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Original article

EFFECT OF CONCURRENT TRAINING ON VO_2 MAX, CERTAIN PHYSICAL VARIABLES AND SPIKE PERFORMANCE FOR YOUNG FEMALE VOLLEYBALL PLAYERS

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Abstract

Purpose. Cardiovascular and strength training workouts either during the same training session or within hours of each other. This sequential exercise regime referred to as “concurrent training.” The purpose of this study was to investigate the effects of concurrent training on vo2 Max, static strength, power, strength endurance and spike performance among young female volleyball players.

Methods. Twenty young female volleyball players (mean +/- SD age, 15 +/- 1.7 years), divided into two experimental groups: (Experimental group -10 young female volleyball players) and (control group -10 young female volleyball players) from the APHRODITE club, Kurdistan Iraq. Training experience of all the participants ranged from 3 to 4 years. Subjects and coaches were required to read and complete a health questionnaire and informed consent document; there was no history of injuries, diabetes or recent surgery. Subjects in experimental group participated in concurrent training for eight weeks, 3 days per week. Subjects completed 8-10 resistance-training exercises first, and then completed their hour of training by walking / jogging / running for up to 30 minutes on a treadmill at a prescribed target heart rate. The Astrand Treadmill Test used to determine the VO_2 Max, and dynamometer instruments used to measure the strength of the leg and back.

Results. The results revealed significant increases in VO_2 Max, strength, power and spike performance for the Experimental group versus the control group.

Conclusions. Finally, the present study shows that eight weeks of concurrent strength and endurance training has beneficial effects on musculoskeletal power and VO_2 Max

Key words: VO_2 Max, concurrent training, volleyball.

Introduction

Volleyball is a sport whose athletes must demonstrate explosive moves, agility, vertical jumps, strong hits and serves. Position rotation requires players to be well rounded and excel at all positions. Strength training will give them the edge needed to excel in this sport. Volleyball athletes will get the best results if they put into practice periodization of their training. Bompa (1993) defines, "Periodization is the process of varying a training program at regular time intervals to bring about optimal gains in physical performance. The goal of periodizing an exercise program is to optimize training during short (e.g., weeks, months) as well as long periods of time (e.g., years, a lifetime, or an athletic career). Using periodization, a competitive athlete is able to peak physical performance at a particular point in time, such as for a major competition." Concurrent training is one method that many coaches employ as it consists of training multiple qualities at equal amounts of focus within the same training phase and often within the same workout. The biggest issue that can arise from this sort of programming is that often times the two or three qualities one is looking to enhance end up competing with each other for adaptation.

In volleyball, a spike is a strategy play that sends the ball over to the opponent giving him or her little chance of returning it. Usually, the ball struck so forcefully so that it lands on the ground.

All types of training, whether it is strength training or long distance running, will produce specific responses from the body which trigger gene expression and molecular changes that in turn cause the body to adapt to the training stimulus in order to make us more prepared to tackle this stressor should we need to face it again (next workout or competition). One of the arguments against concurrent training is that the adaptations that the body's internal environment under goes in response to the differing training stimuli brought on by the multiple qualities being trained in the training day or training phase are on different ends of the spectrum thus confusing the body as to how it should respond and leading to less than favorable adaptations. This referred to as the Interference Phenomenon. (Bell et al., 2000; Dantas et al., 2008).

In 1980, Hickson et al. first provided evidence for the existence of an “interference phenomenon” between resistance and endurance training by demonstrating that strength gains hindered when the two types of training performed concurrently. Since

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that time, the combination of resistance training and endurance training has been frequently used in athletics.

Oxygen uptake (VO2) at maximal exercise considered the best index of aerobic capacity and cardiorespiratory function. Maximal VO2 defined as the point at which no further increase in measured VO2 occurs and a plateau reached, despite an increase in work rate during graded exercise testing.

Strength and endurance training regimes represent and induce distinctly different adaptive responses when performed individually. Typically, strength-training programs involve large muscle group activation of high-resistance, low-repetition exercises to increase the force output ability of skeletal muscle (Sale et al., 1990). In contrast, endurance-training programs utilize low-resistance, high-repetition exercises, such as running or cycling, to increase maximum O2 uptake (VO2 Max). Accordingly, the adaptive responses in skeletal muscle to strength and endurance training are different and sometimes opposite (H. Tanaka and Swensen, 1998). Therefore, the purpose of this investigation was to examine the effects of concurrent training on vo2 Max, static strength, power, and strength endurance among young female volleyball players.

Material and Methods

Experimental approach

Two experimental groups performed a pre- and post-training intervention in which VO2 Max, and the physical variables, including leg strength (LS), back strength (BS), standing long jump (SLJ), and strength endurance for legs and arms (SEL; SEA), were measured.

Experimental group performed concurrent training for one hour per day, three times a week, for eight weeks. Control group performed traditional training in the volleyball court for one hour per day, three times a week, for eight weeks. The groups completed the training programs to see whether this type of training modality would have a positive, negative, or neutral effect on VO2 Max, HR, LS, BS, SLJ, SEL, and SEA.

Participants. Twenty young female volleyball players (mean +/- SD age, 15 +/- 1.7 years), divided into two experimental groups: (Experimental group -10 young female volleyball players) and (control group - 10 young female volleyball players) from the APHRODITE club, Kurdistan Iraq. Training experience of all the participants ranged from three to four years. All subjects were free of any disorders known to affect performance, such as bone fractures, osteoporosis, diabetes, and cardiovascular disease, and had not undergone recent surgery. The participants did not report use of any anti-seizure drugs, alcohol and cortoon consumption, nor cigarette smoking. All participants fully informed about the aims of the study and gave their voluntary consent before participation. The measurement procedures were in agreement with ethical human experimentation.

Training Protocol

The eight-week, in-season training program consisted of resistance training and endurance training.

Procedures

Subjects assessed before and after the eight-week training program. All measurements taken one week before and after training at the same time of day. Tests followed a general warm-up that consisted of running, calisthenics, and stretching.

Astrand Treadmill Test (ATT)

To perform this test you will require:

- Treadmill
- Stopwatch
- Assistant

This test requires the athlete to run as long as possible on a treadmill whose slope increases at timed intervals.

- The athlete warms up for 10 minutes.
- The assistant sets up the treadmill at a speed of 8.05 km/hr (5 mph) and an incline of 0%.
- The assistant gives the commands "GO" starts the stopwatch, and the athlete commences the test.
- Three minutes into the test, the assistant adjusts the treadmill incline to 2.5% and then every two minutes thereafter increases the incline by 2.5%.
- The assistant stops the stopwatch and records the time when the athlete is unable to continue.
- From the total running time, an estimate of the athlete's VO2 Max calculated as follows:
- VO2 Max mLs/kg/min = (Time × 1.444) + 14.99

Where "Time" the recorded test time expressed in minutes and fractions of a minute.

Push-Up Test

A standard push-up begins with the hands and toes touching the floor, the body and legs in a straight line, feet slightly apart, and arms shoulder width apart, extended, and at right angles to the body. Keeping the back and knees straight, the subject lowers the body to a predetermined point, to touch some other object, or until there is a 90-degree angle at the elbows, then returns back to the starting position with the arms extended. This action repeated, and the test continues until exhaustion, until they can do no more in rhythm, or until they have reached the target number of push-ups.

Static Strength Test (LS) (BS)

A back dynamometer used to measure static leg strength. The subject stands on the dynamometer platform and crouches to the desired leg bend position while strapped around the waist to the dynamometer. At a prescribed time, they exert a maximum force straight upward by extending their legs. They keep their backs straight, head erect, and chest high. Three trials performed, and the best score taken. Subjects rested between the trials.

Standing Long Jump Test (SLJ)

The subject stands behind a line marked on the ground with feet slightly apart. A two-foot take-off and

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landing used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts allowed.

Wall Sit Test (WST)

The subject stands comfortably with feet approximately shoulder width apart and back against a smooth vertical wall. The subject then slowly slides their back down the wall to assume a position with both their knees and hips at a 90° angle. The timing starts when one foot lifted off the ground and stopped when the subject cannot maintain the position and the foot returned to the ground. After a period of rest, the other leg is tested. The total time in seconds that the position held for each leg recorded.

Spike performance Test (SP)

Evaluation the Performance levels of Spike by a committee contains three judges, the judge was assessed from 1 to 10 degree, consider that body form and style when the player performed the skill of the Spike.

Statistical Analysis

All statistical analyses calculated by the SPSS statistical package. The results reported as means and standard deviations (SD). Differences between two groups are reported as mean difference ± 95% confidence intervals (mean diff ± 95% CI).Student's t-tests for independent samples were used to determine the differences in physical variables between the two groups. A P-value <0.05 was considered statistically significant.

Results

Table 1. The age, Anthropometric Characteristics and Training experience of the Groups (Mean ± SD)

Group	N	Age [years]	Weight [kg]	Height [cm]	Training experience
Experimental	**10**	**14.89 ± 1.34**	**51.47 ± 4.3**	**164.16 ± 5.06**	**4.00 ± 1.2**
Control	**10**	**14.00 ± 1.01**	**50.35 ± 4.4**	**165.29 ± 5.2**	**3.94 ± 1.6**

Table 1 shows the age and anthropometric characteristics of the subjects. No significant differences were observed in the anthropometric characteristics and training experience for the subjects in the two groups.

Table 2. Mean ± SD and (T) Test between pre – tests and post - tests in VO2 Max, certain physical variables and spike performance for the experimental group.

Variables	Measurement Unites	Experimental group		Sig.
		Before	After	
(VO2Max)	L/min	32.21±0.68	34.55±0.51	Sig.
Leg Strength (LS)	kg	77.16±4.6	92.67±6.3	Sig.
Back Strength (BS)	kg	75.04±3.21	84.71±4.6	Sig.
Arm - Strength Endurance (ASE)	N	10.12±1.3	15.8±1.7	Sig.
Leg - Strength Endurance (LSE)	S	64.78±3.11	72.11±2.57	Sig.
Spike performance (SP)	Degree	5.7±1.3	8.7±1.2	Sig.

Table 2 shows that: Significant Difference between pre – tests and post - tests in all variables for post - tests.

Table 3. Mean ± SD and (T) Test between pre – tests and post - tests in VO2 Max, certain physical variables and spike performance for the control group.

Variables	Measurement Unites	Control group		Sig.
		Before	After	
(VO2 Max)	ml/kg/min	33.47±0.2	33.52±0.29	No Sig.
Leg Strength (LS)	Kilogram	75.24±3.5	76.36±5.6	No Sig.
Back Strength (BS)	Kilogram	76.3±4.6	80.01±3.2	Sig.
Arm - Strength Endurance (ASE)	Number	11.7±1.9	13.3±1.6	Sig.
Leg - Strength Endurance (LSE)	Seconds	64.52±2.57	65.11±2.08	No Sig.
Spike performance (SP)	Degree	5.8±1.4	7.9±1.6	Sig.

Table 3 shows that: Significant Difference between pre – tests and post - tests in (BS), (ASE) and (SP). And no Significant Difference between pre – tests and post - tests in (VO2 Max) (LS) and (LSE)

Table 4. Mean ± SD and (T) Test between post - tests in VO2 Max, certain physical variables and spike performance for the experimental and control groups.

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Variables	Experimental group	Control group	Sig.
(VO_2Max)	34.55±0.51	33.52±0.29	Sig.
Leg Strength (LS)	92.67±6.3	76.36±5.6	Sig.
Back Strength (BS)	84.71±4.6	80.01±3.2	Sig.
Arm - Strength Endurance (ASE)	15.8±1.7	13.3±1.6	Sig.
Leg - Strength Endurance (LSE)	72.11±2.57	65.11±2.08	Sig.
Spike performance (SP)			

Is clear from Table (4) significant differences at 0.05 between post - tests of control and experimental groups in all the variables for the post-tests in the experimental group.

Discussion

The purpose of this study was to determine if concurrent training could enhance VO2 Max, LS, BS, SLJ, WST, and SP among young female volleyball players. The main findings were significant improvements in all physical variables and VO2 Max, which proved concurrent training efficacy.

Kraemer, et al. (1995) reported that concurrent training interfered with leg press and double leg extension strength development. This study also showed that only the resistance-trained group improved in peak and mean power during the Wingate anaerobic test. Bell, et al. (1997) reported interference in strength gains in the subjects of the concurrent group who were female, but not in the male subjects. Another study by Bell, et al. (1991) found that the resistance training group made larger gains in knee extension one repetition maximum (1 RM), but not leg press 1 RM when compared to the concurrent group. A very recent study conducted by Balabinis, et al. (2003) showed that the resistance-training group made greater gains in leg press and bench press 1 RM compared to the concurrent group.

Interestingly, the concurrent group in this study showed greater improvements in many other performance tests conducted. It should also be noted that in all but one of the above studies, changes in VO2 Max were the same for the concurrent and endurance only groups.

Based on the findings of these studies, it seems rather convincing that endurance training interferes with strength development. However, several studies showing no interference in strength development by concurrent training (Hickson, 1980; Dudley and Djamil, 1985; Craig, et al. 1991; Bell, et al. 1997). Sale, et al. (1990) found no interference in strength or endurance development with concurrent training. Actually, the concurrent group improved the most in the number of repetitions performed at 80% of leg press 1 RM. These results may have been due to the hybrid nature of the training program (endurance training = 3 minute bouts at 90%-100% VO2 Max and resistance training = sets of 15-20 repetitions) used.

Abernethy and Quigley (1993) performed a study solely examining concurrent training in elbow extensor muscles. Their study also showed no interference in strength development. Four other studies have also reported no difference in the strength gains of the concurrent and resistance training only groups.

Balbinis, et al. (2003) actually found the concurrent group to improve more than the resistance-training group in Wingate power. In this study, the concurrent group showed greater improvements in 1 RM squat, vertical jump, and Wingate power. Hunter, et al. (1987) showed interference in vertical jump performance when comparing untrained subjects who concurrently trained to those who only resistance trained. However, they failed to show any interference when a group of trained runners who began resistance training was compared to the untrained group who only resistance trained. A recent study conducted by McCarthy, et al. (2002) also reported no strength impairments with concurrent training.

A small number of other studies have examined whether or not adding resistance training to the training regimen of endurance-trained athletes could improve their endurance performance. The results of these studies are also inconsistent. Bishop, et al. (1999) showed that resistance training of endurance-trained cyclists did not improve their performance. In this study, the resistance-trained subjects did improve in the strength test, but showed no difference from the control group in average power output during a 1 h cycle test, lactate threshold, or VO2 Max. Nelson, et al. (1990) reported that 11 weeks of concurrent training actually interfered with gains in VO2 Max as compared to endurance training alone. Here, the authors speculated that because of hypertrophy, a dilution in mitochondrial volume of the type IIa fibers might have occurred in the concurrent group.

Häkkinen, et al. (2005) performed a study showing just the opposite of Nelson's findings. They found that subjects who had resistance trained showed greater improvements in short- and long-term endurance compared to those who only endurance trained. Short-term endurance was 5-8 min to exhaustion and long term was maximal cycling time to exhaustion at 80% VO_2 Max.

Conclusions

It hypothesized that resistance training increased short-term endurance performance by increasing high-energy phosphate and glycogen stores. Short-term endurance may have also been improved by increases in the fast twitch to slow twitch fiber area ratio. Long-term endurance performance believed to have increased due to a delay in the recruitment of fast twitch fibers because of resistance training increasing maximum strength (Nelson, et al. 1990). In addition, long-term endurance performance can benefit from resistance training not only by reducing large motor unit recruitment, but also by improving running or cycling economy. Similar to Hickson's findings (1980), Balabinis et al. (2003) recently reported that those who concurrently trained made greater gains in VO_2 Max than those who only endurance trained.

Practical Applications

Two months of concurrent training, (endurance and resistance training) can improve physical variables VO_2 Max and Spike performance among young female volleyball players.

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