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The Impact of Different Training Methods on Muscular Strength and Anaerobic Power for Volleyball 1st Degree Female Players

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Abstract

Volleyball is one of the game sports that is characterized with a special training nature which requires a specific training routine that helps in enhancing the performance level of players. The aim of this study was to compare the impact of 3 different training methods "plyometric training, weight training, and their combination" on the vertical jump performance, anaerobic power and muscular strength for female 1st degree volleyball players in Egypt. Based on their training, 52 female 1st degree national championship players were divided into 4 groups after excluding 4 players due to injury at the beginning of performing this research: a plyometric training group (n=13), a weight training group (n=11), a plyometric plus weight training group (n=14), and a control group (n=10). The vertical jump test, the fifty-yard run and maximal leg strength were measured before and after a eight-week training period. Subjects in each of the training groups trained 3 days per week, whereas control subjects did normal training routine. The data was analyzed by a 1-way analysis of variance (repeated-measures design). The results showed that all the training treatments showed significant (P<0.05) improvement in the entire tested variables. However, the combination training group showed signs of improvement in the vertical jump performance, the 50 yard dash, and leg strength that was significantly greater than the improvement in the other 2 training groups (plyometric training and weight training). This study provides support for the use of a combination of traditional weight training and plyometric drills to improve the vertical jumping ability, explosive performance in general and leg strength.

Introduction & Research Problem

Volleyball is one of the game sports that is characterized with a special training nature which requires a specific training routine that helps in enhancing the performance level of players (Talha et al, 1997). Upon becoming a member of the volleyball team, each player is expected to accept certain responsibilities that are a part of their participation in the volleyball program as success in this sport depends heavily upon the athlete's special physical abilities like explosive leg power and muscular strength. As in jumping, the athlete must be able to use his/her leg strength as quickly and forcefully as possible. This display comes in the form of speed-strength or power (Yessis, & Hatfield 1986). Power represents the amount of work a muscle can produce per unit of time. An increase in power gives the athlete the possibility of improved performance in sports in which the improvement of the speed-strength relationship is sought (Paul, et. al., 2003) (Aly Elbek et al, 2009).

Sports Training depends recently on other branches of knowledge and their application in the field of sports.

Referring to Keith Davis (2001), Abou Al Ela (2003) states that the theory of dynamic paradigms depends on the understanding of coaches and instructors that the success of training in any sport is above on a number of variables which differ from one athlete to the other there variables determine the nature of training, the availability of equipment and the genetic inheritance of the players (A:480, 481) Accordingly, chshructors and coaches involved new method of training.

The integrative training including weight lifting, plyometric exercises, and other exercises became highly used and recommended in the development of physical power and speed. (3: 65)

Volley ball has a very prestige one’s and influential statues in the Olympics as it is distinguished by the non-fiction of the players.

Volleyball requires special physical fitness abilities as speed and power. The experts of volleyball stress the fact that there is a strong link between the speed and power of players, on the one hand, and there skills of leg movements. Players fail to acquire the basic skills of leg movement if they con not acquire speed and power. (39: 360)

Accordingly, the researcher state that the players should posse’s there basic skills so that they can learn the new techniques in volleyball.

The researcher – as a practitioner in the field – claims That Egypt is typing to maintain presentable performance in international competitions and the Olympics. Consequently, the researcher aims at developing a training program to develop the physical performance of the players and their skills and tactics in volleyball.

This program adept the nother of research that claims that weight lifting and polymeric exercises are the most appropriate test's for developing muscular power and speed. The program is applied though three different sub-programs on the female first team players. The programs aim at drawing correlation between the affect of these programs on the muscular power of the target Population and their vertical jump.

On testing the impact of different training methods on the level of physical abilities of volleyball players, several studies used plyometric training and have shown that it improves power output and increases explosiveness (Adams, et al., 1992; Ioannis, et. al., 2000) by training the muscles to do more work in a shorter amount of time (Holcomba, 1996). This is accomplished by optimizing the stretch-shortening cycle, which occurs when the active muscle switches from rapid eccentric muscle action (deceleration) to rapid concentric muscle action (acceleration), (Wagner, & Kocak, 1997; Potteiger, et. al., 1999). The rapid eccentric movement creates a stretch reflex that produces a more forceful concentric muscle action (Wagner, & Kocak, 1997; Cachnce, 1995) than could otherwise be generated from a resting position (Potteiger, et. al., 1999). The faster the muscle is stretched, the greater the force produced, and the more powerful the muscle movement (Clutch, et. al., 1983; Wagner, & Kocak, 1997). Plyometric exercises that exploit the stretch-shortening cycle have been shown to enhance the performance of the concentric phase of movement (Gehri, et. al., 1998) and increase power output (Adams, et al. 1992; Paul, et. al., 2003).

Many researchers agreed to define jumping as a complex multi-joint action that demands not only force production but also a high power output. Others have underlined the significance of maximal rate of force development in the improvement of explosive jumping performance (Behm, & Sale, 1993; Hakkinen, & Komi, 1985). Plyometric training has been advocated for sports that require the athletes to have explosiveness and an increased vertical jumping ability.

One of the characteristics of plyometric exercises is that it works on the elastic properties of the muscle fibers and connective tissues in a way that allows the muscle to store energy during the deceleration phase and release that energy during the acceleration period (Asmussen, 1974; Bosco, et. al., 1982; Kaneko, et. al., 1983; Stone, &. O'Bryant, 1986). Weight training has been able to improve vertical jumping performance in most cases by 2 – 8 cm (or by 5 – 15 %) (Adams, et al. 1992; Anderst, et. al., 1994; Blakey, & Southard, 1987; Blattner, & Noble, 1979; Ioannis, et. al., 2000).

The comparison of plyometric exercises and weight-training methods has produced controversial results. Plyometric methods have been shown to be more effective (Verkhoshanski, & Tatyan, 1983) (Khayria E. et al 2009), equally effective (Adams, et al. 1992; Anderst, et. al., 1994; Ioannis, et. al., 2000), or less effective (Stone, & O'Bryant, 1986; Verkhoshanski, & Tatyan, 1983) than weight training in improving the vertical jumping ability.

The combination of plyometric exercises and weight training increased (Adams, et al. 1992; Baur, et. al., 1990,, Behm, & Sale, 1993; Ioannis, et. al., 2000) or maintained unaffected vertical jumping performance (Stone, & O'Bryant, 1986). Adams et al. (Adams, et al. 1992) suggested that this combination may provide a more powerful training stimulus for the vertical jumping performance than either weight training or plyometric training alone. However, Clutch et al. (1983) did not reach similar conclusions and Ioannis, et. al. (2000) suggested that the combination of plyometric and weight training increased muscular strength. It seems that researchers have not come to an agreement about the relative effectiveness of plyometric training compared with weight training or the combination of both in the development of the vertical jumping ability. It seems likely that different durations of training periods, different training statuses of the subjects, or different training designs (i.e., training loads or volumes or exercises) might have caused the discrepancy in the results of previous studies.

Therefore, The purpose of the present investigation was to determine how selected variables of vertical jumping performance, namely, leg power, jumping height, and leg strength, are affected by a typical 8-week plyometric training program, a typical 8-week weight-training program, and 8-week training program that combines plyometric exercises and weight training.

Aim of the research:

This research aims at identifying the affect of the different training Methods on muscular power, vertical jumping and the playing serve skill of the female first team players of volleyball as follows:

1) Identifying the effect of polymeric exercises on muscular power, vertical jumping and playing the serve.
2) Identifying the effect of weight lifting on muscular power, vertical jumping and playing the serve.
3) Identifying the effect of the combination of the above training tasks on muscular power, vertical jumping and the playing of the serve.

Hypothesis Research:

1- there is a clear effect of using the poly metric exercises on the muscular power and vertical jump of the target Population.

2- There is a clear effect of using the weight training task on the muscular power and vertical jump of the target Population.

3- There is a clear effect of using the integrative method on the muscular power and the vertical jump of the target Population.

4- There is a clear effect of using the different methods of warning on playing the serve.

Research method:

The researcher used the experimental approach in three experimental training but not in the forth task (control)

1) Research setting:

The priori and posteriori measurements tesk place in the Olympic center in Cairo, Egypt

2) Time:

The study task place starting on the first of January 201 and finished in March 201.

3) Target Population:

The target Population includes 52 players in the ladies first team player of the national Egyptian team. Four players were rejected because of their injury in the priori stapes of research. The players were divided into 4 groups as follows.

1) The first experimental group includes 13 players for the polymeric tasks.
2) The second experimental group includes 11 players for the weight lifting tasks.
3) The third experimental group includes 14 players for the integrative tasks.
4) The fourth group includes 10 players for control.

The following features exit in the target population:-

1) all the players are registered in the national union for volleyball.
2) There age ranges from 22.5 years.
3) They spent 5 years or more in training.
4) All players participate in the national championships in Egypt.

Their punctuality and attendance in all warning exercises during the period of the program.

Table 1. Descriptive data of subject's characteristics

Group	n	Height (cm)	SD	Weight (kg)	SD	Age (y)	SD	serve	SD
Control	10	173.90	+/-7.04	71.31	+/-5.06	21.90	+/-1.3	10.71	+/-0.969
Plyometric	13	175.01	+/-5.36	70.63	+/-6.47	22.75	+/-1.2	8.05	+/-0.935
Weight	11	179.09	+/-9.02	72.90	+/-6.90	21.65	+/-1.0	9.32	+/-0.954
Mixed	14	174.45	+/-6.15	71.75	+/-8.88	22.80	+/-0.8	10.71	+/-0.969

Research terminology:

Plyometric training: Plyometrics, or "PLYOS" for short, are a type of exercise designed to produce fast and powerful movements. They are generally used by athletes to improve performance in sports, especially those that involve speed, quickness and power. In addition, it is possible to find plyometrics used in the fitness field, but to a much lesser degree. Thus, plyometric exercises use explosive, fast-acting movements to develop muscular power and to improve overall speed. In other words, it's exercise that allows muscles to exert maximum force in the shortest amount of time possible.

Weight training: Weight training is a common type of strength training for developing the strength and size of skeletal muscles. It uses the weight force of gravity (in the form of weighted bars, dumbbells or weight stacks) to oppose the force generated by muscle through concentric or eccentric contraction. Weight training uses a variety of specialized equipment to target specific muscle groups and types of movement.

Methods

Subjects

Forty-eight female 1st degree volleyball players in Egypt volunteered to participate in this study (the subjects' characteristics are given in Table 1). All of the subjects played on different teams in 1st degree volleyball national championship. All of the subjects had successfully passed a physical exam and completed a medical history questionnaire in which they were screened for any

possible injury or illness. The subjects received all the necessary information about the study's procedures in oral and written form. Each subject completed a medical history form (special care was given to hypertension and orthopedic status screening), a training background questionnaire, and a written informed consent form.

Vertical Jump Height

Fig (1): Vertical jump height test

Vertical jump height was measured by the stand and reach test (Chu, 1996). A vertical jump test was completed from a 2-foot standing position without a step into the jump. The subjects were allowed to use their hands as they desired. Three test jumps were completed, and the highest of these was recorded. This test was selected because it has high validity (0.80) and reliability (0.93) coefficients (Safrit, 1990) and because it allows arm movement and a squat motion before the jump, such as those performed in sports.

Measurement of the 50 yard dash

Fig (2): 50 yard dash test

The 50-yard dash is one of the short-term tests of muscular power that indirectly reflects the measure of the subject's ability to regenerate ATP during that interval. This test was selected because it has a high correlation coefficient (0.974) with the Margaria- Kalamen Power Test (Fox & Mathews, 1971). This method has the subjects start 15 yards from the start line and time is measured from a start distance of 50 yards.

Measurement of Leg Strength

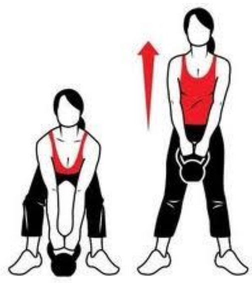

Fig (3): Measurement of leg strength

(1RM) test was performed to assess strength isotonically a one repetition maximum (1RM) test was performed. Leg strength was assessed by the 1RM (1 repetition maximum) squat. In the squat 1RM test, subjects executed the traditional back squat exercise following the NSCA guidelines for the execution of this particular test. However, a manual goniometer was used at the knee to standardize the range of motion. The subjects started the squat exercise at a 30° knee flexion, descended to 90°, and then forcefully returned to the starting position by extending both knees and hips and plantar flexing at the ankles. Testers alerted the subjects when the starting and finishing positions were attained (Brown, et. al., 1986).

Data Acquisition

After analyzing anthropometric measurements for all research groups, members of research sample were proved homogenous. Then each subject underwent measurements of his vertical jumping performance, the 50-yard run and maximal leg strength. Pre-testing was conducted in 5 sessions 1 week before initiation of the training period. The first session included an introduction of the testing methods to the subjects. The second session included the measurement of vertical jumping performance. In the third session, leg strength was determined by the 1RM Squat. During the fourth session, the 50- yard run was measured. There was a 24-hour pause between the testing sessions. Identical measurements were performed in the same order 4 days following the completion of the training period.

Training Methods

After the initial measurements, the subjects were divided into 4 groups: the control group (n = 10), the plyometric training group (n = 13), the conventional weight training group (n = 11), and the combination of plyometric plus weight training group (n = 14). The control group performed natural training routine. The other 3 training groups trained for 8 weeks, 3 days per week. Before the initiation of the training periods, the subjects of all groups were instructed about the proper execution of all the exercises to be used during the training period for all training regimens. The training methods included only leg exercises. None of the subjects had used plyometric exercises before. The training programs were designed to overload the leg muscles involved in the vertical jumping motion and explosive performance.

The subjects in the plyometric group performed four plyometric drills – the Depth jump, the Split squat jump, the Rim jump, the Box to box depth jump. The depth jump height started at 40 centimeters and progressed to 75 centimeters in the Fourth 6-Sessions. The subjects in the weight training group started with four sets of ten repetitions at 40 percent of 1RM during the First 6-Sessions, and progressed to four sets of six at 100 percent of 1RM during the Fourth 6-Sessions. The plyometric-weight training group performed a combination of the two training programs (plyometric and weight training program) but the volume and intensity of the work was reduced by 25 percent (Adams, et al., 1992). All training sessions were supervised. The training programs are shown in Tables 2, 3, 4.

Table 2. Plyometric training (PT) Program

Plyometric	Session 1 to 6	Session 7 to 12	Session 13 to 18	Session 19 to 24
Depth jump	# 3*6(40) 30	3*8 (50) 30	4*7(60) 30	4*8(75) 30
Split squat jump	3*6(-) 30	3*8 (-) 30	4*7(-) 30	4*8(-) 30
Rim jump	3*6(-) 30	3*8 (-) 30	4*7(-) 30	4*8(-) 30
Box to box depth jump	®2*6/4 (40) 30	3*5/5(50) 30	4*5/5(60) 30	4*6/6(75) 30

Sets*reps at (box height (cm)) rest time between sets

® Sets*reps/number of boxes at (box height (cm)) rest time between sets

Table 3. Weight training (WT) Program

Weight training	Session 1 to 6	Session 7 to 12	Session 13 to 18	Session 19 to 24
Squat	# 4*10(40%) 60	4*10(40%) 60	4*8(80%) 50	4*6(100%) 40
Leg press	4*10(40%) 60	4*10(40%) 60	4*8(80%) 50	4*6(100%) 40
Leg extension	4*10(40%) 60	4*10(40%) 60	4*8(80%) 50	4*6(100%) 40
Leg extension	4*10(40%) 60	4*10(40%) 60	4*8(80%) 50	4*6(100%) 40

Sets*reps at (percentage of 1RM) rest time between sets

Table 4. Plyometric + Weight training (PWT) Program

Mixed training	Session 1 to 6	Session 7 to 12	Session 13 to 18	Session 19 to 24
Depth jump	# 3*4 (30) 30	# 3*6(40) 30	3*7(45) 30	4*6(55) 30
Split squat jump	3*4(-) 30	3*6(-) 30	3*7(-) 30	4*6(-) 30
Rim jump	3*4(-) 30	3*6(-) 30	3*7(-) 30	4*6(-) 30
Box to box	® 3*4/3(30) 30	3*4/4(40) 30	3*5/5 (45) 30	3*6/6(55) 30

depth jump				
Squat	ϴ 4*8(30%) 60	4*8(45%) 60	4*6(60%) 50	3*6(75%) 40
Leg press	4*8(30%) 60	4*8(45%) 60	4*6(60%) 50	3*6(75%) 40
Leg extension (squat)	4*8(30%) 60	4*8(45%) 60	4*6(60%) 50	3*6(75%) 40
Leg extension (1 RM)	4*8(30%) 60	4*8(45%) 60	4*6(60%) 50	3*6(75%) 40

Sets*reps at (box height (cm)) rest time between sets

® Sets*reps/ number of boxes at (box height (cm)) rest time between sets

ϴ Sets*reps at (percentage of 1RM) rest time between sets

Statistical Analyses

The researcher used paired t-tests as it was most suitable mean of processing this data to identify any significant differences between the groups at the pre and post measurements for the research variables. An analysis of variance with repeated measures was used to determine significant differences for vertical jump height, leg strength and the 50-yard dash time within the 4 training groups. When a significant difference among the training programs was detected, a pair-wise comparison of the programs was done using a Bonferroni post hoc test to identify significant differences between the training programs. The alpha level was set at 0.05 in order for the difference to be considered significant. All values are reported as mean ± standard deviation (Table 5).

Table 5. Means ± SEs between pre-training and post-training for all the dependent variables for the 4 groups

Group		Vertical jump height	S+/-D	Squat	S+/-D	50 yard dash	S+/-D
Plyometric group	Pre	43.57	+/-7.65	84.60	+/-14.06	6.740	+/-0.63
	Post	52.30	+/-5.61#® ϴ	110.70	+/-14.40#® ϴ Ω	6.440	+/-0.45® ϴ
Weight group	Pre	43.22	+/-6.30	81.80	+/-9.02	6.740	+/-0.37
	Post	50.36	+/-3.44#®©	145.90	+/-22.10#® Ω	6.442	+/-0.40#®©
Mixed group	Pre	43.92	+/-8.15	90.30	+/-12.40	6.710	+/-0.51
	Post	58.39	+/-3.29#® ϴ©	139.60	+/-30.90#® ϴ	5.625	+/-0.41#® ϴ©
Control group	Pre	43.00	+/-7.08	81.00	+/-18.00	6.750	+/-0.54
	Post	45.80	+/-9.53	78.00	+/-13.50	6.638	+/-0.56

Significant difference between pre-training and post-training (P< 0.05).

® Significant difference compared with the control group (P< 0.05).

ϴ Significant difference between the PT and PWT groups (P< 0.05).

© Significant difference between the WT and PWT groups (P< 0.05).

Ω Significant difference between the PT and WT groups (P< 0.05)

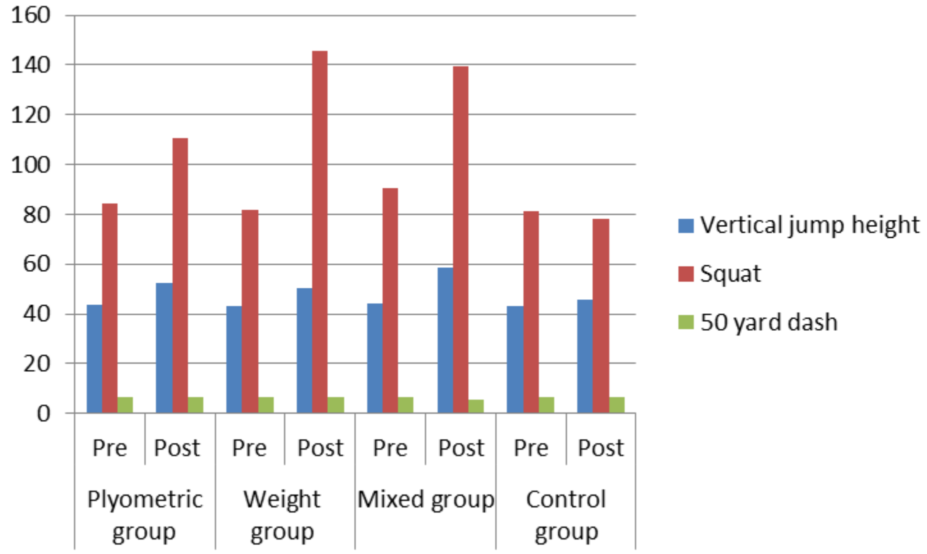

Fig (4): Means of pre and post training research variables

Results:

Above tables shows that means and SEs for vertical jump height, the 50-yard dash and leg strength (in squat tests) are listed in Table 5. ANOVA procedures demonstrated a significant value ($P < 0.05$) for all the tests and the results of the experimental groups were better than those of the control group and the Bonferroni post hoc test was used for a pair-wise comparison of the programs (Table 5). Mixed training was significantly better ($P = 0.001$) than either PT or WT, but there were no differences between PT and WT ($P = 0.842$) in increasing hip and thigh power production and speed as measured by the vertical jump and the 50-yard dash tests. PWT (complex training) training was significantly better ($P = 0.001$) than PT, WT was significantly better ($P = 0.002$) than PT, but there were no differences between PWT and WT ($P = 0.895$) in increasing leg strength production as measured by the 1RM Squat.

Also paired t-tests showed that the experimental groups showed significant increase in the vertical jump height (PT = 8.73 cm, $P = 0.001$; WT = 7.14 cm, $P = 0.002$ and PWT = 14.47 cm, $P = 0.001$), leg strength (PT = 26.1 kg, Wt = 64.1 kg, PWT = 49 kg; $P = 0.0001$), and time for running the 50 yards had decreased (PT = 0.3 sec, $P = 0.063$; WT = 0.298 sec, $P = 0.001$; PWT = 1.085sec, $P = 0.004$) in post-training in relation to pre-training.

Discussions:

This research aimed for determining if plyometric training alone or in combination with weight training can enhance vertical jumping performance, leg strength and speed. The results indicate that short term plyometric training is capable of improving the vertical jumping ability, muscular strength and anaerobic power but its combination with weight training is even more beneficial.

The results of this investigation are in accordance with previous studies (Asmussen, 1974; Adams, et al. 1992; Behm, & Sale, 1993; Cavagna, 1977; Cavagna, 1968, Zaki M. 1998), showing that a combined program of weightlifting and plyometrics can significantly increase the vertical jump ability.

Although it is wide-spread use in athletics and the specific guidelines given regarding its use, more studies are needed to evaluate its effectiveness, especially compared with other conventional training methods such as weight training or its combination with them. The combination of different training methods will promote all the qualities of muscle power and strength. Several previous investigations have failed to find that plyometric training is significantly more effective than other training methods in improving the vertical jumping ability (Clutch, et. al., 1983; Ford, 1983; Holcomba, 1996; Lyttle, 1996; NSCA, 1993).

Furthermore, previous research that used a combination of plyometric and weight training found either an increased (Adams, et al. 1992;

Baur, et. al., 1990; Blakey, & Southard, 1979; Ioannis, et. al., 2000) or unaffected vertical jumping performance (Ford, et. al., 1983). Other investigators (Clutch, et. al., 1983, Lyttle, 1996) found that the combination of plyometric and weight training is equally effective as either plyometric or weight training. The results of the present study indicate otherwise. This combination training provided the most powerful stimulus for improving the vertical jumping ability.

Plyometric training alone, as has been shown by this study and others carried out by authors such as Blattner and Noble (1979) and Bosco (1982), can also have a significant effect in increasing hip and thigh power that is measured by the vertical jump. Bosco believes that this results from enhancing motor unit recruitment and improving the muscles' ability to store kinetic energy within the elastic components of the muscle (Bosco, et. al., 1982). This may enhance hip and thigh power by increasing the explosive capabilities of the athlete. The transfer of this explosiveness to activities other than the vertical jump needs further investigation.

As could be expected, the results of this study illustrated that Plyometric + Weight Training program has a significant effect on Plyometric training and Weight training programs for increasing hip and thigh power as measured by the 50-yard dash test. O'Shea (1985) believes that the dynamic nature of this training is highly conducive to enhancing neuromuscular efficiency (e.g., facilitating the stretch reflex). This in turn allows for excellent transfer of power to other biomechanically similar movements that require a powerful thrust from the hips and thighs, such as running. Training programs that have utilized plyometric exercises have been shown to positively affect performance in power-related movements such as jumping (Blattner & Noble, 1979; Clutch, et. al., 1983; Holcomba, 1996, Lachance, 1995) and speed (Adams, 1984; Ford, et. al., 1983; Rimmer & Sletvert, 2000).

Finally, this study illustrates that a combined PT and WT program significantly increases hip and thigh power production, as measured by the vertical jump, than either the WT or PT program. This result is in accordance with previous studies (Adams, et al. 1992; Baur, et. al., 1990; Blakey, & Southard, 1979; Ioannis, et. al., 2000). Improved muscle performance due to a plyometric training program may also be due in part to increased motor unit functioning. Previous studies have indicated that neuromuscular adaptations such as an increased inhibition of antagonist muscles as well as better activation and co-contraction of synergistic muscles may account for the improvements in power output (Komi, 1984; Lyttle, 1996.).

During a plyometric movement, the muscles undergo a very rapid switch from the eccentric phase to the concentric phase. This stretch-shortening cycle decreases the time of the amortization phase that in turn allows for greater than normal power production (Holcomba, 1996; Potteiger, et. al., 1999.). The muscles store elastic energy and stretch reflex responses are essentially exploited in this manner, permitting more work to be done by the muscle during the concentric phase of movement (Harman, et. al., 1991; Holcomba,

1996).

In this study, maximal strength as measured by the 1RM squat was improved more by weight training than by plyometric training, and there was no significant difference between weight training and plyometric - weight training. This finding probably is related to the nature of muscular strength, that strength is increased in low movement of the phase of eccentric contraction more than during the fast movement of this phase; therefore, a weight training program increases strength more than plyometric training. Weight and plyometric training programs involve eccentric and concentric contractions, but in weight training programs the velocity of the contraction is slower than in plyometric training. Previous studies have documented that strength was increased more during the low velocity movement of the phase of eccentric contraction than during the high velocity of this phase; therefore, a weight training program may stimulate greater strength adaptations.

In contrast to previous studies, the results of the present study indicate that all treatments produce improvement in vertical jumping, explosive performance and muscular strength. However, the combination training treatment evoked the most significant changes in these variables. The discrepancy between these results and the results of previous investigations might be attributed to several reasons. First, the training experience level of the study subjects might offer one explanation. Subjects in the present study were novices in plyometric training in contrast to the subjects in previous investigations. However, they were strength trained enough to be able to sustain plyometric training loads. One needs to be weight trained to enjoy positive adaptations to plyometric training. The second explanation is the nature of the training methods used in the present study and previous investigations.

This study clearly illustrates the close working relationship between neuromuscular efficiency (e.g., multiple fiber recruitment and facilitating the stretching reflex) and dynamic strength performance. With reasonable confidence, it can be said that WT programs are conducive to the development of hip and thigh strength, while the simultaneous application of plyometrics permits effective use of this strength to produce explosiveness in sports or events demanding speed and quickness. In other words, the role of plyometrics is to facilitate the neuromuscular system into making a more rapid transition from eccentric to concentric contractions, whereby maximal ballistic force is generated (Adams, K., et al. 1992). This lends support to the theories of Gambetta (1986); O'Shea (1985); Yessis and Hatfield (1982), who believe that plyometric training is the link between speed and strength.

Another interesting note is that, despite the fact that the subjects in the combination group performed plyometric and weight training on the same day, their performance was not impaired. This result is in accordance with Ioannis (Ioannis, et. al., 2000) who demonstrated that subject performance was not impaired in this procedure. NSCA and others (Chu, 1996; NSCA, 1993) do not recommend performing heavy strength and plyometric training on the same day, with the exception of track and field athletes, who might benefit from a combination of plyometric and weight training program, "complex training." In the present study, there was enough rest between the sessions to allow recovery of the neuromuscular and metabolic systems of the subjects. Plyometric training was performed first to ensure that the subjects would perform the plyometric drills with the proper technique and full explosiveness.

Conclusions:

Power and strength are two major components for volleyball female players so as to achieve higher performance levels and this can be achieved by using mixed or combined training methods which has been proven as an effective way to enhance the levels of fitness components which in turn will affect both technical and tactical performance positively.

Recommendations:

The results of this study provide insight into several aspects for the improvement of athletes' explosiveness and muscular strength as follows:

1- The results of this study claim that training must incorporate special exercises that focus on power development once the strength levels have been improved.
2- Intensity and training volume followed the progressive overload principle in the present study. Weight intensity and the volume of training were built up, gradually allowing the subjects to adjust effectively, especially the subjects who followed the plyometric training methods. Variation of intensity within each week of training seems to have helped subjects who participated in all the training groups.
3- Despite the fact that execution of plyometric training and weight training is not generally recommended on the same day, the present study indicates that this might not be true if adequate recovery is allowed in between.
4- It seems that 8 weeks is an adequate period for the improvement of vertical jumping and muscular strength if the training methods maintain the appropriate intensity and volume.
5- In this study, 3 days of training per week has proven to be an effective training frequency for improving the vertical jump performance and muscular strength. However, this cannot be accomplished during the in-season period. Such training methods should be

incorporated in the pre-season or post-season training periods.

6- The results of this study concern individuals relatively inexperienced in plyometric training. It is possible that advanced athletes in power sports would not exhibit the same magnitude of improvement with the training methods used here. It is possible that more advanced athletes need a different manipulation of training intensity and volume and selection of exercises.

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