Effect of Core Strengthening Training on some Biomechanical and Physical Variables and Spike among Volleyball Players

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This research aims to identify the impact of core strengthening training on some biomechanical and physical variables and the level of spike skills in volleyball. The researcher used the experimental method with a pre-test/post-test measurement design with two groups: an experimental group and a control group. The research sample consisted of 14 female 3rd year students at the Faculty of Physical Education for Girls at Helwan University. They were randomly divided into two groups: 7 in the experimental group and 7 in the control group. The researcher used video recording, biomechanical analysis of performance, and physical tests to measure the physical components in the research. She also used the smash spike test to measure spiking skill. Three training modules of the core training program were applied per week for 10 weeks. The duration of each module was 90 minutes. The research results included greater improvement in biomechanical and physical variables and in the level of spike performance for the experimental group compared to the control group, which indicates the effectiveness of the core training.

Keywords: speed power, power endurance, maximum power.

Introduction

Muscle power and all its kinds (speed power, power endurance, and maximum power) is one of the most important physical components, since it affects the development of several other components such as speed, endurance and agility. It also helps the player perform the required kinetic work. Thus, it is the basis for achieving to advanced levels in the practiced activity.

There are several recent trends in the development of muscle power. However, these trends may not focus on the body core area, despite its importance. Bliss (2005), Dave Chimitz (2003) and Jones (2003) note that the exercises to strengthen the core muscles are key for training athletes in all levels, as it serves as a connection between the upper and lower parts of the body (Bliss, 2005: 56; Schmitz, 2003: 13; Jones, 2003: 24).

William (2003) explains that the core is described as muscular box that includes abdominal muscles from the front, thigh muscles and back muscles around the spine from the back and the diaphragm above. If this system works properly, it results in an increase in kinetic efficiency, increase in the stability of the body and production of enormous power from the core muscles as well as the adjacent muscles (shoulder, arms and legs) (William, 2003).

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Akuthota and Nadler (2004) add that core muscles work on the full transfer of power resulting from the lower part of the body through the trunk to the upper parts. Thus, the weakness of core muscles the center will lead to the incomplete transfer of kinetic energy from the bottom to the top, and therefore poor sport performance. (Akuthota & Nadler, 2004).

In volleyball, the trunk area has an important effect on the performance of skills such as smash spike and smash serve. When the player starts preparing for a spike, a trunk rotation in the opposite direction follows. When the trunk completes its movement, this moment is considered the start of rotation to face the spike direction through transmission of movement from the core section (trunk) to the striking arm, where the shoulders axis spins to face the spike point, followed by a downward movement of the arm and wrist to achieve a strong spike (Hamdy & Sobhy, 1997).

Through the researcher's work in volleyball teaching and training, she noticed the weakness of physical and skill level of the students in the Faculty of Physical Education and especially the smash spike skill. This may be due to attending to the development of the arms and legs muscles, and not paying sufficient attention to the core section of the body. Therefore, she thought to propose a training program targeting the development of the body core, and to identify its impact on the ability of the arms and legs, balance, some biomechanical variables, and the level of performance of spike skill in the research sample.

Method

The researcher used the experimental method, applying a pre-test/post-test measurement design on two groups: an experimental group and a control group.

Participants

The research sample was purposively selected from third year students at the Faculty of Physical Education for Girls at Helwan University. Fourteen female students aged 16-17 years participated in the research. The sample was randomly divided into two groups: a control group (7 students) and an experimental group (7 students). Additionally, the best player in Egypt's national volleyball team was selected as a model to study the biomechanical properties of the smash spike skill. The researcher calculated the equivalence and homogeneity of the sample.

Measures

The questionnaire

The researcher designed 3 questionnaires to survey the experts' opinion on:

- Identifying the most influential physical components in the smash spike skill, which can be developed by core stability strength training.
- Identifying the tests that measure physical components.
- Exploring expert opinions about the proposed program components.

The questionnaires was presented to 6 experts in volleyball and deemed an 80% approval rate by experts acceptable.

Physical tests

- Sargent vertical jump test (to measure the ability of legs muscles).

- Throwing a 3-kgm medicine ball test (to measure the ability of arms muscles).
- Measuring the strength of the back muscles test using a dynamometer.
- Sit ups with bent knees to measure the power of the abdominal muscle groups.
- Standing on the instep test to measure balance.

Skill Test

- Straight smash spike test to measure the player's spike skill.

Used Tools

- Digital video camera with high frequency.
- Kinetic analysis program "Win Analyze".
- A tripod with water balance.
- Dynamometer to measure the strength of the back.
- A scale to measure body weight.
- Restameter to measure body height.
- Bosuball
- Stopwatch, bench, different weight, medicine balls, bounce wall, measuring tape, Volleyball Stadium, volley balls.

Procedures

- Pre-test measurements of physical variables, smash spike performance, and video recording (to calculate the mechanical variables) were conducted for the experimental and the control groups.
- The core stability training program of was applied for 10 weeks, and each week included three 90-minute training modules.
- Tables 1 and 2 show the distribution of training loads for the experimental and control groups throughout the training program.
- The post-test measurements of physical variables, spike skill performance and video recording (to calculate the biomechanical variables) were conducted afterwards.

Table 1 shows the training program

Table (1) Core Stability Training Program

Week	intensity	Sets	Repetitions	Rest between sets
week 1	55 %	2	6	20 sec.
week 2	65 %	2	10	30 sec.
week 3	75 %	3	10	45 sec.
week 4	70 %	3	8	45 sec.
week 5	80 %	4	10	60 sec.
week 6	75 %	3	10	60 sec.
week 7	85 %	4	12	90 sec.
week 8	90 %	5	10	120 sec.
week 9	85 %	5	10	120 sec.
week 10	95 %	5	12	180 sec.

Table 2 shows control group program

Table (2) Control Group Program

Weeks	Intensity	Sets	Repetitions	Rest between sets
week 1-2	55%	2	6	20 sec.
week 3-4	65%	2	10	30 sec.
week 5-6	75%	3	10	60 sec.
week 7-8	85%	4	10	120 sec.
week 9-10	95%	5	10	180 sec.

Results

Tables 3, 4 and 5 show the results of the experimental group.

Table (3) Significance of Differences between the Pre-test and Post-test Measurements of the Experimental Group in the Physical and Skills Variables N=7

Variables	Differences		Mean of ranks	Total of ranks	Z value	Significance
Arms ability	negative ranks	0.00	0.00	0.00	2.366	0.018
	positive ranks	7	4	28		
	equal	0.00				
Legs ability	negative ranks	0.00	0.00	0.00	2.375	0.018
	positive ranks	7	4	28		
	equal	0.00				
Strength of back muscles	negative ranks	0.00	0.00	0.00	2.375	0.018
	positive ranks	7	4	28		
	equal	0.00				
Strength of abdominal muscles	negative ranks	0.00	0.00	0.00	2.371	0.018
	positive ranks	7	4	28		
	equal	0.00				
Balance	negative ranks	0.00	0.00	0.00	2.384	0.017
	positive ranks	7	4	28		
	equal	0.00				
Smash spike	negative ranks	0.00	0.00	0.00	2.371	0.018
	positive ranks	7	4	28		
	equal	0.00				

Significance ≤ 0.05

The previous table shows statistically significant differences between the pre-test and post-test measurements of the experimental group in physical and skills variables in favour of the post-test measurement, as Z value ranged between 2.366 and 2.384.

Table 4 shows differences between the pre-test and post-test measurements of the experimental group in mechanical variables.

Table (4) Significance of Differences between the Pre-test and Post-test Measurements of the Experimental Group in Mechanical Variables N=7

Variables	Differences		Mean of Ranks	Total of ranks	Z value	Significance
The vertical composite of the feet pushing force at the moment of upward movement	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				
The vertical shift of the body's centre of gravity at the spiking moment	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				
Angular velocity of the shoulder joint at the spiking moment	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				
The spiking arm velocity at the spiking moment	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				

Significance ≤ 0.05

As noted from the previous table, there are statistically significant differences between the pre-test and post-test measurements of the experimental group with respect to the mechanical variables, in favour of the post-test measurement. Z value ranged between 2.37 and 2.37.

Table 5 shows change percentage between the pre-test and post-test measurements of the experimental group in physical and skills variables.

Table (5) Change Percentage between the Pre-Test and Post-Test Measurements of the Experimental Group in Physical and Skills Variables

Variables	Measurement Unit	Mean of pre-test measurement	Mean of post-test measurement	Change of Percentage
Arms ability	cm	3.86	4.75	32.06%
Legs ability	cm	23.29	35.29	51.52%
Strength of back muscles	kg	16.85	21.71	28.84%
Strength of abdominal muscles	times	27.28	52.29	91.68%
Balance	sec	2.07	3.8	83.75%
Smash spike	degree	8.86	17	91.87%

The previous table shows that the rate of change between the pre-test and post-test measurements of the experimental group in the physical and skills variables ranged between 23.06% and 91.87%.

Tables 6, 7 and 8 demonstrate the results of the control group.

Table (6) Significance of Differences between the Pre-Test and Post-Test Measurements of the Control Group in Physical and Skills Variables N=7

Variables	Differences		Mean of ranks	Total of ranks	Z value	Significance
Arm ability	negative ranks	0.00	0.00	0.00	2.375	0.018
	positive ranks	7	4	28		
	equal	0.00				
Legs ability	negative ranks	0.00	0.00	0.00	2.366	0.018
	positive ranks	7	4	28		
	equal	0.00				
Strength of back muscles	negative ranks	0.00	0.00	0.00	1.841	0.066
	positive ranks	4	2.5	10		
	equal	3				
Strength of abdominal muscles	negative ranks	0.00	0.00	0.00	1.826	0.068
	positive ranks	4	2.5	10		
	equal	3				
Balance	negative ranks	1	4	4	0.944	0.345
	positive ranks	4	2.75	11		
	equal	2				
Smash spike	negative ranks	0.00	0.00	0.00	2.401	0.016
	positive ranks	7	4	28		
	equal	0.00				

Significance ≤ 0.05

The previous table shows that there are statistically significant differences between the pre-test and post-test measurements of the control group in physical and skills variables in favour of the post-test measurement as Z value ranged between 0.944 and 2.401.

Table (7) Significance of Differences between the Pre-test and Post-test Measurements of the Control Group in the Mechanical Variables N = 7

Variables	Differences		Average ranking	Total ranks	Z value	Significant
The vertical composite of the feet pushing force at the moment of upward movement	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				
The vertical shift of the body's centre of gravity at the spiking moment	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				
Angular velocity of the shoulder joint at the spiking moment	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				
The spiking arm velocity at the spiking moment	negative ranks	0.00	0.00	0.00	2.37	0.018
	positive ranks	7	4	28		
	equal	0.00				

Significance ≤ 0.05

As noted from the previous table, there are statistically significant differences between the pre-test and post-test measurements of the control group in the mechanical variables in favour of the post-test measurement, as Z value ranged between 2.37 and 2.37.

Table (8) Change Percentage between the Pre-test and Post-test Measurements of the Control Group in the Physical and Skills Variables

Variables	Measure Unit	Mean of pre-test measurement	Mean of post-test measurement	Change of Percentage
Arms ability	cm.	3.69	4.15	12.47%
Legs ability	cm.	24.71	29.43	19.1%
Strength of back muscles	kg	15.7	17.71	12.8%
Strength of abdominal muscles	times	24.14	25.86	7.13%
Balance	sec.	2.05	2.23	7.73%
Smash spike	degree	9	12.86	42.89%

Table 8 shows that the rate of change between the pre-test and post-test measurements of the control group in physical and skills variables ranged between 7.13% and 42.89.

Tables 9 and 10 show the differences between the results of the experimental and control groups.

Table (9) Significance of Differences between the Post-test Measurements of the Experimental and Control Groups in Physical and Skills Variables N1=N2=7

Variables	the experimental group		the control group		U Value	Significance
	Mean of ranks	Total of ranks	Mean of ranks	Total of ranks		
Arms ability	10.14	71	4.86	34	6	0.018
Legs ability	10	70	5	35	7	0.026
Strength of back muscles	10.79	75.5	4.21	29.5	1.5	0.001
Strength of abdominal muscles	11	77	4	28	0.00	0.001
Balance	10.86	76	4.14	29	1	0.001
Smash spike	10.86	76	4.14	29	1	0.001

Significance ≤ 0.05

The previous table shows that there are statistically significant differences between the post-test measurements of the experimental and the control groups in physical and skill variables in favour of the experimental group, as U value ranged between 1 and 7.

Table (10) Significance of Differences between the Post-test Measurements of the Experimental and Control Groups in Mechanical Variables N1=N2=7

Variables	the experimental group		the control group		U Value	sig
	Means of ranks	Total of ranks	Means of ranks	Total of ranks		
The vertical composite of the feet pushing force at the moment of upward movement	10.14	71	4.86	34	6	0.017
The vertical shift of the body's centre of gravity at the spiking moment	10	70	5	35	7	0.026
Angular velocity of the shoulder joint at the spiking moment	10.29	72	4.71	33	5	0.011
The spiking arm velocity at the spiking moment	10.86	76	4.14	29	1	0.001

Significance ≤ 0.05

As noted from the previous table, there are statistically significant differences between the post-test measurements of the experimental and the control groups in mechanical variables in favour of the experimental group, as U value ranged between 1 and 7.

Discussion

Discussion of the results of the experimental group:

Tables 3, 4, and 5 show that there are statistically significant differences between the pre-test and post-test measurements of the experimental group in the physical and biomechanical variables and the level of the smash spike skill performance in favor of the post-test measurement.

The researcher attributed these differences to the proposed core training program, structuring the loads in a scientific manner that matches the sample's age, and the use of bosuball which allows performing the exercises properly and interestingly and develops balance when performing on the flat side of the device. The exercises used in the study, such as the ability, power, and balance exercises, in addition to core stability exercises, helped improve the examined fitness elements (the power of the back and abdominal muscles, the muscle power of the arms and legs, and balance).

This is consistent with the results of biomechanical variables, as the value of the vertical composite of the feet pushing force at the moment of upward movement and the value of the vertical shift of the body's center of gravity increased. The researcher attributed this increase to the positive impact of the core training, which had a positive effect on the full transfer of power from the trunk to the part of the body and vice versa. Balance exercises also helped to balance and keep the body in the air in the right position.

Table 4, demonstrates the improvement of the spiking arm's velocity and angular velocity of the shoulder joint at the spiking moment. This is consistent with what Akuthota and Nadler (2004) indicated that the core stability training works on strengthening core muscles, as well as the full transfer of power from the lower part of the body through the trunk to the upper parts of the body, thus leading to good performance.

The results of this study are consistent with the study of Shackle (2010), Kahle (2009), Thomas et al. (2009) that the core training contributed in the improvement of muscle power, muscle ability, and balance.

Discussion of the results of the control group:

Tables 6, 7 and 8 highlight the differences between the pre-test and post-test measurements of the control group in favor of post-test measurement in all the physical and mechanical variables and the level of performance (except for the elements of: the power of the back and abdominal muscles and balance). This may be due to the fact that these elements need more focus in the training program, intensifying their exercises, and increasing the time allocated for their development in the program.

The researcher attributes the improvement in the other physical and mechanical variables is due to the control group's training program, which included the development of general fitness elements, and elements specific to the spike skill

in a balanced manner. In addition to this, regular training for 3 modules per week improves the physical and skills level and thus improves the mechanical variables related to the spike skill.

Also, tables 9 and 10 demonstrate the existence of significant differences between the post-test measurements of the experimental and control groups in favor of the experimental group in the physical and biomechanical variables as well as the level of the smash spike performance. This indicates the positive impact of the core training that led to this improvement.

Recommendations

The researcher recommends the application of the core training program since it has a positive effect on some biomechanical and physical variables as well as the level of spike performance volleyball. She also recommends conducting more studies that address the influence of Core Training on other sports, different samples, and on different age groups.

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