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Effects of a short term plyometric training program on biochemical and physical fitness parameters in young volleyball players

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Abstract. The purpose of this study was to investigate the effects of 6-week Plyometric training program on biochemical and physical fitness parameters. A group of 40 female volleyball players (mean ± SD: age 22.05 ± 1.67 years, height 1.67 ± 0.04m, body mass 58.62 ± 3.73 kg), who participated in inter-college volleyball competition and in the Catch Them Young (CTY) programme volunteered to participate. All participants were informed about the study aim and methodology as well as about the possibility of immediate acceptance at any time of the experimentation. Subjects agreed to the above conditions in writing. They were randomly assigned into plyometric (P) and control (C) groups, n=20 each. Written consent, approved by the Directorate of Sport, Guru Nanak Dev University, Amritsar, Punjab, India was obtained from each subject prior to data collection. Group (P) was subjected 6-week Plyometric training program 45 min a day and the control group did not perform any Plyometric training techniques. No Significant between-group differences were found in the plyometric (P) group, in haemoglobin (t=0.0318), urea (t=1.422), uric acid (t=0.160), total cholesterol (t=1.406), triglyceride (t=1.422) and aerobic capacity (t=0.326) as the analysis of the performed examinations shows that the calculated value of t is less than tabulated value of (t=1.729) for the selected degree of freedom and level of significance whereas significant between-group differences were noted in body composition (t=2.465*) and abdominal strength & endurance (t=.13.424*), since the calculated value of t is greater than tabulated value of t (t=1.729). No significant changes were found in the control groups.
Keywords: *plyometric training, volleyball players, biochemical, physical fitness parameters*

Introduction

Volleyball is an intermittent sport that requires players to participate in frequent short bouts of high-intensity exercise, followed by periods of low-intensity activity (1,2). The high intensity bouts of exercise, coupled with the total duration of the match (90 min), requires players to have well-developed aerobic and anaerobic alactic (ATP-CP) energy systems (3, 2). Considerable demands are also placed on the neuromuscular system during the various sprints, jumps (blocking and spiking), and high-intensity court movement that occurs repeatedly during competition (4). As a result, volleyball players require well developed speed, agility, upper-body and lower body muscular power, and maximal aerobic power (VO_2max). Team Volleyball, like several other ball games, requires not only technical and tactical skills but also great deal of physical fitness (5,6). Several studies have documented the physiological and anthropometric characteristics of volleyball players (7, 8, 9, 10), with the fitness of players typically increasing as the playing standard is raised (11, 12, 13).

Smith et al. (12) compared physical, physiological, and performance characteristics of national- and college-standard volleyball players and found significantly higher block and spike jumps, 20-m speed, and VO_2max in the national-standard players, suggesting that physiological capacities play an important role in the preparation and selection of elite volleyball players (12). In volleyball, the majority of the studies have reported the characteristics of women's volleyball players or junior volleyball athletes of different However, to our best knowledge, only Marques et al. in 2009 (6) examined the anthropometric and strength characteristics of elite male volleyball athletes and determine if differences exist in these characteristics according to playing position.

Despite the increase in professionalism, there is a paucity of research on performance characteristics of elite volleyball players. Therefore, here we study the effect of 6-week plyometric training program on biochemical and physical fitness parameters in young volleyball players.

Materials and Methods

A group of 40 female volleyball players (mean ± SD: age 22.05 ± 1.67 years, height 1.67 ± 0.04m, body mass 58.62 ± 3.73 kg), who participated in inter-college volleyball competition and in the Catch Them Young (CTY) programme volunteered to participate. All participants were informed about the study aim and methodology as well as about the possibility of immediate acceptance at any time of the experimentation. Subjects agreed to the above conditions in writing.

They were randomly assigned into plyometric (P) and control (C) groups, n=20 each.

Written consent, approved by the Directorate of Sport, Guru Nanak Dev University, Amritsar, Punjab, India was obtained from each subject prior to data collection. Group (P) was subjected 6-week Plyometric training program 45 min a day and the control group did not perform any Plyometric training techniques. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise (table 1).

Training Week	Training Volume (foot contacts)	Plyometric Drill	Sets X Reps	Training Intensity
Week 1	80	Side to side ankle hops Standing jump and reach Front cone hops	2 X 12 2 X 12 5 X 4	Low Low Low
Week 2	100	Side to side ankle hops Standing long jump Lateral jump over barrier Double leg hops	2 X 10 5 X 6 2 X 12 5 X 4	Low Low Medium Medium
Week 3	110	Side to side ankle hops Standing jump and reach Front cone hops Double leg hops Lateral cone hops	2 X 10 4 X 6 2 X 10 3 X 8 2 X 8	Low Low Medium Medium Medium
Week 4	100	Diagonal cone hops Standing long jump with lateral sprint Lateral cone hops Single leg bounding Lateral jump single leg	4 X 8 4 X 6 2 X 9 4 X 7 4 X 4	Low Medium Medium High High
Week 5	100	Diagonal cone hops Standing long jump with lateral sprint Lateral cone hops Cone hops with 180 degree turn Single leg bounding Lateral jump single leg	2 X 5 4 X 4 4 X 5 4 X 7 4 X 5 2 X 7	Low Medium Medium Medium High High
Week 6	100	Diagonal cone hops Hexagon drill Cone hops with change of direction sprint Double leg hops Lateral jump single leg	2 X 10 2 X 10 4 X 6 3 X 4 4 X 6	Low Low Medium Medium High

Table I. Plyometric 6-week training protocol

Measurement of Biochemical Parameters. A 5 ml of venous blood was drawn from an antecubital vein. Haemoglobin (Hb), urea and uric acid were measured following standard methodology. Total cholesterol (TC) and triglyceride (TG) were determined by enzymatic method using Boehringer Mannhein kit. Blood samples were analyzed immediately by a lactate analyzer. Special care was taken to prevent contamination from sweat and to enhance rapid circulation.

Measurement of Physical Fitness. Aerobic Capacity (One-Mile Run): Students were instructed to run a mile as fast as possible. Walking was permitted for students who could not run the total distance. The time taken to complete the run was recorded in minutes and seconds. Students who attempted the One-Mile Run and did not complete it were marked with a code of 59 minutes and 59 seconds and were scored Incomplete. The equation used for estimating VO_2max for the One-Mile Run is provided in figure 1.

VO_2 max = (.21 * age * gender) – (.84 * BMI) – (8.41 * time) + (.34 * time * time) + 108.94
- Gender = 1 for males and 0 for females
- Time is in minutes (Convert One-Mile Run time from minutes and seconds to minutes for use in this equation by dividing the seconds by 60 and adding the resulting decimal to the minutes.)
- BMI is Body Mass Index

* *signifies multiplication

Figure 1. Equation for Estimating VO_2 max for the One-Mile Run

Body Composition (Skinfold Measurement). Skinfold Measurements estimates body fat by taking the median or middle value from three ordered measurements of the thickness of skinfolds on the triceps and calf of the right side of the body. A device called a skinfold caliper was used to take these measurements. Using the Body Composition Conversion Chart, the measurements were converted to percentages of body fat. The CDE also accepts measurements of body fat obtained from automated skinfold caliper. Automated skinfold calipers are computerized devices used to acquire, calculate, and display the percentage of body fat together with computer-entered data, such as age and gender. The equations used for estimating percent body fat for Skinfold Measurements are provided in figure 2.

Boys percent body fat = (0.735 * [triceps value + calf value]) + 1.0
Girls percent body fat = (0.610 * [triceps value + calf value]) + 5.0
- Triceps value = median value from three skinfold measurements from triceps site
- Calf value = median value from three skinfold measurements from calf site

*signifies multiplication

Figure 2. Equations for Estimating Percent Body Fat

Abdominal Strength and Endurance (Curl-Up). Students were instructed to complete as many Curl-Ups as possible (to a maximum of 75), at a specified pace of about one Curl-Up every three seconds. The pace was called or played on a pre recorded tape or CD. On a mat, students lay on their backs with their knees bent at a 140^{o} angle, feet flat on the mat and their hands at their sides, palms facing down. Moving slowly, students curled up, sliding fingers across a measuring strip on the mat, and then curled back down until the head touched the mat. Students were stopped after reaching 75 Curl-Ups, when the second form break occurred, or at four minutes.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 14.0 was used for all analyses. Student's t-test for independent data was used to assess the between-group differences and for dependent data to assess the Post-Pre differences. In all the analyses, the 5% critical level ($p\leq0.05$) was considered to indicate statistical significance.

Results

The results of biochemical and physical fitness parameters in volleyball players from plyometric (P) and control (C) groups are presented in Table II & III. No Significant between-group differences were found in the Plyometric (P) group, in haemoglobin (t=0.0318), urea (t=1.422), uric acid (t=0.160), total cholesterol (t=1.406), triglyceride (t=1.422) and aerobic capacity (t=0.326) as the analysis of the performed examinations shows that the calculated value of t is less than tabulated value of (t=1.729) for the selected degree of freedom and level of significance whereas significant between-group differences were noted in body composition (t=2.465*) and abdominal strength & endurance (t=.13.424*), since the calculated value of t is greater than tabulated value of t (t=1.729). No significant changes were found in the control groups.

Variable	Plyometric			Control		
	Pre	Post	t-value	Pre	Post	t-value
Hb ($g.dl^{-1}$)	12.3±0.4	12.±0.5	0.0318	11.9±0.9	11.9±1.0	0.544
Urea ($mg.dl^{-1}$)	24.2±2.1	24.5±2.3	1.422	23.3±2.4	23.2±2.5	0.418
Uric acid ($mg.dl^{-1}$)	3.7±0.4	3.7±0.5	0.160	3.8±0.5	3.8±0.4	0.346
Total Cholesterol ($mg.dl^{-1}$)	88.0±4.6	94.5±4.2	1.406	89.0±5.6	89.4±5.5	1.566
Triglyceride($mg.dl^{-1}$)	87.2±5.0	87.5±5.2	1.422	87.8±4.0	87.5±4.0	0.295

Table II. Mean values (±SD) of biomechanical parameters in the plyometric (P) and control (C) groups (n = 20 each)

Variable	Plyometric			Control		
	Pre	Post	t-value	Pre	Post	t-value
Aerobic Capacity	41.8±5.3	42±4.5	0.326	42.3±4.7	42.3±4.7	0.125
Body Composition	23.8±2.4	24.7±2.5	2.465*	23.6±1.7	23.3±2.3	1.465
Abdominal Strength and Endurance	24.0±2.2	38.6±4.1	13.424*	20.7±2.1	20.6±2.4	0.156

Table III. Mean values (±SD) of physical fitness parameters in the plyometric (P) and control (C) groups (n = 20 each)

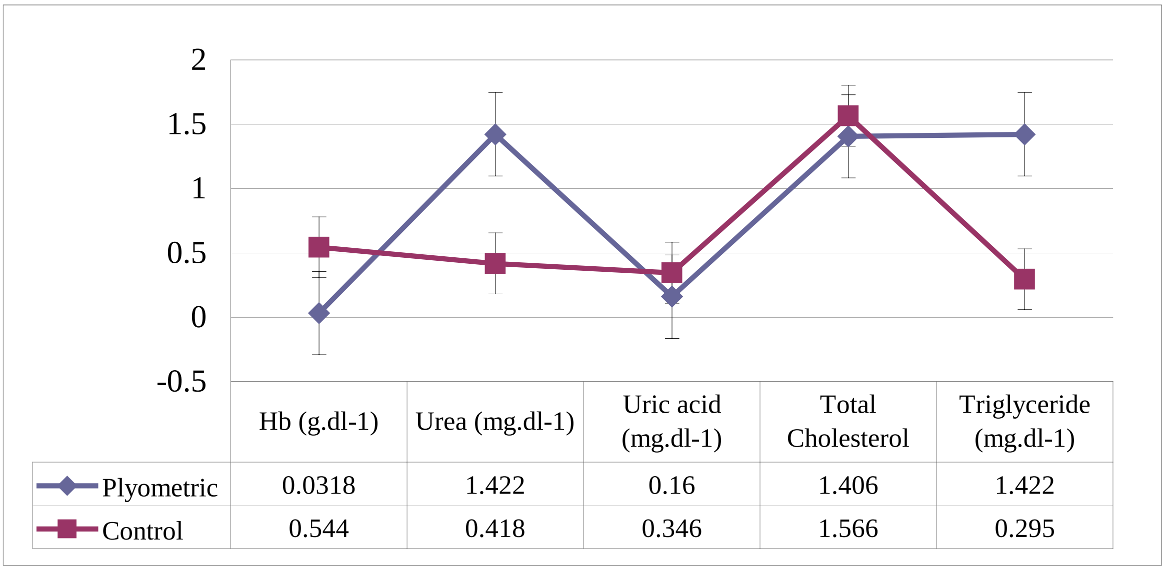

Figure 3. t-value of biomechanical parameters in plyometric (P) and control (C) groups (n = 20 each)

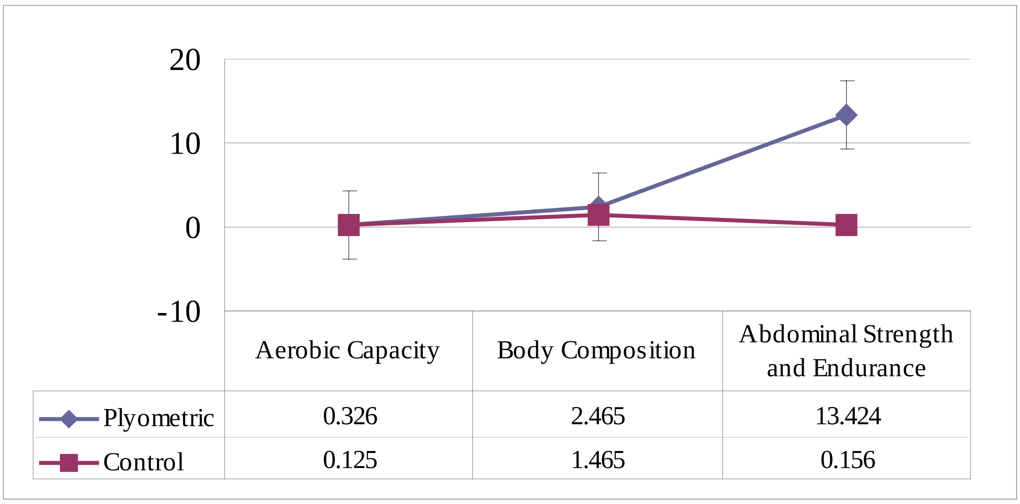

Figure 4. t-value of physical fitness parameters in the plyometric (P) and control (C) groups (n = 20 each)

Disscusion

Since the ancient times, it has been believed that a suitable physique is important to achieve success in particular sports (14). Judging the performance of the human body by its size, shape and form has been a topic of great concern. The purpose of the present study was to investigate the effects of 6-week plyometric training program on biochemical and physical fitness parameters. No significant between-group differences were found in the plyometric (P) group, in haemoglobin (t=0.0318), urea (t=1.422), uric acid (t=0.160), total cholesterol (t=1.406), triglyceride (t=1.422) and aerobic capacity (t=0.326). These findings are supported by other reports that showed that the regular participation in physical activity is associated with lower plasma level of triglycerides. Level of fitness influences the lipid profile as physically fit and active individuals tend to have lower levels of lipids than less active individuals. Whereas Significant between-group differences were noted in body composition (t=2.465*) and abdominal strength & endurance (t=.13.424*). No significant changes were found in the control groups. The body composition especially in an athlete is a better guide for determining the desirable weight rather than using the standard height-weight-age table of normal population due to the presence of high proportions of muscular content their total body composition (15, 16). In addition, body fat plays an important role for the assessment of physical fitness of the players. These findings are supported by other reports that showed that the significantly higher strength of back and grip were noted in senior players compared to juniors. As boxing is a combat sports, many activities are forceful and explosive (e. g. punches, movements, changing pace etc.). The power output during such activities is related to the strength of the muscles involved in the movements. Thus, it might also diminish the risk of injury (16). Moreover, grip and back strength also have significant impact on the performance. The higher levels of back and grip strength in the senior players may be due to their higher body mass and high level strength training compared to the junior boxers (17).

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