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Effect of Plyometric Training on Developing the Explosive Power of Leg Muscles to Enhance the Performance Level of Some Acrobatic Elements on the Balance Beam Apparatus

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Abstract: The current study aims at improving the performance level of some acrobatic elements of gymnastics performers on the balance beam through plyometry training to improve the explosive power of leg muscles. Study was performed on a randomly chosen sample of 8 female gymnastics performers of Smoha Sports Club, registered in the Egyptian Federation of Gymnastics season 2009–2010 for first and second class. The researcher used the experimental approach with one group (pre-, intermediate and post-tests). The training program took (8) weeks (3 training units per week). Results showed that the recommended training program led to improving the explosive power of leg muscles as the percentages of improvement were as follows: 3.5%-12.34% for pre/intermediate tests, 2.79% - 16.22% for intermediate/post-tests and 6.4% - 30.41% for pre-/post-tests. Also, the recommended training program led to improving the performance level of acrobatic elements under investigation as the percentages of improvement were as follows: 10.66% - 13.11% for pre/intermediate tests, 10.99% - 12.29% for intermediate/post-tests and 22.82 - 27% for pre-/post- tests. These results indicate that using the recommended plyometry training program improved the explosive power of leg muscles and performance level.

Key words: Plyometry · Explosive power · Acrobatic elements · Balance beam

INTRODUCTION

Performance on the balance beam is difficult as the motor pattern includes some acrobatic elements besides artistic gymnastic elements with varied degrees of difficulty. It consists of five special requirements from among the top nine difficult elements as artistic gymnastic elements include jumps and spins on one foot then forward, sideward and backward acrobatic elements and finally the ending movements [1].

Noticing the selected motor patterns, it is clear that they are not free of acrobatic elements like Salto Forward Tucked, Salto Backward Tucked, Free Cartwheel and Free Walkover Forward. They are all performed from stance or from some steps. But most performers do not show a good performance level because the center of gravity does not reach the maximum altitude over the apparatus. So these acrobatic elements are included under the C/D difficulty level due to the decrease of physical level specific for such skills which, in turn, decreases the performers' performance level. Also, these acrobatic elements depend on the explosive power of leg muscles to reach maximum altitude.

It is necessary for gymnastics performers to have a good explosive power in leg muscles as it is essential for performing these skills easily and in a controllable manner. Using plyometry as a progressive training approach helps developing explosive power and improving leg muscles' speed [2,3]. Plyometry is based on fast stretch of the muscle, just before contraction. This leads to a powerful explosive contraction. Plyometry is a set of jumping exercises that develop explosive power through putting the muscle into a stretching state just before the explosive contraction [4]. It is necessary for gymnastics performers to have a good explosive power as it is essential for performing motor skills, especially on the balance beam [5,6].

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The researcher thinks that using plyometry is essential for developing the explosive power of leg muscles to improve the performance level of some acrobatic elements of gymnastics performers on the balance beam. The current research aims at improving the performance level of some acrobatic elements of gymnastics performers on the balance beam through:

- Identifying the effect of plyometry on developing the explosive power of leg muscles in gymnastics performers.
- Identifying the effect of developing the explosive power of leg muscles on improving the performance level of some acrobatic elements (Salto Forward Tucked, Salto Backward Tucked, Free Cartwheel and Free Walkover Forward).

The Researcher Hypothesized That:

- There are statistical significant differences between the means of pre-Intermediate- and post-measurements on the explosive power of leg muscles in favor of the post- measurement.
- There are statistical significant differences between the means of pre- Intermediate- and post-measurements of the performance level of some acrobatic elements (Salto Forward Tucked, Salto Backward Tucked, Free Cartwheel and Free Walkover Forward) in favor of the post measurement.

MATERIALS AND METHODS

The researcher used the experimental approach with one group (pre-, intermediate and post-tests). Sample of the study (8 performers) was chosen randomly from among female gymnastics performers of Smoha Sports Club, registered in the Egyptian Federation of Gymnastics season 2009 - 2010 for first and second class.

Table 1 indicates that squewness values were between (3±) which means that data is free from arbitrary recurrence.

The study was performed from 1/7/2009 to 28/8/2009 (8 weeks with 24 training units). Application tests and recommended program were done in the gymnastics hall - Smoha Sports Club - Alexandria.

The equipments used in the study were: a restameter for measuring heights , medical balance for measuring weights, stop watch ,measuring tape, chalk, graded board, cones, boxes, high density mats, recording form, balance beam, the recommended training program.

The Following Physical Tests, with High Validity and Stability Values, Were Chosen According to Literature Review:

- Vertical jump from stance [7]
- Vertical jump from running [8]
- Ability of vertical jump [7]
- Wide jump from stance [7]
- Jump with ascent leg [9]

Technical performance level of acrobatic elements was measured according to judgment criteria of the Egyptian Federation of Gymnastics using 6 female judges [1].

Third

The Recommended Training Program: The researcher selected exercises that are similar to technical performance phases. These exercises were as follows:

Table 1: Sample description on basic studied variables

	No	Variable	Measurement	Means	Median	SD	Inflation	Squewness
Growth rates		Age	Year	13.59	13.60	0.84	-0.11	-0.53
		Height	cm	151.31	150.56	3.50	-0.13	0.27
		Weight	Kg	45.31	45.00	2.80	-0.37	0.38
Physical tests	1-	Vertical jump from stance	cm	28.18	27.75	1.79	-1.25	0.43
	2-	Vertical jump from running	cm	30.87	31.25	1.78	-0.46	-0.32
	3-	Ability to vertical jump	cm	32.56	33.00	1.67	-1.54	-0.44
	4-	Wide jump from stance	cm	142.50	143.50	3.58	2.22	-1.48
	5-	Jump with ascent leg	cm	148.37	149.50	3.88	-0.57	-0.98
Technical tests	1-	Free cartwheel	Point	6.81	6.80	0.23	0.48	0.36
	2-	Free walkover forward	Point	6.66	6.65	0.25	-1.54	0.05
	3-	Salto forward tucked	Point	6.67	6.75	0.36	0.55	-0.98
	4-	Salto backward tucked	Point	6.48	6.55	0.32	-0.02	-1.02

Table 2: Training program for 1st and 2nd weeks

Day	Part	Duration (minute)	Content	Intensity	Volume	Rest interval (second)
Saturday	Warm-up	15	Stretches and flexibility	(60%) of maximum ability	10-12×3	90-120
	Plyometry	30	Exercises (1-3-6-7-10)			
	Cool-down	5	Relaxation and stretches			
Monday	Warm-up	15	Stretches and flexibility	(60%) of maximum ability	10-12×3	90-120
	Plyometry	30	Exercises (2-5-9-11-13)			
	Cool-down	5	Relaxation and stretches			
Wednesday	Warm-up	15	Stretches and flexibility	(60%) of maximum ability	10-12×3	90-120
	Plyometry	30	Exercises (4-8-12-14-15)			
	Cool-down	5	Relaxation and stretches			

- Jumping in place with both feet.
- Jumping sideward with both feet.
- Jumping to touch a target.
- Jumping up and bending knees to chest
- Forward lunge with jumping up and return to original position.
- Bending knees and advance with jumps.
- Consecutive forward jump over cones.
- Sideward jump over one cone.
- Alternating jump up (stand on the middle of the box with one foot and the other is on the ground)
- Jump forward with lifting knees up over 10 boxes (30cm in height) with 50cm distance between each two boxes.
- Facing the box and knees are half bent Jumping up and forward to stand on the box, push and land on boxes (30 cm in height).
- Standing over the edge of a box facing another box. Land on the floor then jump to the other low box then jump up with swinging arms forwards and up.
- Consecutive sideward jump over cones
- Hop forward with right foot then left foot over 10 boxes (20 cm in height) with 50cm distance between each two boxes.
- Stand with bent knees on high density mats, alternating jump up [10-17].

The researcher considered the principle of load increase progression so that intensity is between 60 - 75% of maximum ability of the performer. Load intensity is controlled through increasing the boxes height so that height of boxes when jumping with both feet is 30-40cm, while it becomes 20-30cm when performing with one foot [11-13].

Intensity distribution during the program period was as follows: 60% for 1st and 2nd weeks, 65% for 3rd and 4th weeks, 70% for 5th and 6th weeks and 75% for 7 thand 8 th weeks form maximum ability of the performer (Table 2).

Pre-test was performed on 1-2/7/2009 for physical tests and technical performance tests of acrobatic elements.

The recommended training program was applied during the pre-season phase from 4/7/2009 to 26/8/2009 (3 training units per week). Duration of each training unit was (50) minutes. Total number of units was 24.

An intermediate test was performed to assure the program's effectiveness on 30-31/7/2009. Post-tests were performed immediately after the program on 27-28/8/2009 following the same protocols of the pre-tests. The researcher used the following statistical treatments: Means - Standard Deviation - Squewness - Inflation - Variance Analysis - L.S.D test - Variance rate (%).

RESULTS AND DISCUSSION

Table 3 shows variance significance among the three tests (pre- / intermediate / post-) on physical ability variables on $p \leq 0.05$. It is clear that there are statistically significant differences among the three tests. This led the researcher to perform (L.S.D) tests to identify the minimum value of variance significance among tests. Table 3 shows statistically significant differences among the three tests (pre / intermediate / post) on physical ability variables as f value ranged between 15.954 and 52.160.

Table 4 shows the minimum value of variance significance among the study three tests (pre- / intermediate / post-) on physical ability variables. Table 4 shows statistically significant differences among the three tests (pre / intermediate / post) on physical ability variables in favor of the post- test.

Table 5 shows percentage of improvement among the study three tests (pre- / intermediate / post-) on physical ability variables.

Table 5 shows percentage of improvement among the study three tests (pre / intermediate / post) on physical ability variables as the percentage between

Table 3: Variance analysis among the study tests (pre / intermediate / post) on physical ability variables .n=8

No	Variable	Variance source	Freedom degree	Total of squares	Means of squares	(f) value
1-	Vertical jump from stanceInter-tests	2	297.063	148.531	*31.085	
		Intra-tests	21	100.344	4.778	
		Total	23	397.406		
2-	Vertical jump from running	Inter-tests	2	268.563	134.281	*52.160
		Intra-tests	21	54.063	2.574	
		Total	23	322.625		
3-	Ability to vertical jump	Inter-tests	2	229.188	114.594	*38.312
		Intra-tests	21	62.813	2.991	
		Total	23	292.000		
4-	Wide jump from stance	Inter-tests	2	334.083	167.042	*15.954
		Intra-tests	21	219.875	10.470	
		Total	23	553.958		
5-	Jump with ascent leg	Inter-tests	2	506.583	253.292	*19.466
		Intra-tests	21	273.250	13.012	
		Total	23	779.833		

(f) Value on freedom degree of 2, 21 and $p \leq 0.05$ = *3.47

Table 4: Minimum value of variance significance among tests (pre / intermediate / post) on physical ability variables .n=8

				Means difference			
No	Variable	Tests	Means	Pre-	Intermediate	Post-	L.S.D
1-	Vertical jump from stance	Pre-	28.18		*↑3.44	*↑8.57	1.88
		Intermediate	31.62			*↑5.13	
		Post-	36.75				
2-	Vertical jump from running	Pre-	30.87		*↑3.81	*↑8.19	1.38
		Intermediate	34.68			*↑4.38	
		Post-	39.06				
3-	Ability to vertical jump	Pre-	32.56		*↑3.50	*↑7.56	1.49
		Intermediate	36.06			*↑4.06	
		Post-	40.12				
4-	Wide jump from stance	Pre-	142.50		*↑5.00	*↑9.12	2.78
		Intermediate	147.50			*↑4.12	
		Post-	151.62				
5-	Jump with ascent leg	Pre-	148.37		*↑5.38	*↑11.25	3.10
		Intermediate	153.75			*↑5.87	
		Post-	159.62				

Table 5: Percentage of improvement among the study three tests (pre- / intermediate / post-) on physical ability variables .n=8

				Variance rate (%)		
No	Variable	Tests	Means	Pre-	Intermediate	Post-
1-	Vertical jump from stance	Pre-	28.18		12.20	30.41
		Intermediate	31.62			16.22
		Post-	36.75			
2-	Vertical jump from running	Pre-	30.87		12.34	26.22
		Intermediate	34.68			12.63
		Post-	39.06			
3-	Ability to vertical jump	Pre-	32.56		10.75	23.63
		Intermediate	36.06			11.26
		Post-	40.12			
4-	Wide jump from stance	Pre-	142.50		3.50	6.40
		Intermediate	147.50			2.79
		Post-	151.62			
5-	Jump with ascent leg	Pre-	148.37		3.62	7.58
		Intermediate	153.75			3.81
		Post-	159.62			

Table 6: Variance analysis among the study tests (pre- / intermediate / post-) on technical performance variables (n=8)

No	Variable	Variance source	Freedom degree	Total of squares	Means of squares	(f) value
1-	Free cartwheel	Inter-tests	2	12.606	6.303	110.995
		Intra-tests	21	1.193	0.057	
		Total	23	13.798		
2-	Free walkover forward	Inter-tests	2	9.316	4.658	65.102
		Intra-tests	21	1.503	0.072	
		Total	23	10.818		
3-	Salto forward tucked	Inter-tests	2	11.561	5.780	45.485
		Intra-tests	21	2.669	0.127	
		Total	23	14.230		
4-	Salto backward tucked	Inter-tests	2	12.253	6.127	74.531
		Intra-tests	21	1.726	0.082	
		Total	23	13.980		

(f) Value on freedom degree of 2, 21 and p=0.05 = *3.47

Table 7: Minimum value of variance significance among tests (pre / intermediate / post) on technical performance variables. n=8

				Means difference			
No	Variable	Tests	Means	Pre-	Intermediate	Post-	L.S.D
1-	Free cartwheel	Pre-	6.81		*↑?0.86	*↑1.77	0.20
		Intermediate	7.67			*↑0.91	
		Post-	8.85				
2-	Free walkover forward	Pre-	6.66		*↑0.71	*↑1.52	0.23
		Intermediate	7.37			*↑0.81	
		Post-	8.18				
3-	Salto forward tucked	Pre-	6.67		*↑0.86	*↑1.70	0.30
		Intermediate	7.53			*↑0.84	
		Post-	8.37				
4-	Salto backward tucked	Pre-	6.48		*↑0.85	*↑1.75	0.24
		Intermediate	7.33			*↑0.90	
		Post-	8.23				

Table 8: Percentage of improvement among the study three tests (pre /intermediate / post) on technical performance variables. n=8

				Variance rate (%)		
No	Variable	Tests	Means	Pre-	Intermediate	Post-
1-	Free cartwheel	Pre-	6.81		12.62	25.99
		Intermediate	7.67			11.86
		Post-	8.85			
2-	Free walkover forward	Pre-	6.66		10.66	22.82
		Intermediate	7.37			10.99
		Post-	8.18			
3-	Salto forward tucked	Pre-	6.67		12.89	25.48
		Intermediate	7.53			11.15
		Post-	8.37			
4-	Salto backward tucked	Pre-	6.48		13.11	27.0
		Intermediate	7.33			12.29
		Post-	8.23			

pre- and post- tests ranged between 6.4% and 30.41%, in favor of the post- test. The researcher thinks that these statistically significant differences among the tests and the percentage of improvement are due to the application of the recommended plyometry training program that led to improve the explosive power of leg muscles as plyometry training works on improving the ability to jump through explosive power exercises using stretch reaction. It, also, stimulates the largest possible number of motor units involved in effort. This, in turn, leads to a fast powerful contraction that works on improving explosive performance. Talha Hosam [6] indicated that this type of training depends on acceleration and deceleration moments that happen to balance the body during its dynamic movements. This type helps developing explosive power of leg muscles and improving the dynamic performance of jumping .This is in agreement with previous studies mentioning that plyometry training

improves explosive power of leg muscles [13, 18]. This proves the first hypothesis stating "There are statistically significant differences between the means of pre- Intermediate and post- measurements on the explosive power of leg muscles in favor of the post-measurement".

Table 6 shows variance significance among the three tests (pre / intermediate / post) on technical performance variables on $p \leq 0.05$. It is clear that there are statistically significant differences among the three tests. This led the researcher to perform (L.S.D) tests to identify the minimum value of variance significance among tests. Table 6 shows statistically significant differences among the three tests (pre- / intermediate / post-) on technical performance variables as (f) value ranged between (45.485 and 110.995).

Table 7 shows the minimum value of variance significance among the study three tests (pre / intermediate / post) on technical performance variables. Table 7 shows statistically significant differences among the three tests (pre- / intermediate / post-) on technical performance variables in favor of the post- test.

Table 8 shows percentage of improvement among the study three tests (pre/intermediate / post-) on technical performance variables. Table 8 shows percentage of improvement among the study three tests (pre- / intermediate / post-) on technical performance variables as the percentage between pre- and post- tests ranged between (22.82% and 27%) in favor of the post- test. The researcher thinks that these statistically significant differences among the tests and the percentage of improvement are due to the application of the recommended plyometry training program that led to elevating the body center of gravity on the balance beam. This, in turn, led to improving the technical performance level of acrobatic elements. This is in agreement with HosamEl-Din [19] who indicated that plyometry training aims at improving ascent level in sports performances depending on jumping in one of its phases. Allawy and NasR El-Din [7]and Allawy [20] indicated that explosive power of leg muscles play a major role in identifying performance levels in sports activities depending on the speed and powerful jump using legs in achieving maximum power in least possible duration.Abd El-Maksoud [21] indicated that the most important advantage of plyometry training is that it increases motor performance through increasing the muscles ability to contract faster and more explosively .This proves the first hypothesis stating "There are statistically significant differences between the means of pre- intermediate and post- measurements of the performance level of some acrobatic elements (Salto Forward Tucked, Salto Backward Tucked, Free Cartwheel and Free Walkover Forward) in favor of the post measurement".

CONCLUSION

- The recommended plyometry training program improved the explosive power of leg muscles in the study sample.
- The development of the explosive power of leg muscles helped in improving the technical performance level of acrobatic elements on the balance beam.

Recommendations:

- Using the recommended plyometry training program to improve the explosive power of leg muscles.
- Concentrating more on plyometry training, putting in mind that it should be similar to technical performance as this will improve the technical performance of gymnastics performers on the balance beam.

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