.895	190.603*
	Inter-performances	6	0.280	0.04667	
	Total	8	18.070		

F value on P≤0.05 = 5.14

Table (29)
Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary Conformity	Good Conformity	Mastery
Horizontal acceleration	Preliminary conformity				
	Good conformity	-1.31			
	Mastery	1.196			
Horizontal momentum	Preliminary conformity	-24.09	---	-3.42*	-2.06*
	Good conformity	-27.51		---	1.36*
	Mastery	-26.15			---

Table (30)
Multiple Regression equation for choosing performance indicators of the body center of gravity during stability and balance phase

Point = 8.081-0.158 x (vertical momentum)
R = 0.926 R^2 = 0.858
Point = 8.396-1.179 x (resultant acceleration)
R = 0.924 R^2 = 0.854

Table (31)
Variance analysis among the three performances in the body center of gravity during stability and balance phase

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Vertical momentum	Intra-performances	1	333.865	333.865	667.649*
	Inter-performances	4	2	0.5	
	Total	5	335.865		
Resultant acceleration	Intra-performances	1	6.024	6.024	1139.188*
	Inter-performances	4	0.0211	0.00529	
	Total	5	6.045		

F value on P≤0.05 = 5.14

Table (32)
Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary Conformity	Good Conformity	Mastery
Horizontal acceleration	Preliminary conformity		---		
	Good conformity	15.33		---	
	Mastery	0.411			---
Resultant momentum	Preliminary conformity		---		
	Good conformity	2.328		---	
	Mastery	0.324			---

Table (33)

Multiple Regression equation for choosing performance indicators through learning phases for horizontal distance, center of gravity altitude and performance duration

Point = 0.287-27.042 x (horizontal distance) + 22.420(center of gravity altitude)

$R = 0.907$ $R^2 = 0.822$

Point = 2.659+4.744(final phase duration)

$R = 0.967$ $R^2 = 0.936$

Table (34)

Variance analysis among the three performances in the for horizontal distance, center of gravity altitude and performance duration

Variable	Source	Freedom Degrees	Sum of Squares	Mean of Squares	F
Horizontal distance	Intra-performances	2	0.0222	0.0111	8.1228*
	Inter-performances	6	0.0082	0.00136	
	Total	8	0.0304		
Center of gravity altitude	Intra-performances	2	0.0042	0.0021	1.26
	Inter-performances	6	0.01	0.00166	
	Total	8	0.0142		
Final phase duration	Intra-performances	2	1.524	0.762	451.132*
	Inter-performances	6	0.0101	0.00168	
	Total	8	1.534		

F value on P≤0.05 = 5.14

Table (35)

Shefee test for identifying distinctive indicators

Variables	Performance Phases	Mean	Preliminary Conformity	Good Conformity	Mastery
Horizontal distance	Preliminary conformity	0.81	---	-0.100*	-0.110*
	Good conformity	0.71		---	-0.01
	Mastery	0.70			---
Center of gravity altitude	Preliminary conformity	1.100	---		
	Good conformity	1.1400		---	
	Mastery	1.1500			---
Final phase duration	Preliminary conformity	0.1333	---	0.46*	1.0067*
	Good conformity	0.5933		---	0.5467*
	Mastery	1.140			---

Discussion:

Tables (3-6-9-12-15-18-21-24-27-30-33) are concerned with turning biomechanical variables of the skill into biomechanical indicators related to moments of technical performance. Using multiple regression equation the following indicators of body angles are concluded: leg-foot angle – thigh-leg angle – trunk-thigh angle – upper arm-trunk angle – upper arm-forearm angle. Body center of gravity indicators are as follows: horizontal acceleration – resultant speed - horizontal strength - resultant strength -

horizontal momentum – vertical momentum – resultant momentum – resultant acceleration. Other indicators are: horizontal distance – center of gravity altitude – final phase duration.

Tables (4-7-10-13-16-19-22-25-28-31-34) showed differences among biomechanical indicators according to the motor learning phases, using variance analysis. All variable (F values between 35.56 and 39445.378) are significant in favor of mastery phase, except for center of gravity altitude as (F) value was 1.26.

Tables (5-8-11-14-17-20-23-26-29-32-35), using Sheffee test, showed the distinctive indicators comparing the three levels of performance related to moments of performance. As for Maximum fade out moment, distinctive biomechanical indicators are upper arm- forearm angle, horizontal acceleration, horizontal strength and resultant strength as they differentiated the three phases in favor of the mastery phase. Only resultant speed is not a distinctive indicator as it did not differentiate among the three phases. As for feet-off-the beam moment, distinctive biomechanical indicators are foot-leg angle and resultant momentum, while upper arm-forearm angle, resultant speed and vertical momentum are only normal indicators as they did not differentiate among the three phases.

After maximum fade out moment for bending knees, bent legs are stretched with pushing from the spine to give the body maximum elevation during feet-off the beam moment. Forces resulting in circular movements during flight begin before the performer leaves the beam surface. Biomechanical distinctive indicators for flight and circling moment are upper arm-trunk angle, thigh-leg angle, horizontal acceleration and resultant momentum as they differentiated among the three phases in favor of the mastery phase. At this moment, trunk and arms begin circling heavily due to arm braking at maximum elevation. This transfers momentum to lower limbs to elevated the upper body. Thus, thigh joint speed increases to shorten the circling diameter and the upper and lower parts of the body come closer to form the curved shape needed for circling.

As for feet-touching- the beam moment, distinctive biomechanical indicators are foot-leg angle and horizontal momentum, as they differentiated among the three phases in favor of the mastery phase. Horizontal acceleration was considered a normal indicator as it differentiated between good conformity and mastery phases.

Conclusions:

The researcher concluded the following distinctive biomechanical indicators to differentiated among the three levels of performance (preliminary conformity – good conformity – master):

1. Maximum fade out distinctive indicators are upper arm- forearm angle, horizontal acceleration, horizontal strength and resultant strength.

2. Feet-off the beam distinctive indicators are foot-leg angle and resultant momentum.

3. Flight and circling distinctive indicators are upper arm-trunk angle, thigh-leg angle, horizontal acceleration and resultant momentum.

4. Feet-touching-the beam distinctive indicators are foot-leg angle and horizontal momentum.

5. Stability and balance distinctive indicators are thigh-trunk angle, vertical momentum and resultant acceleration.

6. Duration of performance for final phase.

7. Predictive equations indicating the performance level of the Salto backward biked

on the balance beam during motor learning phases.

Recommendations:

The researchers recommend the following:

1. Using distinctive indicators to evaluate the biomechanical efficiency of performing Salto backward biked on the balance beam.

2. Using the concluded predictive equations in measuring the performance improvement of Salto backward biked on the balance beam during three levels of performance

3. Coaches should study basics of biomechanics and motor analysis to solve technical performance problems for gymnastic performers.

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