Original Article

The effect of circuit resistance training on upper limb muscle strength in volleyball attacker players

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Abstract

Aim: To find out effect of circuit resistance training on upper limb muscle strength in volleyball attacker players. **Objectives:** To study effect of circuit Resistance Training on strength of triceps, deltoid, shoulder internal rotator muscles and on workout volume in volleyball attacker players. **Procedure:** 30 Subjects were collected according to inclusion and exclusion criteria. Consent was taken from respective subjects to conduct the study. Respective protocol was followed for Group A (Controlled Group) and Group B (Experimental Group); over 5 weeks, with 3 sessions per week .Pre and post values of Subjects were assessed by using 10 RM and Push up test. The statistical tests used for analysis of result were: Paired t-test and unpaired t- test. Mean standard deviation and standard error was carried out for both groups. **Result:** After 5-weeks of training period, the B group showed more improvement in Strength of Triceps ($P< 0.050$) considered significant, Deltoid ($p< 0.040$) considered significant, Shoulder internal rotators($p<0.030$) considered significant and Push up performance ($p<0.000$) Considered extremely significant. **Conclusion:** This study concludes that Circuit Resistance Training is more effective in improving the strength of shoulder internal rotators, deltoid and triceps Muscles as compare to regular Training in volleyball players.

Key Words: Volley Ball Attacker players, Volley Ball, Circuit Resistance training, 10 RM, Push up Test

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INTRODUCTION

Volleyball, a popular sport was invented by William G. Morgan, physical education director. In volleyball the teams are separated by a high net, the players hit a ball back and forth. Each team is allowed three hits to get the ball over the net to the other half. Volley ball court is 18 meters long and 9 meters wide, Divided into two 9 x 9 meter courts. The top of the net is 2.43 meters above the centre of the court for men's competition and 2.24 meters for women's competition. Attack Line - It is a line 3 meters from and parallel to the net in each team court. It divides the court into "back row" and "front row" areas.

Strength is the ability of muscle to exert maximal force or torque at a specified velocity; it varies for different muscle actions such as eccentric, concentric and isometric. Often coaches and athletes associate the term strength only with force that can be exerted during isometric muscle action. This is often determined using a one repetition maximum test in which strength is assessed as the maximum weight the athlete can lift once through the complete range of motion.[2] During serving and spiking, the rotator cuff muscles are important in generating the necessary power to move the shoulder. While rarely completely torn in young players, these muscles can get irritated or fatigued with overuse. Often, rest, physical therapy and athletic training services may be enough to resolve pain. Common finger injuries include fractures, dislocations, and tendon and ligament tears. Ankle injuries are the most common injury to volleyball players and responsible for the most lost playing time. Patellar tendinitis is common in any athlete subjected to repetitive, forceful jumping activities, such as spiking and blocking. Shin splints, Groin Strain, Hamstring strain Sprained ankle, Calf Strain, Plantar Fascitis are other common injuries Volleyball performance can be improved primarily by developing

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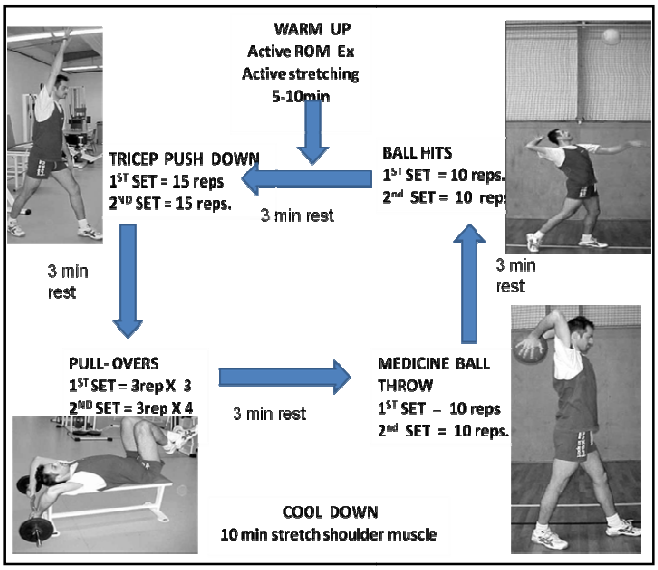
better technique and greater explosive power. Both the serve and the spike require explosive activity from the shoulder muscles to ensure maximum speed to the ball at the moment of contact.[6] Because of the long-range effects on performance over a season and even an entire career, the modification of injury risk is fundamental to training program.[1] The second objective of this program is to improve competitive performance. An effective spike is a function of the player's speed and strength and the height of the hit, and each of these 3 criteria can be improved with strengthening programs.[6] Specific programs to improve performance have been based on the studies whose work focused on both a general preparation for competition and the prevention of injuries. These authors used strengthening exercises to develop the muscles of the upper limbs to prevent injuries and the muscles of the lower limbs to improve jump height.[6] The explosive muscle power seen in the moves and jumps of volleyball are determinant to success. "Hypertrophic" strengthening, however, may increase body weight and may decrease jump height. The current program of "explosive" power-building, on the other hand, improves muscular coordination and intramuscular synchronization. This approach to strengthening minimizes the hypertrophic effect. It is based on 1 repetition maximum (1RM), which is defined as the highest load lifted in 1 repetition. The work intensity for this program is established between 85% and 95% of the 1RM.[6]

Procedure

A pre and post experimental study was conducted in Sports department in Pune University, Maharashtra; India. Professional university level male volley ball attacker players were included with age between 18-24 years. Ethical clearance was taken from the ethical committee of D.Y Patil College of physiotherapy, Pune. Total 30 Samples were randomly allocated in respective Groups i.e Group A (Controlled Group) and Group B (Experimental Group).Subjects were collected according to inclusion and exclusion criteria. They were all trained by same coach. Then Consent was taken from the respective subjects to conduct the study. Respective protocol was followed for Group A and Group B; and protocol was programmed over 5 weeks, with 3 strengthening sessions per week (15 sessions for the whole program). The volleyball players are evaluated once a week to determine 1RM values and follow the individual progression.

METHODOLOGY

10RM was evaluated for triceps, deltoid, internal rotators of shoulder and Assessment for number of repetitions was done in push up test. 1 RM was calculated by asking the subject to lift the maximum amount of weight through available range of motion; to avoid muscle fatigue, weights were set so that 1RM lift was calculated within 3-5 attempts. 10 RM was calculated by asking the subject to lift the maximum amount of weight through available range of motion 10 times. A rubber band is used for the warm-up, with the volleyball players performing 2 sets of 30 arm extensions. Active Movements of all joints. After stretching the shoulder muscles, they then carry out 2 circuits of 4 exercises [6]



Material Used

- Weight plates (different weights)
- Gym Equipments 1) Bench press.

2) Triceps pull down

- Medicine ball, Volley ball

RESULTS

The statistical tests used for the analysis of the result were: Paired t-test and Unpaired t- test, Mean standard deviation and standard error was carried out for all the groups in this study for both the groups. In this table following statistical formulae have been used for analysis:

Table 1: Comparison between 0 - 2 - 5 weeks of 10 RM of Triceps between Group A and Group B

A: Descriptive Statistics

Group A	Mean	N	SD	SEM
Week 0	4.267	15	1.116	0.2881
Week 2	4.733	15	1.178	0.3042
Week 5	5.733	15	1.208	0.3119

Group B	Mean	N	SD	SEM
Week 0	4.533	15	1.26	0.3254
Week 2	5.2	15	1.279	0.3302
Week 5	7.6	15	1.703	0.4397

B: Students Unpaired t test

Group A and Group B	Paired Differences					t	df	p-value
	Mean	SD	SEM	95% Confidence Interval of the Difference				
				Lower	Upper			
Week 0 – 2	0.2	0.3579	0.1106	-0.02648	-0.4265	1.809	28	0.050
Week 2 – 5	1.4	0.6325	0.2024	0.9855	1.815	6.918	28	0.000
Week 0 -5	1.6	0.7287	0.2146	1.16	2.04	7.457	28	0.000

Table 2: Comparison between 0 - 2 - 5 weeks of 10 RM of Deltoid between Group A and Group B

A: Descriptive Statistics

Group A	Mean	N	SD	SEM
Week 0	5.9	15	1.442	0.3723
Week 2	6.5	15	1.35	0.3485
Week 5	6.833	15	1.41	0.3641

Group B	Mean	N	SD	SEM
Week 0	5.567	15	1.498	0.3869
Week 2	6.133	15	1.316	0.3397
Week 5	8.467	15	1.529	0.3948

B: Students Unpaired t test

Group A and Group B	Paired Differences					T	df	p-value
	Mean	SD	SEM	95% Confidence Interval of the Difference				
				Lower	Upper			
Week 0 – 2	-0.0333	0.3716	0.1297	-0.299	0.2324	-0.257	28	0.040
Week 2 – 5	1.997	0.5233	0.1714	1.646	2.348	11.652	28	0.000
Week 0 -5	1.967	0.6325	0.1956	1.566	2.367	10.055	28	0.000

Table 3: Comparison between 0 -2- 5 weeks of 10 RM of Shoulder Internal Rotators Between Group A and Group B

A: Descriptive Statistics

Group A	Mean	N	SD	SEM
Week 0	4	15	0.7557	0.1952
Week 2	4.967	15	0.8756	0.2261
Week 5	5.733	15	0.8209	0.2119

Group B	Mean	N	SD	SEM
Week 0	4.2	15	1.099	0.2837
Week 2	4.833	15	1.144	0.2955
Week 5	6.833	15	1.423	0.3675

B: Students Unpaired t test

Group A and Group B	Paired Differences					t	df	p-value
	Mean	SD	SEM	95% Confidence Interval of the Difference				
				Lower	Upper			
Week 0 – 2	-0.3334	0.2968	0.1458	-0.6322	-0.0346	-2.286	28	0.030
Week 2 – 5	1.233	0.5976	0.1817	0.8611	1.605	6.788	28	0.000
Week 0 -5	0.9	0.7432	0.2254	0.4384	1.326	3.994	28	0.000

Table 4: Comparison between 0 - 2 - 5 weeks of Push Up Test between Group A and Group B

A: Descriptive Statistics

Group A	Mean	N	SD	SEM
Week 0	6.867	15	1.356	0.3501
Week 2	7.6	15	1.639	0.4231
Week 5	9	15	1.604	0.414

Group B	Mean	N	SD	SEM
Week 0	7	15	2.507	0.6473
Week 2	8.867	15	3.021	0.7799
Week 5	11.73	15	3.127	0.8075

B: Students Unpaired t test

Group A and Group B	Paired Differences					t	df	p-value
	Mean	SD	SEM	95% Confidence Interval of the Difference				
				Lower	Upper			
Week 0 – 2	1.134	0.9155	0.2819	0.5566	1.711	0.024	28	0.000
Week 2 – 5	1.467	1.06	0.3187	0.8141	2.12	4.603	28	0.000
Week 0 -5	2.6	1.223	0.3695	1.843	3.357	7.036	28	0.000

DISCUSSION

The weight training is one of the most popular forms of exercise for enhancing an individual's fitness as well as for conditioning athletes. Coaches and athletes are well aware that the system of resistance training they select will influence strength. [1]

In overhead sports shoulder problems are very common, predominantly in highly skilled sportsmen, because of the intense practice, short recreational time, high intensity, and repetitive loads caused by specialization on certain tasks in the game, for example pitching for the baseball pitcher. [9]

A highly skilled volleyball player attacks about 40 000 times a year. The impact occurs in an ante version of about 1700 to 1400 in neutral rotation. The speed of the hand at this moment is approximately 13.1 m s-' and accelerates the ball to velocities of up to 120 km h-'. Only 19.1% of this velocity originates in the glen humeral joint.' After the impact, the movement of the arm decelerates. This results in the production of dynamic eccentric forces at the posterior shoulder girdle musculature and the biceps.

A change in one of the components of the shoulder girdle leads to a complete change in shoulder motion. The orientation of the scapula is predicted in the upright position mainly from the length of the trapezius and levator scapulae muscles, and to a lesser extent from the length of the rhomboids and serratus anterior muscle. [6,7]

In recreational athletes same symmetry between the two shoulders in all the measured variables. As in tennis or baseball players, volleyball players also have a depressed playing shoulder. This leads to a narrowed subacromial space in the upright position. [13.] In this study, from two groups one group was given circuit weight training protocols and other group was doing their regular exercise protocol. Group A was control group and Group B was experimental group. Weight training was given for three days per week for the duration of 5 weeks and 3 days per week for best results.[6] Rest interval of 3 minute was given was given between sets. Measurements were taken after 2 weeks and after 5 weeks.

In this study a significant difference in 10 RM of Triceps, Deltoid and shoulder internal rotators is seen in Group A. Thus there is improvement in strength of Triceps, Deltoid and shoulder internal rotators in Group A after training at 0 to 2 to 5 weeks in order.

Also, a significant difference in 10 RM of Triceps, Deltoid and shoulder internal rotators is seen in Group B. Thus there is improvement in strength of Triceps, Deltoid and shoulder internal rotators in Group B after training at 0 to 2 to 5 weeks in order.

Improvement in individual muscle strength and power after weight training is mainly because of two factors:

- Neural – motor component
- Contractile component

The neural adaptations with weight training are increased integrated electromyography and rate of motor unit activation. Improved motor unit synchronization, lowering of neural inhibitory reflex, Inhibition of golgi tendon organ

Contractile component - Muscle size

Various neural adaptations occur after weight training are stated above. This causes increase in strength. Neural facilitation increases which largely accounts for rapid and significant increase in early weeks which often occurs without increase in muscle size and cross – sectional area. The amount of training that occurs in muscle fiber is determined by the extent to which it is recruited [20]

There is also increase in electric activity of muscle in strength training. This is given by increased integrated electromyography activity. There is significant increase in strength in novice individual; this reflects enhanced ability to recruit motor units. Studies show neural adaptation play greater role in increasing strength during early phase of strength training in women. Lifting heavy weights for few repetitions, causes maximal stimulation of muscle, leading contraction of many fibers at same time[20] There is also muscle tissue adaptation in which muscle size increases, cross –sectional area are increase and there is high relationship between cross- sectional area and strength[20] Weight training causes neural adaptations leading to improvement in muscle power. There is increase in motor unit firing rate. Firing rate is controlled by central nervous system. Motor unit firing rate affects rate of force development. Force rate is important in improving power.[24] Neural adaptation increases strength and improve co–ordination. This is helpful in powerful movements because there is increased contractile capacity and synchronized release of elastic energy within muscle. These neural adaptations include reflex motor unit facilitations of contraction, improved motor unit synchronization and inhibition of golgi tendon organ.[20] Synchronization of motor unit firing rate also cause greater power and increase the time during which high muscle tension can be maintained. Neural disinihibition is reduced by training which affects golgi tendon organ role in preventing full contractions. Therefore, allows more forceful contraction. [20]

In this study a significant difference in 10 RM of Triceps, Deltoid and shoulder internal rotators is seen more in Group B than Group A. Thus there is improvement in strength of Triceps, Deltoid and shoulder internal rotators in Group B more than Group A after training at 0 to 2 to 5 weeks in order.

The tension producing capacity of the muscle is directly related to the physiological cross sectional area of the individual muscle fibers. Hypertrophy is caused by increase in myofibrillar volume after the extended period of moderate to high intensity resistance training [4]

Neural adaptation are attributed to motor learning and improved co ordination and include increased recruitment in the number of motor units firing as well as an increased rate and synchronization of firing .it is speculated that these changes are caused by a decrease in the inhibitory function of the CNS , decreased sensitivity of Golgi tendon organ or changes at the myoneural junction of the motor unit [4].Metabolic changes Adenosine Tri Phosphate (ATP) storage, myoglobin and CP storage is also increased the creatine phosphokinase and myokinase enzymes are also increased.

The tensile strength of the connective tissues in the muscle , tendons , ligaments is also increased along with the bone mineral density consequently stronger ligaments and tendons may be less prone to injury [4]

Rest interval is a critical element of resistance training program and it is necessary to allow time for the body to recuperate from the acute effect of the exercise , as associated with muscle fatigue or to offset the adverse responses such as exercise induced delayed onset muscle soreness. Only with the balance progressive loading and adequate rest intervals will muscle performance improve [4]

Circuit training enables one part of body to recover from exercise while exercising the other area and therefore minimizes muscle fatigue. Also when muscle relaxes between each repetition of reciprocal muscle contractions which helps to maintain blood supply to contracting muscle and helps to delay the muscle fatigue [4]

Studies have shown that the rest period between sets and exercises has a significant effect on the total training volume, decrease in maximal voluntary contraction, exercise torque and fatigue perception. Decreased training volume in isolated exercises and in a training session with short rest periods between sets and exercises might in part be the result of physical and/or metabolic stress.

Resistance exercise with short rest intervals (1 min or less) leads to greater increases in circulating catecholamines, cortisol, and growth hormone than exercise bouts with longer rest intervals. Nor epinephrine, epinephrine, cortisol, and growth hormone have all been implicated as causative agents behind the immunological changes that occur as a result of heavy resistance exercise sessions.

Results indicate that during a resistance exercise session, if sufficient time is available, resting 3 minutes between sets and exercises allows greater workout volume for the upper body exercises examined. Recovery of ATP requires 3 to 5 min, and Creatinine phosphate recovery occurs within 6 to 10 and likely influences subsequent exercise intensity [10]

Circuit training thus induces strength improvements greater than regular training and endurance training , it also improves the ability to tolerate increasing level of muscular fatigue . Circuit training enhances the overall body strength including the strength and resiliency of muscles tendon , ligaments integrity of joints and density of bone structures with improvement in movement skill and body awareness. Circuit training includes aerobic exercise session which causes strength training as well as the endurance benefits.

Circuit training thus is an excellent way to simultaneously build strength and stamina. The circuit training format utilizes a group of strength exercise that are completed sequentially one after another. Each exercise is performed

for a specified number of repetitions and for prescribed time period before moving on to the next exercise, each exercise is separated by a longer rest period and total no of circuits performed during the training sessions vary depending on training level (beginner ,intermediate, advance). This exercise thus can be used on a regular basis throughout the training year or it can be specifically introduced for the preparation of particularly important or difficult matches in a championship. During the competition season, however, both players and trainers need to take into account the time needed to recover from the fatigue it generates when adding it to the general training program. In fact, the schedule of weekly competitions in volleyball was taken into consideration in the development of this program. The influence of strength training on endurance performance is an unresolved question. Earlier studies have found that concurrent strength and endurance training interfered with optimal development of muscle strength but, in contrast, did not affect the development of endurance (Dudley and Djamil 1985; Hickson 1980). However, recent studies have found that the addition of strength training has a negative influence on endurance (Andersen *et al*. 1992; Rusko and Bosco 1987). Thus differences in training programmes, experimental design and particularly the way of estimating endurance could remain the limitation of this study.

CONCLUSION

This study concludes that Circuit Resistance Training is effective in improving the strength of shoulder internal rotators, deltoid and triceps of volley ball players. The circuit Resistance Training is more effective in improving the strength compare to regular Training in volleyball players. Further research including power training (i.e. a type of training in which the loads are lower than In heavy resistance training but the contraction velocities are much higher) or a combination of strength and power training is needed to show if there is some strength training regime that can increase maximal and explosive strength without interfering with the development of endurance.

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