ORIGINAL ARTICLE

A Profile of Fitness Parameters and Performance of Volleyball Players

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Abstract:

Background: Ball games require comprehensive ability including physical, technical, mental and tactical abilities. Among them, physical abilities of players exert marked effects on the skill of the players themselves and the tactics of the team. Therefore players must have the physical abilities to meet the demand of the sport. Volleyball is one of the most popularly played games in the world. Unfortunately, the level of performance of the Indian volleyball players lags far behind the international standards. *Aim of the Study*: The present study was aimed to assess flexibility, muscular endurance, power and cardio-respiratory endurance of volleyball players and to compare the results with age matched controls. Also, to compare the findings of the volleyball players with that of the international norms from the available literature and to make some suggestions for the improvement in their performance level. *Material and Methods*: The study was carried out in 40 male volleyball players aged between 17 to 26 years and 40 ages matched male controls. Physical fitness parameters namely flexibility, muscular endurance, power and cardio-respiratory endurance were measured, data was analyzed using unpaired 't'-test. *Results*: It was observed that all physical fitness parameters were significantly more in players as compared to their aged-matched controls but when values of the subjects were compared to international standards; our subjects were behind the recommended norms for the elite volleyball players. *Conclusion*: The volleyball players have more advantage of flexibility muscular endurance, power and cardio-respiratory endurance.

Key Words: Flexibility, Muscular Endurance, Power, Cardio-Respiratory Endurance, Bicycle Ergometry, VO_2 max.

Introduction:

Today, sport has become cultural phenomenon of great magnitude and complexity. Its scope is awesome; nearly everybody has become involved in some or other way in it. It has got mass participation.

Various research studies conducted by experts in physical education and sports have emphasized the importance of investigating the specific structures, co-related with the various sports activities, for the selection and development of talent in sports and for better performance at different levels of sports competition.

There are numerous factors which are responsible for the performance of a sportsman. These are physical, mental, technical and tactical. Among them, physical abilities are most important. Performance also depends on skills, training, motivation and physiological factors. The poor performance of Indian athletes and sportsmen at the international competition has been of great concern, especially to the

coaches, physical educationists and sports scientists. Efforts have been made to improve the standards of our sportsmen since long; however, little success has so far been achieved in this respect.

Volleyball is one of the most popularly played games in the world. It is the game of power agility as well as speed. Physical fitness is of paramount importance in this game. Hence, the health related aspects play a crucial role in the performance of the players.

So, this present study was undertaken to measure certain basic physical fitness parameters like flexibility, muscular endurance, power and cardio-respiratory endurance of volley ball players and to find out the lacunae in the physical fitness level so that we can come up with some valuable suggestions to improve the performance level of volleyball players. With this in mind a study was undertaken to assess physical fitness parameters of volleyball players of university team and players playing above university level (state level, national level) players as compared to age matched controls and international standards.

Material and Methods:

The present study was carried out in the sports physiology laboratory of physiology department Dr. Vaishampayan Memorial Government Medical College, Solapur after taking approval of the ethical committee.

This study included 40 male volleyball players aged between 17 to 26 years, who were selected for university team in last three years and still playing at university level, state level or national level. This was our study group. The control group consisted of 40 age matched male students of Dr. Vaishampayan Memorial Government Medical College, Solapur which included undergraduate students, interns and residents. The study was carried out in 2011-2012 and the total duration of study was six months.

Surprisingly few studies on physical fitness parameters have been done on male volleyball players in India; hence the present study intended to fill this lacuna by choosing male subjects.

Participation in the study was voluntary and informed written consent was taken from all subjects from study and control groups.

Exclusion criteria:

1) Those players who were not regularly practicing were excluded from the study.
2) Those players who were injured during practice or during matches were excluded. Minor injuries included sprains and strains and major injuries included recurrent shoulder dislocation, fracture ankle joint, fracture patella, ligament injuries etc.
3) Players with major respiratory illness or cardio-vascular illness in past were excluded from the study.

Following physical fitness parameters were taken in both the groups and standard methods were employed to measure fitness parameters.

1. Flexibility :

Sit and reach test: This test is used to measure the development of hip and back flexion as well as extension of the hamstring muscles of the legs. The object is to see how far a person can extend his fingertips beyond his foot line with the legs straight.

A measuring tape was struck on floor and a line perpendicular to the tape at 15 inches was marked on the floor. After sufficient warm-up, the subject was asked to sit down and line up his heels with the near edge of perpendicular line with the tape in between the two heels and slide his seat back beyond the zero end of the tape. An assistant stood and braced his toes against the subject's heels as he stretched forward so that his heels should not slip over the perpendicular line. Also, two assistants held subjects knees in locked position. Then, the subject was asked to stretch forward slowly and steadily without jerks, keeping his knees locked and heels not more than 5 inches apart and to touch the fingertips of both hands as many inches down the stick as possible.

The best of three trials measured to the nearest quarter of an inch was the test score of the subject which was recorded in the record sheet [1]

2. Muscular Endurance :

In the present study, muscular endurance was tested by dynamic relative type. In this type, the performer executes identical repetitions of a movement through a designated distance and over an unlimited amount of time. The test is scored in terms of the numbers of correct executions completed. Following tests were done in the present study

(a) Push-ups:

The objective was to measure the endurance of the arms and shoulder girdle i.e. upper body muscular endurance. From a straight arm front leaning rest position, the performer was asked to lower the body until the chest touches the mat and then to push upwards to the straight arm support. The exercise was continued for as many repetitions as possible without rest. The score was the number of correct push-ups executed.

Precautions taken:

→ The performer should not sag or pike his body but should maintain a straight line throughout the exercise.

→ The score was terminated when the performer stopped to take rest.

→ If the chest did not touch or if the arms were not completely extended on an execution, the trial was not counted.

Thus only the total numbers of push-ups executed correctly were recorded [1]

(b) Sit-ups:

Numbers of sit ups with bent knees were noted to measure the endurance of abdominal muscles. The only equipment required for this test was a mat and a yardstick.

From a lying position on the back, the performer was asked to flex his knees over the yardstick while sliding his heels as close to his seat as possible. The yardstick was held tightly under the knees and the performer was instructed to slide his feet forward slowly. At the point where the yardstick drooped to the mat, the heel line and seat line were marked to indicate how far the feet remained from the seat during the bent knee sit up exercise. Then, the subject was asked to interlace the fingers behind the neck and to perform sit ups. The left elbow should touch the inside of the right knee and the right elbow should touch to the inside of the left knee alternately. The subject was asked to repeat the exercise as many times as possible.

Precautions taken:

Repetitions were not counted,

i) If finger tips did not maintain contact behind the head.

ii) When the knees were not touched by elbows.
iii) When the subject pushed off the floor with the elbow.

The total number of sit-ups executed were counted and recorded in the subjects record sheet. [1]

3. Power (vertical jump):

a) Vertical jump without approach (Sargent chalk jump)

The objective of this test was to measure the power of the legs in jumping vertically upwards. The equipment and materials needed were a yardstick, several pieces of chalk and a smooth wall surface at least 12 feet from the floor. The subject was asked to stand with his side towards the wall and to reach as high as possible with the heels on the floor and to make a mark on the wall with one inch piece of chalk which he held in his hands nearest to the wall. This was the normal reach of the subject which was noted in centimeters.

The subject was then asked to swing arms downwards and backwards, assuming a crouched position with the knees bent at about a right angle and jump as high as possible. The highest point of the jump reached which the subject marked on the wall was noted. This was the vertical jump executed by the subject without approach.

b) Vertical jump with approach:

The subject was asked to take three steps from the wall for spike approach,. taking the start from the end of third step the subject was asked to approach the wall giving himself a momentum and then to jump with two foot take-off as high as possible reaching for the highest point of the wall with both his hands extended and to mark the chalk on the wall.

After 3-5 trials, best jump with approach was noted. Number of centimeters between the normal reach and the jump with approach measured nearest to the half centimeter was the score of the subject which was recorded and entered into his record profile [1].

4. Aerobic Capacity (Cardio-respiratory endurance):

VO_2 max [Maximum Oxygen Uptake] is regarded by large number of exercise physiologists as the most appropriate measure of Aerobic Capacity or Cardio-respiratory fitness.

In the present study VO_2 max was found out using Bicycle Ergometer [2]. Bicycle Ergometry: measures work. A Bicycle Ergometer is a stationary bicycle which can be adjusted for seat level and for resistance to pedaling thus permitting a wide variety of workloads.

Procedure:

After leveling the Ergo meter, it was connected to the mains. The subject was asked to sit and after making appropriate adjustments for the height of seat and angle of the handle, the stop switch was stared for number of wheel revolutions and the subject was asked to pedal at 50 RPMs constantly keeping the load minimum. After 30 to 45 seconds of warm up, the load was set at desired level and the stop watch was reset. The subject was asked to pedal at 50 RPMs constantly for 6 minutes.

At the end of every minute, the heart rate of the performer was noted. If the heart rate observed at the end of 5^{th} minute and 6^{th} minute differed by more than 5 beat/minute, the test is prolonged for 1 to 2 more minutes until a steady state was achieved. The average of last 2 minutes was designated as the heart rate at that load. [3]

Our ultimate aim was to find out the amount of work done by the subject in unit time to find out KPM/min (Kilo pound meters per minute). This is found by the formula:

KPM/min=2 NW/T

Where,

N=No. of revolutions of wheel

W=Reading of balance in Kgs (Load)

T= Time in minutes

Then using Modified Astrands Rhyming nomogram, we found out VO_2 max by keeping one end of ruler on the KPM/min scale and other end at the pulse rate scale. The intersection of the ruler at VO_2 max scale gave the reading in liters. Correction of age factor was done according to the table by multiplying age factor by value of VO_2 max in Lit/min.

VO_2 max was found out in ml/min/Kgs and by multiplying it by 1000 and dividing by the subjects body weight. The formula is:

VO_2 max (ml/min/Kgs) = [(VO_2 max in Lit/min X 1000)/Body weight]

Interpretation of maximum oxygen uptake was done using a standard table developed by the American Heart Association in which the norms are grouped into five categories (Low, Fair, Average, Good and High). Thus the aerobic capacity or cardio-respiratory fitness status of an individual can be found out.

Results:

Table 1: Flexibility Test of Study and Control Groups

Test	Study/Control subjects	Mean	SD	SEM	p value	S/NS
Trunk Flexibility (inches)	Study subjects	20.38	2.835	0.448	< 0.05	S
	Control subjects	17.16	2.533	0.401		
Shoulder Goniometry (Degrees)	Study subjects	178.45	2.012	0.318	< 0.05	S
	Control subjects	175.05	2.087	0.330		
Knee Goniometry (Degrees)	Study subjects	140.25	5.615	0.888	< 0.05	S
	Control subjects	135.43	2.438	0.385		

S: Significant, NS: non-significant, SD: STD deviation, SEM: STD Error Mean

Table 2: Muscular Endurance Tests of Study and Control Groups

Test	Study/Control subjects	Mean	SD	SEM	p value	S/NS
Pushups (No.)	Study subjects	28.90	4.174	0.660	< 0.05	S
	Control subjects	19.08	7.054	1.115		
Sit ups (No.)	Study subjects	38.80	6.843	1.082	< 0.05	S
	Control subjects	19.18	8.000	1.265		

S: Significant, NS: non-significant, SD: STD deviation, SEM: STD Error Mean

Table 3: Power of Study and Control Groups

Power Testing	Study/Control subjects	Mean	SD	SEM	p value	S/NS
Without approach (cms)	Study subjects	51.45	9.556	1.511	< 0.05	S
	Control subjects	39.125	8.585	1.357		
With approach (cms)	Study subjects	62.60	9.737	1.540	< 0.05	S
	Control subjects	48.30	11.407	1.804		

S: Significant, NS: non-significant, SD: STD deviation, SEM: STD Error Mean

Table 4: Cardio-respiratory Endurance (Bicycle Ergometry) of Study & Control Groups

	Study/Control subjects	Mean	SD	SEM	p value	S/NS
VO_2 Max (ml\kg\cms)	Study subjects	44.559	6.7545	1.067	< 0.05	S
	Control subjects	30.668	4.405	0.696		

S: Significant, NS: non-significant, SD: STD deviation, SEM: STD Error Mean

Discussion:

1) Flexibility:

Flexibility is the ability of an individual to move the body and its parts through as wide range of motion as possible without undue strain to the articulations and muscular attachments.

Flexibility provides another dimension in performance that allows a higher degree of freedom and ease of movement coupled with some important implications for greater safety from injury.

Flexibility of a certain joint does not necessarily indicate flexibility in other joints, and there is no general flexibility test for total body flexibility. Flexibility is specific for a given joint and to a particular sport [4].

It is a test of basic proficiency so it is used in many skills. The different joints vary in the range of flexibility. So the specific joints can be checked in this regard.

Two types of flexibility tests are present;

1] Relative flexibility tests – These are designed to be relative to the length or width of a specific body part. In these test, we measure not only the movement but also the length or width of an influencing body part.

2] Absolute flexibility test – In these tests we measure only the movements in relation to an absolute performance goal.

Flexibility scores may be reported as linear measurements when readings are taken by tape, flexomeasure or as rotatory measurements where scores occur in degrees of rotation as determined by the use of a protractor or a goniometer.

In volleyball, the players have to move suddenly in forward direction, sideways or downward directions, so flexibility of hip and back is of utmost importance. So, we have decided to go with sit and reach test.

In our study, the mean trunk flexibility of study

subjects has been 20.38" and that of control subjects 17.16" and the difference has been found to be statistically significant.

M.J Duncan et al[5] have found mean values for sit and reach test in national level volleyball players to be 23 1\2" which has been more than our subjects.

Lee E.J. et al [6] have found significant and positive correlation between vertical jump and hip flexion. His findings have supported the assumption that greater flexibility is related to greater skilled performance. Thus, he has concluded that greater hip flexibility may benefit the jumping ability.

Flexibility of shoulder joint has been assessed by measuring range of motion of shoulder flexion by goniometer.

Flexion of shoulder joint has been found to be 178.45 degrees in study subjects and 175.05 degrees in control subjects, the difference being statistically significant.

AAOS (American Academy of Orthopedic Surgeons) [7] has given maximum shoulder flexion value of 180 degrees, thus, values in our study correlate with AAOS.

Knee joint flexibility is found to be 140.25 degrees in study subjects and 135.43 degrees in control subjects, the difference being statistically significant.

Boone et al [8] have found mean knee flexion to be 140.2 +\-5.2 degrees. Our findings correlate with their findings.

Thus, we can conclude that study subjects in our study have good flexibility when compared to control subjects and also, the values of shoulder and knee flexion coincide with the international standards.

For improving flexibility of trunk, various lower back and hamstring stretch exercises are advised which are to be done regularly and executed properly and gradually.

2) Muscular Endurance:

Muscular endurance is the ability to repeat a series of muscle contractions without fatigue. Volleyball has been described as "Interval" sport with both anaerobic as well as aerobic component. In long matches or tournament play, the players have to bend, jump and move thousands of times which need good muscular endurance. It is one of the required qualities for excelling in volleyball [9].

In our study, upper body endurance has been assessed by number of maximum push-ups, executed correctly by the study subject and control subjects. The average number of maximum push-ups for study subjects has been 28.90 and for control subjects 19.08, the difference being statistically highly significant.

But, when compared with national level volleyball players our subjects have had a low muscular endurance.

Similarly lower body muscular endurance has been assessed by number of sit-ups [Bent knees] executed correctly. In our study, mean number of sit-ups executed properly for study subjects have been 38.8 and for controls 19.18, the difference being statistically significant.

When compared to national level [66-above advanced] elite athletes, our subjects fall into intermediate performance level.

This means, though the muscular endurance of our study group bears statistical significance with the control group but still it lags behind when compared to national or international standards.

Berger, Richard A. et al [10] have shown that

training [dynamic overload] programmes improved performance on muscular endurance exercises. But, Dennison J.D. et al [11] have stressed equal importance of both isotonic as well as isometric exercise programmes in improving muscular endurance.

Thus, muscular endurance can be improved by proper weight training, isotonic exercise and isometric exercises.

3) Power (vertical jump):

Power may be defined as the ability to release maximum force in the fastest possible time as in jumping and throwing activities. Athletic power measurement is expressed in terms of the distance through which the body or an object is propelled through space.

The game of volleyball is a game of power. For peak performance in volleyball, the muscles which are the source of power must be strong. It is important for a volleyball player to have explosive power in legs because he has to jump hundreds of times during the match or tournament for executing spiking skill or blocking skill. Thus, a good vertical jump during the spike and block depends on strength, speed and technique.

We have found that vertical jump without approach has been 51.45cms in study subjects and 39.12cms in control subjects. The difference has been statistically significant. Also, vertical jump with three stride approaches has been found to be 62.60cms in study subjects and 48.30cms in control subjects which again has been statistically significant.

Fleck S.J. et al [12] have found vertical jumping distance of 54.4 +\- 4.5cms in national team volleyball players and 45.5 +\- 6.4cms. in university team volleyball players. Our study has included majority of university level volleyball players, so our finding are consistent his findings.

S. K Saggar et al [13] have found vertical jump with approach score for the international volleyball players as 76.00cms where as in our study; the same has been 62.60cms.

Hakkinen et al [14] have suggested 4-5 weekly sessions for playing drills and competitive games and 2-3 weekly sessions for physical conditioning for strength and explosive strength training for volleyball players to improve their vertical jumping ability significantly as well as spike and block jumps during competitive season.

Lawrence Grey, Kumar V et al [15] have emphasized the importance of plyometric exercises (high intensity exercises to enhance speed, agility and power), weight and sprint training in volleyball players. They have found huge improvements in speed, agility and power, thus increasing the vertical leap for volleyball.

Kasabalis A. et al [16] have found a significant correlation between anaerobic power and jumping performance in volleyball players and they have suggested that vertical jump may predict maximum anaerobic power and could be used by the coaches as a practical and easy to apply field screening test for evaluation in volleyball training.

Mac Colloway [17] has stressed that most important type of training needed for a volleyball player was power and core strength. He has stated that power involves the simultaneous reaction of the hips, knees and ankles while the abdominals and low back are used for the support. He has suggested hang deans, push press\jerks, power shrugs along with

plyometrics (jumps, hops, bounds etc.) for development of power.

Sheppard J.M. [18] has shown that to progress from junior to senior national team, volleyball players must increase their vertical jump for counter movement and spike.

Thus, from the findings and suggestions of various workers we conclude that, power is one of the most important parameter determining the performance level of volleyball players at high level. Exercises like isotonic and isometric weight training, rope skipping, ankle strengthening exercise, ballistic resistance training, hip flexibility exercises, sprinting and most of all plyometrics help in improvement of vertical jumping ability for spiking and block skills development in the game of volleyball.

4) Aerobic capacity [Cardio-Respiratory Endurance]:

Cardio respiratory endurance is defined as the ability of the circulatory and respiratory systems to adjust and to recover from the effects of exercise or work.

It helps to classify persons by assessing their present physical condition, and predict success in certain activities.

Cardio respiratory endurance is characterized by moderate contraction of large muscle groups for relatively long periods of time, during which maximum adjustment of the cardio respiratory systems are heavily loaded because these two systems directly support muscle work. The effectiveness of these two systems then becomes the limiting factor in endurance, thus in vigorous activities of long duration, oxygen supply to the tissue is the main limitation. Therefore the primary objective of cardio respiratory endurance training is to improve the supply of oxygen to the working muscles.

Thus, cardio respiratory endurance is one of the key components of physical fitness.

The most accurate measure of this ability is generally considered to be maximal oxygen uptake [VO_2 max] which measures the amount of oxygen consumed per kilogram of body weight per minute of exercise.

Heart rate increases with oxygen consumption, and since the latter is considered to be the most valid measure of cardio respiratory fitness, this relationship has been utilized in tests to predict oxygen consumption. Thus, heart rate provides a great deal of information about the body's reaction to the stress of exercise and it is quick and easy to measure. Hence, it can serve as a valuable tool to monitor the strenuousness of an exercise program and provide a valid indicator of an individual's condition in the measurement of cardiovascular fitness.

VO_2 max is defined as the greatest oxygen uptake attained by an individual while breathing air at sea level during the performance of physical work.

Volleyball incorporates both aerobic and anaerobic components. Good cardio respiratory fitness is necessary for long duration matches or during tournament where the players have to play 3 to 4 matches in a day.

In the present study, VO_2 max has been found using Bicycle Ergometer. The mean VO_2 max for study subjects has been found to be 44.55 ml\kg\min and for control subjects 30.68 ml\kg\min the difference being statistically significant.

Smith D.J. et al [19] has found VO_2 max of 56.7 ml\kg\min, in Canadian national volleyball team and 50.3 ml\kg\min in university volleyball

players. As majority of subjects in our study are of university team, our values are less as compared to his values for university team players.

Verma S.K. et al [20] have reported VO_2 max of sedentary subjects as 36.8 +\- ml\kg\min and for elite volleyball players as 50 +\- 3.9 ml\kg\min. Values for both subjects and controls in our study are consistent with his finding.

Pollock et al [21] have compared the training effects on running, walking and bicycling for cardiovascular function. All three programmes produce significant improvement. Training effects are independent of mode of training, when frequency, duration and intensity are held constant.

Our findings suggest that though the VO_2max in study subjects is higher than that of control subjects, it is lesser as compared to International Standards.

Gabett T and Georgieff B [22] have emphasized the importance of lower body muscular power and maximal aerobic capacity with increased playing level in volleyball players.

Thus, many research workers have emphasized various training modalities for the improvement of cardio respiratory endurance. These are rope skipping, running, walking, bicycling and various isotonic and isometric exercises. All these exercises performed at a level to bring about 60% differences in resting and maximum heart rate will definitely improve cardio respiratory endurance.

We hope our study will help the coaches to develop some standard selection criteria for selecting the players to form successful volleyball team. Also, testing should be done in order to see what deficiencies are there and in which areas so that we can determine the correct course of action to take in designing a programme for that particular individual. It will help an individual player to improve his own performance.

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