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Full Length Research Paper

Effects of 6-week plyometric training on biochemical and physical fitness parameters of Indian jumpers

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The purpose of this study was to investigate the effects of 6 week plyometric training on biochemical and physical fitness parameters of inter collegiate jumpers. A group of 30 jumpers (mean ± SD: age 22.02 ± 1.64 years, height 1.78 ± 0.04 m, body mass 75.5 ± 5.2 kg), who participated in inter-college athletic competition volunteered to participate in this study. The study was approved by the Ethics Committee of Directorate of Sport in Guru Nanak Dev University, Amritsar, India. All participants were informed about the study aim and methodology. All the subjects agreed to the above conditions in writing. They were randomly assigned into plyometric training (P) and control (C) groups, n=15 each. Plyometric group (P) was subjected to 6 week plyometric training program of 30 min a day and the control group did not perform any plyometric training techniques. The following biochemical and physical fitness parameters were determined: haemoglobin ($g.dl^{-1}$), urea ($mg^{.}dl^{-1}$), uric acid ($mg^{.}dl^{-1}$), total cholesterol ($mg^{.}dl^{-1}$), triglyceride ($mg^{.}dl^{-1}$), aerobic capacity, body composition and trunk strength and endurance. A paired (samples) t-test was used in data analysis. The level of $p \leq 0.05$ was considered significant. Significant between-group differences were found in aerobic capacity (t=2.40*), body composition (t=2.43*) and abdominal strength and endurance (t=2.96*) whereas no significant between-group differences were noted in haemoglobin (t=1.25), urea (t=1.14), uric acid (t=1.10), total cholesterol (t=1.61) and triglyceride (t=1.56).The plyometric training may be recommended to improve and maintain physical fitness parameters of Jumpers.

Key words: Plyometric training, biochemical parameters, physical fitness, Jumpers.

INTRODUCTION

The performances of jumping events are depending upon biochemical and physical fitness parameters of the athletes. Plyometrics training can help players strengthen these skills. Plyometric is a form of exercise which involve repeated rapid stretching and contracting of muscles to increase power are referred to as “explosive-reactive" power training (Chu, 1998). Plyometrics are training techniques used by athletes in all types of sports to increase strength and explosiveness (Flecl et al., 2004). Plyometrics consists of a rapid stretching of a muscle (eccentric action) immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle and Earle, 2000). Researchers have shown that plyometric training, when used with a per-iodized strength training program, can contribute to improvements in vertical jump performance, acceleration, leg strength, muscular power, increased joint awareness, and overall proprioception (Adams et al., 1992; Anderst et al., 1994; Miller et al., 2002). Plyometric training works on two models, which have been propose to explain this phenomenon. The first is the Mechanical model, in this model; elastic energy is created in the muscles and tendons and stored as a result of a rapid stretch (Asmussen et al., 1974; Bosco et al., 1982). This stored energy is then released when the stretch is followed immediately by a concentric muscle action. The effect is like that of stretching a spring, which wants to return to its natural length. The spring in this case, is a component of the muscles and tendons called the series elastic component.

The second model is the Neurophysical model, when a quick stretch is detected in the muscles, an involuntary

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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 VO2max from the 20 m PACER.

and protective response occurs to prevent overstretching mechanical model and injury. This response is known as the stretch reflex. The stretch reflex increases the activity in the muscles undergoing the stretch or eccentric muscle action, allowing it to act much more forcefully. The result is a powerful braking effect and the potential for a powerful concentric muscle action. If the concentric muscle action does not occur immediately after the pre-stretch, the potential energy produced by the stretch reflex response is lost (that is, if there is a delay between dipping down and then jumping up, the effect of the counter-dip is lost). It is thought that both the mechanical model (series elastic component) and the neurophysical model (stretch reflex) increase the rate of force production during plyometrics exercises (Guyton et al., 1995; Hunter et al., 2000).

The plyometric is concerned with the jumping ability of the athletes and helps to improve the performance. With view of the above cited study the investigators of present study wants to know, is the plyometric training effects only jumping ability or its effects other permeates like biochemical and physical fitness parameters of the Jumpers.

MATERIALS AND METHODS

A group of 30 jumpers (mean ± SD: age 22.02 ± 1.64 years, height 1.78 ± 0.04 m, body mass 75.5 ± 5.2 kg), who participated in inter-college athletic competition volunteered to participate in this study. The study was approved by the Ethics Committee of Directorate of Sport in Guru Nanak Dev University, Amritsar, India. All participants were informed about the study aim and methodology. All the subjects agreed to the above conditions in writing.They were randomly assigned into plyometric training (P) and control (C) groups, n=15 each. Plyometric group (P) was subjected to 6 week plyometric training program of 30 min a day and the control group did not perform any plyometric training techniques.

Measurement of biochemical parameters

To measure the biochemical parameters of the jumpers, 5 ml of venous blood was drawn from an antecubital vein after a 12 h fast and 24 h after the last session of exercise. Hemoglobin (Hb), urea and uric acid were measured following standard methodology (Mukharjee, 1997). Total cholesterol (TC) and triglyceride (TG) were determined by enzymatic method using Boehringer Mannhein kit (Mukharjee, 1997).

Measurement of physical fitness parameters

Aerobic capacity

20 m progressive aerobic cardiovascular endurance run (PACER) is provided to estimate aerobic capacity. The 20 m PACER estimates aerobic capacity from the number of laps (20 m in distance) that are completed. Students are instructed to run as long as possible across a distance and at a specified pace set to music played from a tape. For this test, a set of parallel lines is drawn 20 m apart. Students start on one line, run the distance, and touch the opposite line with one foot. Once they hear the sound of a single beep, students turn around and run back to the starting line. Every minute, indicated by a triple beep, the pace gets faster. Students continue in this manner until they fail twice to touch the line before they hear the single beep. The equations used for estimating VO_2max measurements are provided in Figure 1.

Body composition

Skin fold measurement

Skin fold measurements estimates body fat by taking the median or middle value from three ordered measurements of the thickness of skin folds on the triceps and calf of the right side of the body. A device called a skin fold calliper was used to take these measurements. Using the body composition conversion chart (found in the FITNESSGRAM® Test Administration Manual), the measurements were converted to percentages of body fat. The equations used for estimating percent body fat for skin fold measurements are provided in Figure 2.

Trunk extensors strength and flexibility

To measure the trunk extensor strength and flexibility of the jumper's, trunk lift test was used. While lying face down on a mat, students were asked to slowly lift the upper body off the floor, using the muscles of the back, to a maximum of 12 inches. Students were asked to hold the position for measurement (that is, distance from the floor to the student's chin), which was recorded in whole inches only and the highest score was recorded.

Plyometric 6 week training protocol

The six week Plyometric training protocol were prepared to know

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 skin fold measurements from triceps site
- Calf value = median value from three skin fold measurements from calf site
  - *signifies multiplication signifies multiplication

Figure 2. Equations for estimating percent body fat.

Table 1. Six week plyometric training protocol.

Training week	Training volume (foot contacts)	Plyometric drill	Sets X reps.	Training intensity
		Side to side ankle hops	2 × 12	Low
1	80	Standing jump and reach	2 × 12	Low
		Front cone hops	5 × 4	Low
		Side to side ankle hops	2 × 10	Low
		Standing long jump	5 × 6	Low
2	100	Lateral jump over barrier double	2 × 12	Medium
		leg hops	5 × 4	Medium
		Side to side ankle hops	2 × 10	Low
		Standing jump and reach	4 × 6	Low
3	110	Front cone hops	2 × 10	Medium
		Double leg hops	3 × 8	Medium
		Lateral cone hops	2 × 8	Medium
		Diagonal cone hops	4 × 8	Low
		Standing long jump with lateral sprint	4 × 6	Medium
4	100	Lateral cone hops	2 × 9	Medium
		Single leg bounding	4 × 7	High
		Lateral jump single leg	4 × 4	High

Table 1. Contd.

5	100	Diagonal cone hops	2 × 5	Low
		Standing long jump with lateral sprint	4 × 4	Medium
		Lateral cone hops	4 × 5	Medium
		Cone hops with 180 degree turn	4 × 7	Medium
		Single leg bounding	4 × 5	High
		Lateral jump single leg	2 × 7	High
6	100	Diagonal cone hops	2 × 10	Low
		Hexagon drill	2 × 10	Low
		Cone hops with change of direction sprint	4 × 6	Medium
		Double leg hops	3 × 4	Medium
		Lateral jump single leg	4 × 6	High

Table 2. Mean standard deviation (SD) and t-value of pre and post test of biochemical parameters of plyometric and control group.

Variables	Plyometric group			Control group		
	Pre	Post	t-value	Pre	Post	t-value
Hb ($g.dl^{-1}$)	12.38 ± 0.5	12.54 ± 0.7	1.25	12.17 ± 07	12.10 ± 0.8	0.86
Urea ($mg \cdot dl^{-1}$)	24.93 ± 2.3	25.13 ± 2.5	1.14	24.47 ± 2.7	24.67 ± 2.5	0.71
Uric acid ($mg \cdot dl^{-1}$)	3.73 ± 0.4	3.94 ± 0.5	1.10	3.73 ± 0.6	3.80 ± 0.6	0.80
Total Cholesterol ($mg \cdot dl^{-1}$)	88.33 ± 5.5	89.60 ± 6.8	1.61	89.67 ± 4.8	90.13 + 4.3	1.16
Triglyceride($mg \cdot dl^{-1}$)	87.07 ± 4.1	88.40 ± 4.4	1.56	88.00 ± 3.5	88.40 ± 3.8	0.79

the effects of 6 week plyometric training on biochemical and physical fitness parameters of inter collegiate jumpers.The Plyometric training program was based on recommendations of intensity and volume from (Piper and Erdmann, 1998), using similar drills, sets, and repetitions. Training volume ranged from 80 foot contacts to 110 foot contacts per session while the intensity of the exercises increased for five weeks before tapering off during week six as recommended by Piper and Erdmann (1998) and used previously in another study (Miller et al., 2002). The intensity of training was tapered so that fatigue would not be a factor during post-testing. The plyometric training group trained at the same time of day, two days a week, throughout the study. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise. Six week plyometric protocol is mentioned in Table 1.

DATA ANALYSIS

A paired (samples) t-test was used in data analysis. The level of $p \leq 0.05$ was considered significant.

RESULTS

The results of biochemical parameters and physical fitness parameters in plyometric training (P) and control (C) groups are presented in Tables 2 and 3. Significant between-group differences were found in aerobic capacity (t=2.40*), body composition (t=2.43*) and abdominal strength and endurance (t=2.96*) since the calculated value of t is greater than tabulated value of t (1.76) for the selected degree of freedom and level of significance whereas no significant between-group differences were noted in haemoglobin (t=1.25), urea (t=1.14), uric acid (t=1.10), total cholesterol (t=1.61) and triglyceride

Table 3. Mean, standard deviation (SD), and t- value of pre and post test of physical fitness parameters of plyometric and control group.

Variables	Plyometric group			Control group		
	Pre	Post	t-value	Pre	Post	t-value
Aerobic capacity	43.54 ± 1.1	44.29 ± 1.0	2.40*	43.48 ± 0.9	43.36 ± 1.0	0.47
Body composition	14.26 ± 1.7	14.66 ± 1.1	2.43*	14.42 ± 1.4	14.32 ± 1.3	0.55
Trunk Strength and flexibility	9.40 ± 1.2	10.14 ± 1.0	2.96*	9.06 ± 1.1	9.14 ± 1.2	0.66

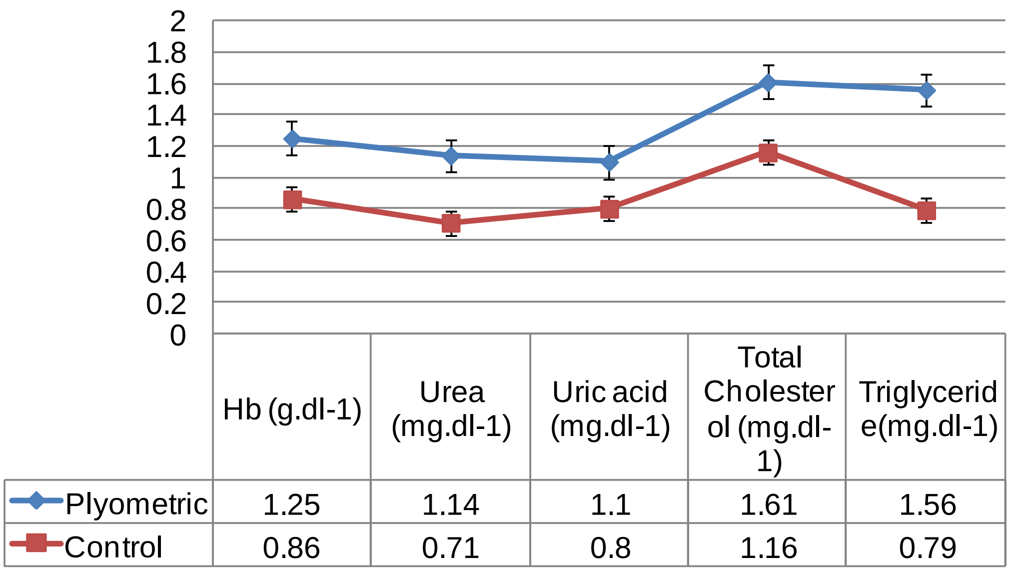

Figure 3. t-value of biomechanical parameters in the plyometric (P) and control (C) groups (n = 15 each) of 6-week plyometic training.

(t=1.56) since the calculated value of t is smaller than tabulated value of t (1.76) for the selected degree of freedom and level of significance. No significant changes were noted in the control group. The graphical representation of t-value of biomechanical and physical fitness parameters in the plyometric training (P) and control (C) groups (n = 15 each) of 6 week plyometric training is exhibited in Figure 3 and 4, respectively.

DISCUSSION

Physiological responses to physical training, including Plyometric have been well studied by many investigators. It may be expected to positively influence many physical and biochemical functions. In a previous study of plyometric training, the authors speculated that improvements were as a result of enhanced motor unit recruitment patters (Potteiger et al., 1999). Plyometric training has been shown to be one of the most effective methods for improving explosive power and other physical fitness parameters. A wide variety of athletes can benefit from power training particularly if it follows or coincides with a strength training programme. A wide variety of training studies shows that plyometrics can improve performance in vertical jumping, long jumping, sprinting and sprint cycling. It appears also that a relatively small amount of plyometric training is required to improve performance in these tasks. Just one or two types of plyometric exercise completed 1 to 3 times a week for 6 to 12 weeks can significantly improve physical fitness parameters (Blackey and Southard, 1987; Bartholomeu, 2001).

Additionally, only a small amount of volume is required to bring about these positive changes that is, 2 to 4 sets of 10 repetitions per session or 4 sets of 8 repetitions. Using a variety of plyometric exercise such as depth jumps, counter-movement jumps, leg bounding and hopping etc., can improve physical fitness parameters and performance of Jumpers (Scoles, 1978; Baur et al., 1990), while the majority of studies have focused on untrained subjects, trained athletes such as jumpers have improved their performance with plyometrics (Wagner et al., 1998; Diallo et al., 2001). Therefore, more studies are needed to determine the result of plyometric training and how it affects biochemical parameters and physical

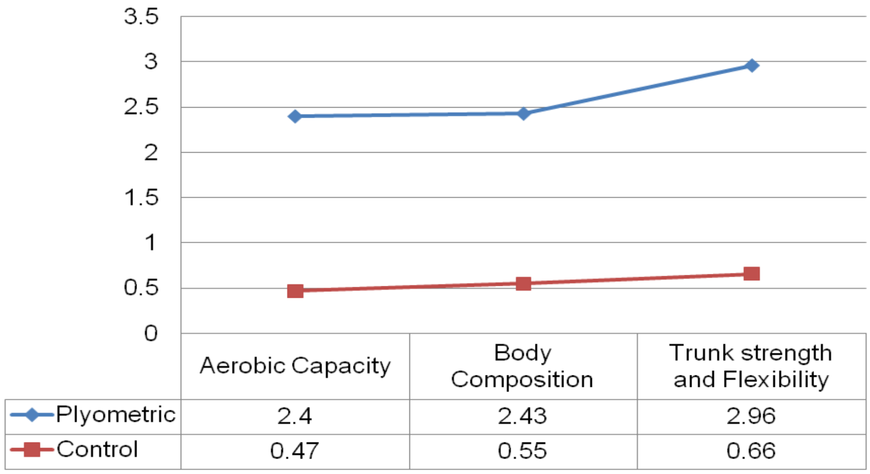

Figure 4. t-value of Physical Fitness parameters in the plyometric (P) and control (C) groups (n=15 each) of 6 week plyometic training.

fitness parameters. The experimental findings of this study indicate that the non-significant between-group differences were found in the plyometric group on Biochemical parameters that is, haemoglobin (t=1.25), urea (t=1.14), uric acid (t=1.10), total cholesterol (t=1.61), triglyceride (t=1.56) and significant between-group differences were found in the plyometric group on physical fitness parameters that is, aerobic capacity (t=2.40*), body composition (t=2.43*) and abdominal strength and endurance (t=2.96*) whereas, no significant changes were noted in the control group. These findings are supported by Ford et al. (1983), Fatouros et al. (1998), Gehri et al. (1998), Rimmer et al. (2000) and Matavulj (2001).

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