Journal of Applied Sports Science
December 2015, Volume 5, No. 4

The Effect of Dynamic Balance Training Program On Some Physical Abilities and Biomechanical Variables to Enhance the Volleyball Spike Performance for Female Under-16.

Amira Abdel- Hamid Shawki Abdul Aziz

Department of Training and Movement Sciences, Faculty of Physical Education for Girls, Alexandria University, Egypt.

Mansour Abdel-Hamid Attaallah

Department of Physical Education Foundations, Faculty of Physical Education for Men, Alexandria University, Egypt.

Abstract

The purpose of this study was to identify the effect of Dynamic Balance training program on Some Physical Abilities and selected biomechanical variables to enhance the Volleyball Spike Performance for Female Under-16. Eight female volleyball juniors from Smouha Sporting Club (age 14.91 ± 0.69, Height 168.13 ± 1.96 cm, weight 58.13 ± 3.18 kg, and training age 6.13 ± 0.64). Physical abilities were also measured. Each player performed three spike trials pre and post-measurements the best one was chosen for biomechanical analysis. Data were collected using two digital synchronized cameras (JVC9800, 120 Hz) to videotape the performance. The biomechanics analysis was done using the three-dimensional software Winanalyez v2.5). Eight weeks, six sessions per week training program was set before post-measurements. The main results showed significant differences between pre-measurements and post-measurements in all physical abilities. Results also indicated significant differences at 0.05 level between pre-measurements and post-measurements of the center of the body mass velocity (COM) in the takeoff phase and the trunk angle in the hand back swing phase. Other biomechanics variables showed non-significant differences. The study concludes that the dynamic balance training program had a positive effect on improving the volleyball spike performance for female under-16.

Introduction:

Volleyball is a team game, which has been subject of several studies aiming at developing the game in terms of performance and playing methods to fit with the changing and unexpected playing situations. a good preparing of female junior players is a mainstay in every development for global achievements. The development requires, in particular from young female players, development of volleyball technical skills as well as physical abilities and assessment of the quality of these abilities (Bale, Mayhew, Piper, Ball, & Willman, 1992; Thissen-Milder & Mayhew, 1991). These abilities are in close connection with female under 16 and it had a direct relation to the performance.

Volleyball spike is an important skill for a successful volleyball offense because it decreases the ability of the defense to keep the ball in play (Ferris, Signorile, & Caruso, 1995; Forthomme, Croisier, Ciccarone, Crielaard, & Cloes, 2005). Spike has its own characteristics that distinguish it from other volleyball skills. It is a difficult skill in view of the limited space of the court. The tactical work specified for the hit requires special motor conditions and abilities. Coaches often focus on the spike skill as a combined major skill in competition. Therefore the importance of balance is best demonstrated in the player's stability when the player lands in own court after spike, therefor may avoid falling on the ground and quickly resume the play(Abendroth-Smith & Kras, 1999). the effective and balanced movements of a volleyball player require maintaining balance after takeoff and in landing in order to control the body in the air, and providing opportunities to take the offensive again.(Kenny, 2006)

Balance training is a key component of any well planned exercise program. Balance is the foundation for movement and improves body awareness, power, quickness, coordination and control(Gagetein, 1995).

Dynamic balance is the ability to maintain stability while in motion or in movement of the body or part of the body from one point to another and in maintaining stability (Roth, Miller, Ricard, Ritenour, & Chapman, 2006) (Matsuda, Demura, & Uchiyama, 2008) also is defined as the ability to maintain the center of gravity within the base of support with minimal sway(Horak, 1987; Kisner & Colby, 2007; Lees, Vanrenterghem, & De Clercq, 2004).

Several studies focus on the field of balance training to prevent injuries in volleyball like (Hassan Sadeghi, Ardalan Shariat, Enayatollah Asadmanesh, & Mosavat, 2013; Şahin et al., 2015; Sawdon-Bea & Sandino, 2015). But a few studies didn't focus on how to improve the balance in the flight phase for female under16. Female players' are more prone to losing their ability to maintain their balance in the air than men due to weaker quadriceps and hamstring strength (Bahr & Bahr, 1997; Renstrom et al., 2008) this may lead to technical errors that affect the spike's immediate objective of scoring points, while keeping on serving hits and handling the ball. In addition to, the female players' ability to maintain their balance during flight phase will effect to their loss there balance during landing phase, thus leading to mid-line crossing error and loss of the ball. It may also make the player unable to perform the successive motor duties at the required speed. The importance of this experimental study to identify the main weaknesses form biomechanical analysis, physical abilities tests and apply the dynamic Balance training program to enhance the Volleyball Spike Performance for Female Under-16.

Methods

Subjects: eight female volleyball juniors players from Smouha Sporting Club (age 14.91 ± 0.69, Height 168.13 ± 1.96 cm, weight 58.13 ± 3.18 kg, training age 6.13 ± 0.64).all players informed about protocol procedures and accept to participate to this study

Procedures: Each player performed three spike trials, the best one was chosen for biomechanical analysis. Data were collected using two digital synchronized cameras (JVC9800, 120 Hz) to videotape the performance. The biomechanical analysis was done using the three-dimensional software Winanalyez v2.5). Figure 1 illustrates preparation of the three-dimensional calibration cube in the location specified for skill performance. Figure 2 illustrates the bacillary form for skill performance.

Figure (1)
preparation of the three-dimensional calibration cube in the location specified for skill performance

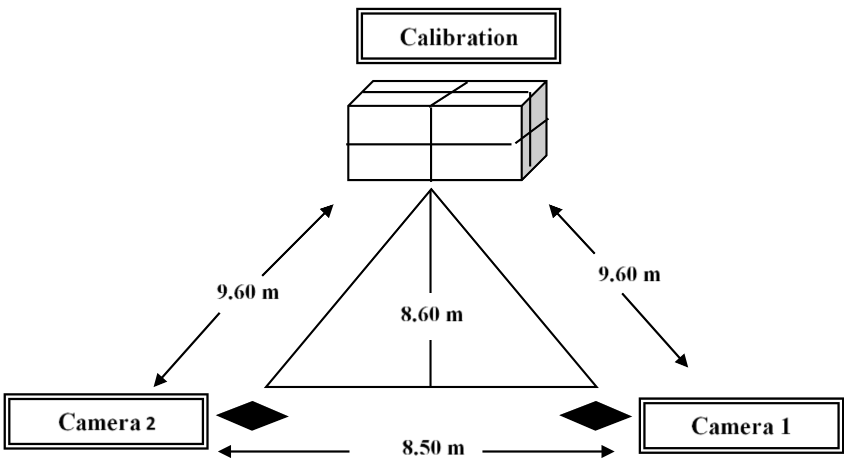
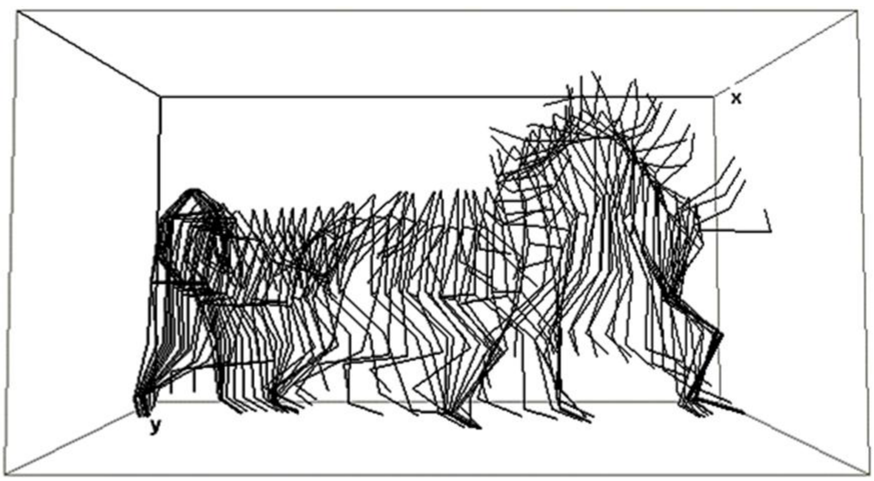


Figure (2)
stick figure for spike skill performance



Proposed training programs -

8 weeks were assigned for program implementation and were distributed over the proposed program different periods.

Number of training sessions was set at 6 sessions per week.

Training session time ranged between 90 and 135 minutes depending on session target and intensity load used.

Total program training sessions were 48 in number.

Number of exercises in a session ranged between 6 and 8 exercises.

Average performance time ranged between 25 and 30 seconds.

Average relief periods ranged between 15 and 45 seconds, when heart rate averaged 120 beat/second.

Transition time between exercises ranged between 15 and 45 seconds.

Group repetitions ranged between 3 and 5 times.

Inter-group average relief periods ranged between 3 and 5 minutes.

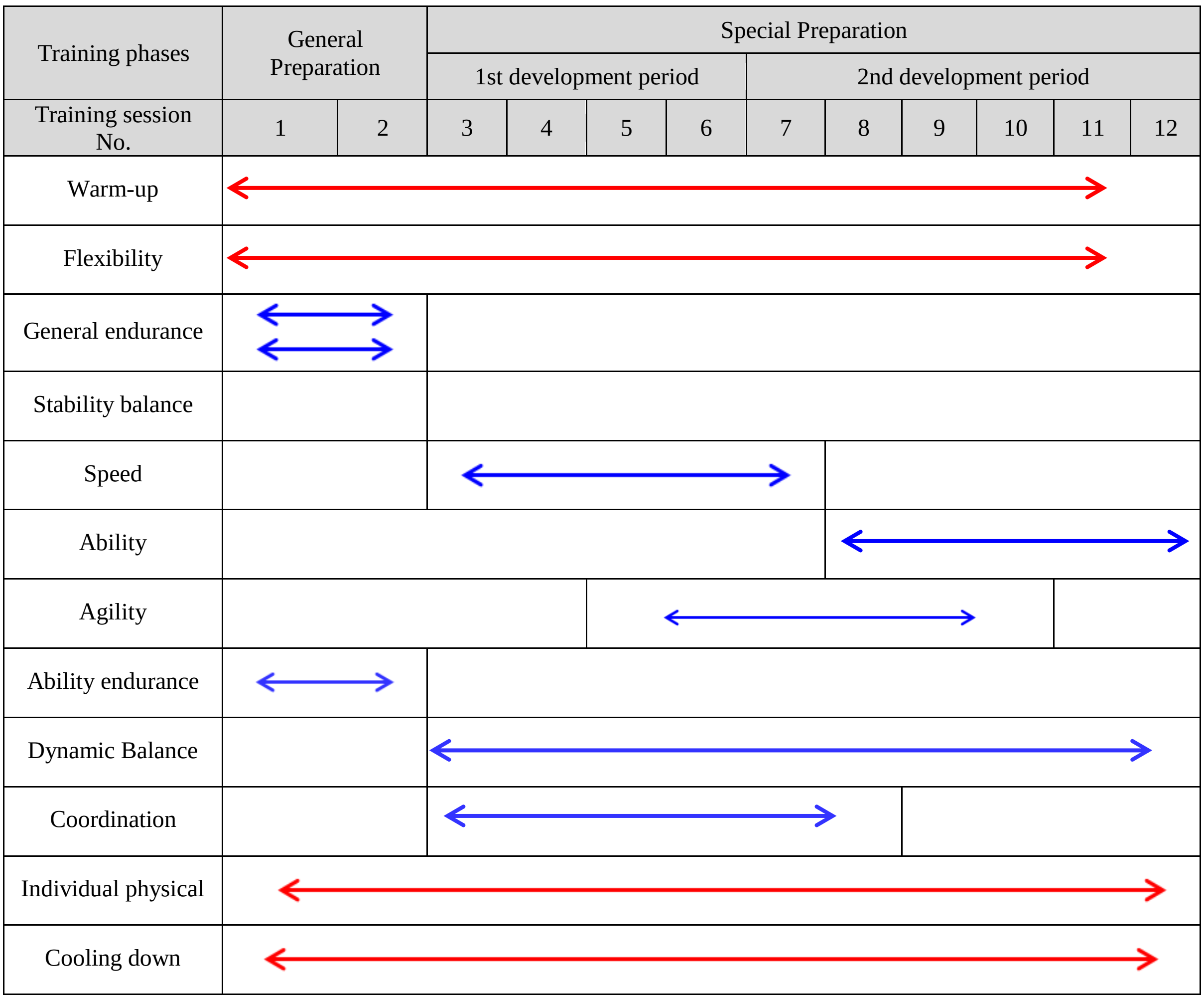
Total program time is 90 training hours.

High and low-intensity interval training using the circular style was used.

1. Planning for the preparation period

The scientific foundations were closely followed when planning for the general and special physical preparation periods, and the appropriate sequence was also taken into consideration when planning the activities required for the proper development of physical abilities necessary for the motor skill under discussion.

Figure (3)
Time distribution of the training units components in the proposed training program



2. Identification of the training load system in the proposed program:

The training loads of the general and special preparation training units were distributed using the 1: 1 and 2: 1 systems.

Figure 4:
Training intensity load according to proposed program training stages and weekly units time table

Load intensity and training phases time				
Training phases		General Preparation	Specific preparation	
			1st development period	2nd development period
Training phases Load intensity	Max.			
	High			
	Medium			
Time		(6X190)= 1140 minutes	(430 X 3)= 1290 minutes	(990 X 3) = 2970 minutes
			(1420 X 3) = 4260 minutes	

Average Load intensity and weekly training sessions time															
Weeks		1st	2nd	3rd		4th		5th		6th		7th		8th	
Training loads number		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th
Weekly session training load	Max														
	High														
	Medium														
Time		90	100	110	90	110	120	130	110	115	120	130	120	130	135

Statistical analysis:

A mean and standard deviation descriptive statistics in all variables was used to obtain reliable data characterization. Paired-samples t-test was used to assess the training effects within groups. Significance was maintained at the 0.05 level. All statistical analyses were performed by using SPSS software (V. 20.0).

Results:

Table (1) results shows the Mean and standard deviation descriptive statistics of research sample basic variables, physical abilities and spike skill, and this confirms that sample is free from abnormal distributions defects. It is also evident that all variance coefficients of the basic variables, physical abilities and spike skill ranged between 1.17% and 12.52%, a value which is less than 20% of the average, which shows the homogeneity of research sample in all the variables under consideration. Table (2) shows a significant differences at the level of 0.01 between the pre-measurements and post measurements favoring post measurement of all physical abilities. The calculated T values ranged between 7.26 and 27.03, and the improvement percentage ranged between 13.10% and 111.93%. Table (3) shows significant differences at the level of 0.05 between pre-measurements and post-measurements favoring post measurements of body center of mass during the pushing phase and body COM resultant velocity in the swinging phase while differences in other biomechanical variables were not significant. Table (4), shows significant differences at the level of 0.01 between pre-measurements and post measurements favoring post measurements of spike skill, with an improvement percentage of 130.49%.

Table (1)

Mean and standard deviation descriptive statistics of research sample basic variables, physical abilities and spike skill

Statistics / variables		Measurement unit			n = 8 Mean	SD
Basic variables	Age	(year)			14.91	0.69
	Height	(cm)			168.13	1.96
	Weight	(kg)			58.13	3.18
	training age	(years)			6.13	0.64
Physical variables	static balance	standing with instep on a cube	(seconds)		54.00	4.07
	Dynamic balance	Dynamic balance test	(marks)		35.63	10.46
	Ability	Sitting up	15 second	(number)	9.75	0.71
		Modified Burpee		(number)	9.13	0.64
		Raising the trunk from layout position		(number)	8.88	0.64
		Vertical jump from standing		(cm)	44.13	3.44
		pushing a 3 kg Medicine ball	Right arm	(meters)	6.16	0.49
			Left arm	(meters)	5.40	0.62
	Speed	Maximum	20 m sprint	(number)	3.88	0.24
		Motor	run in place 15 seconds	(seconds)	19.50	0.53
	Flexibility	Trunk back bending from layout position	(cm)		21.25	2.66
	Agility	Zigzag running	(seconds)		19.93	0.56
	coordination	Numbered circles	(seconds)		8.79	0.63
Motor skill	spike accuracy	(marks)			10.25	0.71

Table (2):

T-test Pre and post measurements and change percentage in physical abilities (N = 8)

Statistics / Variables			Measurement unit	Pre measurement Mean	Pre measurement SD	Post measurement Mean	Post measurement SD	Difference Mean	T	Change percentage %
Balance	Stability balance		(seconds	54.00	4.07	93.25	2.66	39.25-	**25.61	72.69
	Dynamic balance		(marks)	35.63	10.46	75.50	19.99	39.88-	**8.51	111.93
Speed power	Sitting up	15 s	(number)	9.75	0.71	15.88	0.64	6.13-	**15.39	62.87
	Modified Burpee		(number)	9.13	0.64	15.13	0.64	6.00-	**18.33	65.72
	Raising the trunk from layout position		(number)	8.88	0.64	15.00	0.53	6.13-	**27.03	69.03
	Vertical jump from standing		(cm)	44.13	3.44	57.25	3.65	13.13-	**10.92	29.75
	Pushing a 3 kg		(meters)	6.16	0.49	8.32	0.64	2.16-	**7.76	35.06

Statistics / Variables		Measurement unit	Pre measurement		Post measurement		Difference Mean	T	Change percentage %
			Mean	SD	Mean	SD			
	medical ball	(meters)	5.40	0.62	6.98	0.23	1.58-	**9.02	29.26
Speed	Maximum	(number)	3.88	0.24	3.33	0.17	0.55	**13.81	14.18
	Motor	(seconds)	19.50	0.53	25.63	1.19	6.13	**13.90	31.44
Flexibility	Trunk back bending from layout position	(cm)	21.25	2.66	42.25	4.20	21.00-	**10.41	98.82
Agility	Zigzag running	(seconds)	19.93	0.56	17.32	0.24	2.61	**11.20	13.10
coordination	Numbered circles	(seconds)	8.79	0.63	7.26	0.41	1.53	**10.55	17.41

** Significant differences to p <0.01 * Significant differences to p <0.05

Table (3):
Mean and standard deviation, T-test Pre and post measurements and change percentage in selected biomechanical variables (N = 8)

Statistics / Variables		Measurement units	Pre measurement		Post measurement		Difference Mean	T	Change Percentage %
			Mean	SD	Mean	SD			
Damping	Damping time	sec	0.113	0.038	0.132	0.032	-0.019	-0.872	16.4
Pushing	Pushing time	sec	0.180	0.051	0.153	0.038	0.027	2.126	14.8
	Distance from minimum to maximum height	m	0.55	0.061	0.60	0.04	-0.05	-1.680	9.4
	Body COM resultant velocity	m/s	2.95	0.458	3.34	0.48	-0.39	*3.908	13.4
	Body COM resultant force	N	445.35	173.183	632.66	297.55	-187.31	-1.098	42.1
Arm swing	Hand COM resultant velocity	m/s	2.98	2.157	3.88	2.317	-0.898	-0.794	30.1
	Hand COM force resultant	N	30.72	12.425	41.65	5.23	-10.93	-1.492	35.6
	Elbow angle	deg	132.33	18.453	137.35	28.55	-5.02	-0.336	3.8
	Trunk angle	deg	139.25	12.115	161.64	12.51	-22.38	*3.067	16.1
Hitting	Resultant Body force	N	755.28	378.209	920.99	81.45	-165.70	-1.084	21.9
	Hand COM resultant velocity	m/s	7.73	1.343	8.63	1.51	-0.91	-1.733	11.7
	Hand COM resultant force	N	41.85	6.612	45.27	9.79	-3.42	-0.766	8.2
	Shoulder angle	deg	116.298	26.456	128.42	9.50244	-12.12	-1.046	10.4
	Shoulder angular velocity	deg/s	396.517	226.577	470.91	261.39	-74.40	-0.510	18.8
	Elbow angle	deg	141.770	18.715	144.22	30.26	-2.45	-0.147	1.7
	Trunk angle	deg	125.63	16.176	133.21	24.23	-7.58	-1.235	6.0

** Significant differences to p <0.01 * Significant differences to p <0.05

Table (4):
T-test Pre and post measurements and change percentage in the performance level (N = 8)

Statistics / Skill		Measurement unit	Pre measurement		Post measurement		Difference Mean	T	Change %
			Mean	SD	Mean	SD			
Motor skill	spike accuracy	Marks	10.25	0.71	23.63	1.60	13.38-	23.67**	%130.49

** Significant differences to p <0.01 * Significant differences to p <0.05

Discussion

A successful volleyball spike performance demands different factors concerning spike jump an appropriate amount of concerning factors or we can say balanced combination of those variables results in optimum performance level. The results of this study shows significant differences at the level of 0.01 between the pre-measurements and post-measurements favoring post measurements of all physical abilities and the training program was effective in developing the physical abilities discussed. These significant differences in abilities can be attributed to the experimental group's training program, which included balance specific exercises, resulting in improved balance, in addition to many factors that govern it. (Harper & Martin, 1985) .

Significant differences were also found between the pre-measurements and post-measurements of abilities favoring post measurements. These differences in ability can be attributed to the effect of the proposed program which included a variety of exercises which took into account load standardization in terms of intensity, volume and density, in the light of measuring the maximum of each exercise, according to the individual ability of each female junior player. Exercises for the trunk and arm muscles involving swinging and side work led to rapid contractions of the longitudinal, lateral and oblique straight abdominal muscles. This helped support body movement and balance during skill performance, increasing the pushing force of ground to ball.

The training program also included arm and shoulder-bone flexion, extension and abduction exercises with sub-maximum intensity and high speed, according to players abilities, with suitable rest periods, as well as jump, rebound and hopping exercises to achieve maximum height up and forwards with maximum alternate double-foot and one-foot work. This helped improve the ability of hip, thigh and leg muscles using muscle elasticity before contraction by shortening to give them motor speed through the highest strength and speed possible, which is one of the requirements of volleyball skill performance such as the spike skill. (Hsieh & Christiansen, 2010).

This study showed that improvement in ability to the effectiveness of the exercises included in the proposed training program. Such exercises subject the working muscles to a fast stretching followed by a fast central contraction based on the foundations of plyometric training. This is done through special exercises, such as push-up with the body's resistance, and the quick passing of the ball from the standing and sitting positions. Such movements are repeatedly performed using the arms and shoulder when handling the ball. The power enables the player to perform a spike over the block. Feet exercises produce a great leg muscle force, enhancing the fast performance of motor skills, such as the spike and blocking skills

The same table shows significant differences in maximum speed between pre-measurements and post-measurements, favoring post measurement. This is attributed to the proposed training program which included exercises for deep jump, rebound and hopping to develop the explosive power, leading to the development of speed, and exercises for running sprinting and using the fixed bicycle and the treadmill. Such exercises are important for offensive and blocking skills, because the player needs intermittent fast sprints according to the different playing situations throughout the match. The program also had a positive effect on motor speed and transitional speed among female junior players.

The table also shows significant differences in flexibility between pre-measurements and post-measurements favoring post measurements. This is attributed to the positive change in trunk flexibility because of the program plyometric exercises to stretch the back, abdomen, leg and arm muscles. These exercises significantly contributed to increasing the ability of these muscles, tendons and ligaments to stretch, consequently increasing motion range of the joints. This latter ability is an important requirement for performing the spike skill and for helping the working muscles gain motor power during the skillful performance. It also plays an effective role in reducing muscle pain during training, delaying fatigue onset, reducing the cramp risk and delaying fatigue onset. Flexibility has thus helped maintain smooth and coordinated movement especially during jumping, running and spikes. (Gagetein, 1995).

It was also found that there are significant differences in agility between pre-measurements and post measurements favoring post-measurements. The authors attribute these differences to the effectiveness of the exercises included in the training program, especially the zigzag run between cones at different speeds and in different directions with balance, coordination and accuracy between arms and legs movements, sprinting followed by stopping to change direction, jumping while changing direction, on-foot and double-foot rope jumping and shuttle running. Differences are also attributable to the similarity between the exercises used and the skillful performance of spikes in volleyball.

Table 3 shows significant differences at the 0.05 level between pre-measurements and post-measurements favoring post measurements in the resultant velocity of the body center of gravity during the pushing phase and the trunk angle in the swinging phase. Body COM velocity resultant in swinging phase, whereas no differences were found in other biomechanical variable. Damping time in post-measurements was larger than the same in pre-measurements with an average difference of 0.019 seconds, i.e. a 16% change in order to give opportunity to the arm to swing back to the widest range possible. This swinging contributes to the takeoff process, and this phase gives the player the opportunity to convert horizontal force gained from running to vertical pushing force. This is consistent with results reached by (Abendroth-Smith & Kras, 1999; Hsieh & Christiansen, 2010; Lees, et al., 2004).

This affected the pushing time which was shorter in post-measurements at an average difference of 0.027 seconds and at a change percentage of 14.8%. The distance from maximum damping to maximum COM height was, however, greater in post measurements at an average difference of 0.05 cm and at a change percentage of 9.4%. This shows that the aim of jumping "the highest distance in the shortest time" has been achieved(Lees, et al., 2004). The body COM resultant velocity at the pushing moment was greater in post measurements at an average difference of 0.39 and a change percentage of 13.4%. This change in velocity was followed by a significant change in the body resultant force at the pushing moment at an average difference of 187.31 Newton and a change percentage of 42.1%. During the swinging phase concentration was laid on increasing the resultant velocity of the hitting hand because it is the link that hits the ball at the end of the swinging phase. The average difference between pre-measurements and post-measurements was 0.898 ml/s, with a change percentage of 30.1%).

There was also an increase in the resultant force of the hand in the swinging phase at an average difference of 10.93 Newton and a change percentage of 35.6%. This is done by focusing on exercises that increase this link's acceleration, keeping the link's gravity stability ($F = ma$). Such exercises are closely connected to speed training exercises. During this phase the elbow angle has a significant effect on the hitting arm because the wider the angle, the greater the opportunity to extend the hitting arm during the swinging. This is reflected in movement in basic phase (hitting). The average difference between pre-measurements and post-measurements was 5.02 degrees, with a change percentage of 3.8%.

The trunk is also considered one of the most important links that connect the force produced by the lower limb muscles and properly transfer it to the upper limb ending with the hitting arm. In this phase a group of exercises was set with the aim of increasing trunk flexibility. The group included exercises for the trunk and arm muscles, involving swinging and side turns leading to rapid contractions of the longitudinal, lateral and oblique straight abdominal muscles. This helped to support the body movement and balance during the skill performance, while increasing the pushing force from the ground to the ball, so that the trunk can reach the maximum possible range of motion to lengthen the force exertion distance in order to increase the mechanical work ($W = Fd$) at the hitting moment The average difference between pre-measurements and post-measurements was 22.38 degrees, with a change percentage of 16.1%.

Hitting is the main phase in which the force acquired from previous phases is used to properly and forcibly hit the ball to achieve the hitting objective(Blazevich, 2007). Exercises were therefore set to help increase the force by which the body moves at the hitting moment. The difference in the body's resultant force between pre-measurements and post measurements was 165.70 Newton with a change percentage of 21.9%. A review of previous speed and force exercises of the hitting hand showed an increase in the post-measurement of the resultant speed of that hand 0.91 m/s with a change percentage of 11.7%. The difference in the resultant force of the hand was 3.42 N with a change percentage of 8.2%. This increase in the hitting hand speed and force was due to making use of the swinging phase and using maximum force at the hitting moment.

An increase was also found in shoulder angle in the post measurement at an average difference of 12.12 degrees and a change percentage of 10.4%. This was accompanied by an increase in shoulder’s angular velocity at an average difference of 74.40 degree/s and a change percentage of

18.8%. Since the shoulder joint is an arm-rotating axis, an increase in the shoulder angle and the angular velocity would lead to an increase in the applied on the ball. In order to get maximum arm stretching, the increase in the elbow angle must be maintained at the hitting moment. This is demonstrated in the results of this study, where the average difference in elbow angle at the hitting moment was 2.45 degree with a change percentage of 1.7%. at the hitting moment and with the arm entering the hitting phase, the trunk angle is bent, but as far as the player will succeed in preventing this, the trunk would follow the hitting arm and this was why the angle was wider in the post-measurement than in the pre-measurement, at an average difference of 7.28 degrees and a change percentage of 6.0%.

Table 4 shows significant differences in the spike skill before and after the experiment indicating that spike skill performance has improved before and after the experiment. This is attributed to the proposed training program, which contained a set of specific exercises carried out using regular training loads that affected the development of physical abilities, which in turn led to an improvement in the spike skill performance level.

Conclusions:

On the basis of the results obtained from the present study the following conclusions can be drawn the dynamic Balance training has been shown to be effective for physical abilities of the volleyball female players under 16 improvements and also reduce the rates of missing spike. There was significant difference between pre and post measurements in some biomechanics variables center of mass speed in the takeoff phase and trunk angle in the arm backswing on the other hand there was non- significant in the other variables . Furthermore, training individually for static and dynamic balance among these individuals for competitive sport. This study suggest that training program should focus in the balance exercise in the flight phase.

References:

1. Abendroth-Smith, J., & Kras, J. (1999). More B-BOAT: The Volleyball Spike. Journal of physical education and recreation., 70(3), 56.
2. Bahr, R., & Bahr, I. A. (1997). Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. SMS Scandinavian Journal of Medicine & Science in Sports, 7(3), 166-171.
3. Bale, P., Mayhew, J. L., Piper, F. C., Ball, T. E., & Willman, M. K. (1992). Biological and performance variables in relation to age in male and female adolescent athletes. J Sports Med Phys Fitness, 32(2), 142-148.
4. Blazevich, A. (2007). Sports biomechanics the basics: optimising human performance, from http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=217310
5. Ferris, D. P., Signorile, J. F., & Caruso, J. F. (1995). The Relationship Between Physical and Physiological Variables and Volleyball Spiking Velocity. The Journal of Strength and Conditioning Research, 9(1), 32-36.
6. Forthomme, B., Croisier, J.-L., Ciccarone, G., Crielaard, J.-M., & Cloes, M. (2005). Factors Correlated With Volleyball Spike Velocity. The American Journal of Sports Medicine, 33(10), 1513-1519.
7. Gagetein, A. (1995). Balance Training Exercise For Volley ball. a publication of the American Volleyball coaches Association, 13(4).
8. Harper, H. A., & Martin, D. W. (1985). Harper's Review of biochemistry. Los Altos, Calif.: Lange Medical Publications.
9. Hassan Sadeghi, Ardalan Shariat, Enayatollah Asadmanesh, & Mosavat, M. (2013). The Effects of Core Stability Exercise on the Dynamic Balance of Volleyball Players. IJAEP, 2(2).
10. Horak, F. B. (1987). Clinical measurement of postural control in adults. Phys Ther, 67(12), 1881-1885.
11. Hsieh, C., & Christiansen, C. (2010). The effect of approach on spike jump height for female volleyball players. Int. J. Sports. Sci. Coaching International Journal of Sports Science and Coaching, 5(3), 373-380.
12. Kenny, G. (2006). Volleyball Steps to Success: Human Kinetics.
13. Kisner, C., & Colby, L. A. (2007). Therapeutic exercise : foundations and techniques. Philadelphia: F.A. Davis.
14. Lees, A., Vanrenterghem, J., & De Clercq, D. (2004). Understanding how an arm swing enhances performance in the vertical jump. J Biomech, 37(12), 1929-1940. doi: 10.1016/j.jbiomech.2004.02.021

15. Matsuda, S., Demura, S., & Uchiyama, M. (2008). Centre of pressure sway characteristics during static one-legged stance of athletes from different sports. Journal of sports sciences, 26(7), 775-779.

16. Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., . 17. Engebretsen, L. (2008). Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. British journal of sports medicine, 42(6), 394-412.

17. Roth, A. E., Miller, M. G., Ricard, M., Ritenour, D., & Chapman, B. L. (2006). Comparisons of Static and Dynamic Balance Following Training in Aquatic and Land Environments. JOURNAL OF SPORT REHABILITATION, 15(4), 299-311.

18. Şahin, N., Bianco, A., Patti, A., Paoli, A., Palma, A., & Ersöz, G. (2015). Evaluation of knee joint proprioception and balance of young female volleyball players: a pilot study. Journal of Physical Therapy Science, 27(2), 437-440. doi: 10.1589/jpts.27.437

19. Sawdon-Bea, J., & Sandino, N. (2015). The Effects of a Static and Dynamic Balance-Training Program in Female Volleyball Players. J Athl Enhancement, 4:1. doi:10.4172/2324-9080.1000189.

20. Thissen-Milder, M., & Mayhew, J. L. (1991). Selection and classification of high school volleyball players from performance tests. J Sports Med Phys Fitness, 31(3), 380-384.