

Impact of maximal power training with and without plyometric on speed endurance and upper body power of team handball players

Balaji Ethiraj^{1ABCDE}, Murugavel Kamatchi^{2ABCDE}

¹C.B.M College, Coimbatore, Tamil Nadu, India

²Bharathiar University, Coimbatore, Tamil Nadu, India

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Abstract

Purpose: The aim of this research is to investigate the impact of maximal power training with and without plyometrics on speed endurance and upper body power of team handball players.

Material: Sixty college level men team handball players were randomly selected from Coimbatore district as subjects. Their age ranged between 18 and 25 years. The selected subjects were divided into three equal groups consisting of twenty each. No attempt was made to equate the groups. Experimental group I (n = 20) underwent maximal power training with plyometrics (MPTWP), Experimental group II (n = 20) underwent maximal power training without plyometrics (MPTWOP) for a period of 12 weeks and group III (n = 20) acted as control group (CG), the subjects in control group were not engaged in any training programme other than their regular work. Data obtained were evaluated in SPSS package.

Results: The F value revealed that the speed endurance and upper body power were significantly improved due to the influence of maximal power training with plyometrics.

Conclusions: As a result, 12 weeks of maximal power training with plyometrics can be said to increase the speed endurance and upper body power of team handball players.

Keywords: team handball, maximal power training, plyometrics, speed endurance, upper body power.

Introduction

Human muscle is composed of two broad categories of muscle cells (fibers). The slow twitch muscle fiber is characterized by high endurance, but slow rate of force production and low power output. In contrast, the fast twitch fibers possess low endurance, but a fast rate of force production and high power output. Slow twitch fibers are innervated regularly by normal daily activity; however the fast twitch fibers are used only during muscle contractions requiring high force or rapid movement. In the aged there is a selective disuse atrophy of fast twitch fibers which is most likely a result of physical activity levels which have declined to a chronically low intensity [1].

Metter et al. [2] reported that muscle power declines at a 10% faster than strength in men. Skeleton et al. [3] have shown that isometric strength declines 1-2% per annum but muscle power approximately 3.5% per annum in men over 65 years old. To what extent these changes are related to the process of aging associated with alterations in hormone balance such as decreased androgen levels in both men and women and/or decrease in the amount/intensity of normal daily physical activities is difficult to interpret [4].

Maximal power is the decisive factor of performance in activities requiring one movement series with a objective of producing high speed at release or impact [5]. Neuromuscular actions which increase power production are needed in putting, jumping and striking movements. In addition, sudden bursts of power are required when rapidly changing direction or accelerating during various sports or athletic events.

The ability to get maximal power throughout complicated motor skills is of overriding significance to prospering athletic ability across several sports. A vital issue visaged by scientists and coaches is that the development of effective and economical coaching-programmes that enhance maximal power production in active, multi-joint movements. Such training is considered as power training.

The speed and power with which athletes can produce muscular actions determine successful performance in most sports. This stage of training is necessary to enhance the speed spectrum that body is allowed to operate within. Therefore, the body will only be able to move within a set range of speed that is determined by the nervous systems [6]. This is achieved through two phase of training termed power training and maximal power training.

The premise behind power training is the superseding of a more traditional strength exercise (e.g., barbell squats) super setted with a plyometric/power exercise of similar joint dynamics (e.g., squat jumps). This is to enhance prime mover strength while also improving the rate of force production (how quickly a muscle can generate force).

Newton and Kraemer [7] have explained this form of training as "ballistic" resistance training. Recently, weight training routines have been modified to make this form of training more dynamic, thereby major limitation of traditional weight training [8]. In a study by Kaneko et al. [9] the best weight for the improvement of muscular power was calculated to be 30% of the maximum load; similar results were obtained by Pedemonte [10]. Wilson et al., [8] did a comparative study using dynamic weight

training at approximately 30% of maximum in which the load was accelerated through the full range of motion using a jump squat action. This was termed as maximal power training, as the load used was one that get the most out of the mechanical power production of the work out.

According to Wilson [11] maximal explosive power training involves performance of dynamic weight training at the load which maximizes mechanical power output. This involves lifting loads in the range of 30 to 45 percent of maximum at high speed.

It ought to be clear that the exercises should not be general weight-training exercises where the bar reaches zero velocity at the end of the movement. This would be disadvantageous to the stated goal of raising explosive power.

One explanation is to believe of MPT as a marriage between strength training and plyometrics. Maximal power training could be considered a form of plyometrics training that is specifically performed at a load which maximizes the power output of the exercise. The loading is greater than plyometrics because more load than body weight is used, but lighter than conventional weight training.

Incorporating these methods of MPT is not without hazards, however. The danger is that, due to external loading, the exercises have greater impact forces as well as greater contact times at a slower velocity than plyometric training, where there is no external load. This makes it imperative that athletes have a very good training base or they will be at greater risk of injury.

More recently, it was argued that to increase power and performance in explosive sport tasks it may be best to train with the resistance that maximizes the mechanical power output (Pmax). It was argued that by using the load or resistance that generated the Pmax during the training exercise various specific neuromuscular adaptations may occur, which in turn may transfer more readily to explosive sport tasks. It has been shown, for example, that adaptations to heavy resistance training lead mainly to improvements in the concentric force and rate of force production capabilities. Conversely, low-load, high-velocity plyometric training leads mainly to an increase in the eccentric rate of force development capabilities [12]. Theoretically, maximal power training methods may lead to an improvement in power or power training adaptations through a combination of these separate concentric and eccentric capabilities. This may be rationalized as due to both favorable neural and muscle fiber adaptations that result from the specific stresses placed on the neuromuscular system during training with resistances that maximize power output.

Neuromuscular adaptation to maximal power training also results in improved intra muscular coordination better linkages between the excitatory and inhibitory reactions of a muscle to many stimuli. As a result of such adaptation the CNS 'learns' when and when not to send a nerve impulse that signals the muscles to contract and perform a movement [13].

Utilization of maximal power training is the next

progression to produce maximal acceleration and rate of force production. This phase of training is typically reserved for high-level athletes who require maximal levels of power. An elementary association between strength and power that utter that a personal cannot own a high level of power while not initial being comparatively robust. Therefore, improving and preserving maximal strength is important while viewing the future improvement of power.

Plyometrics are exercises characterized by rapid stretch-shorten cycle (SSC) muscle actions [14]. The ability to aim both short and long SSCs as well as the ballistic nature of these actions, plyometric workouts are very particular to a mixture of movements usually encountered in sport. Hence, it is not amazing that the employ of plyometrics in power training schedule has been exposed to significantly improve maximal power output during sports-specific movements [15].

Similar to ballistic workouts, plyometrics are theorized to bring out precise adaptations in neural drive, the rate of neural activation and inter muscular control, which result in improved RFD capacity. Adaptations to the aforesaid mechanisms driving improved performance during SSC movements are also theorized to contribute to enhanced maximal power production following plyometric training [16].

Therefore, the high degree of specificity of plyometric training to a variety of sporting actions make power training schedule incorporating plyometric exercises very efficient at enhancing maximal power in sports-specific movements.

The plyometric method is ranked among the most frequently used methods for conditioning in handball [17]. Plyometric training when used with a periodized strength training program, can contribute to improvements in vertical jump performance, acceleration, leg strength, muscular power, increased joint awareness, and overall proprioception [18]. Hence, maximal power training with and without plyometrics was selected as independent variables.

Team Handball is played by two teams, composed of six players and a goalkeeper each, who try and throw the ball into their opponents' goal. Since the basis of the game is catching, throwing, jumping and shooting at goal, handball is a sport that develops the bodies of young players as well as keeping older players physically fit.

In several team sports like hockey, football, handball, and rugby speed is frequently associated with successful performance [19]. However the playing fields and the nature of the game presents a different kind sprint compared to a 100 m sprint. The playing field for handball is 20 × 40 m with an even effective smaller playing field, as the court players are not allowed inside the goalkeepers designated area. Given that the required distance to achieve maximal velocity for field athletes is 40 m from a standstill start and 29 m from a running start [20] and the playing field in handball is small, top speed is not likely to be achieved very often. Consequently, the ability to accelerate to considered being a more fundamental factor

for performance in team sports, rather than top speed [21]. This is also true for other team sports [22].

The importance of speed is most evident throughout sprinting (e.g. during fast breaks and in one-on-one situations) whilst power is explosive to vital actions (e.g. jumping and throwing actions).

The aim of strength training programme is the improvement of speed, speed endurance, power, take off power, reactive power and power endurance. These parameters, while interdependent, contain several distinct and measurable differences that are critical to success in team handball. For example, power refers to the rate of applying force, take off power more specifically refers to the power needed to project the body vertically. The height of the jump is directly proportional to leg power. Reactive power, on the other hand, refers to the ability to change the directions immediately such as landing from a vertical jump and making the transition from throwing to blocking.

The paramount importance to team handball player is power/speed endurance- the ability to repeat these power and speed moves throughout the match. Clearly, those players with the greatest speed and power during the later stages of the match will have a significant advantage. The importance of speed and power in team handball players is demonstrated below in the average values achieved on performance tests for the Russian National team before the 1988 Olympics in Seoul. 30 m sprint-4"1-4"25; triple jump-8.60 m; vertical jump-93 cms [23].

The aim of this research was to determine the impact of maximal power training with and without plyometrics on speed endurance and upper body power of team handball players.

Hypothesis. The hypothesis argued in this paper is that team handball players can significantly increase the speed endurance and upper body power by combining technical and tactical sessions with maximal power training with plyometrics over a consecutive 12 weeks period. Therefore, the objective of this research was to investigate the changes in the parameters produced during 12 weeks of maximal power training with plyometrics and maximal power training without plyometrics in sixty college level team handball players.

Materials and methods

Participants

In order to address the hypothesis presented herein, we selected sixty college level men team handball players. Their age ranged between 18 and 25 years ($M = 20.75$, $SD = 1.55$). The selected subjects were divided into three equal groups consisting of twenty each. No attempt was made to equate the groups. Experimental group I ($n = 20$) underwent maximal power training with plyometrics training (MPTWP), experimental group II ($n = 20$) underwent maximal power training without plyometrics training (MPTWOP) for a period of 12 weeks and group III ($n = 20$) acted as control group (CG), the subjects in control group were not engaged in any training programme other than their regular work.

Research Design

The evaluated parameters were speed endurance (150 m run) and upper body power (Medicine ball put). The parameters were measured at baseline after 12 weeks of MPTWPT and 12 weeks of MPTWOPT and the effects of the training were examined.

Before the tests, the subjects underwent 5 minutes of low intensity aerobic run and 10 minutes of dynamic and static stretching of upper and lower extremity muscles for general warm-up [24].

Training Protocol

In each training session the training was imparted for a period 60 minutes. The maximal power training with plyometrics, which included 5 minutes warming up and 5 minutes relaxation procedure after training programme for three days per week for a period of 12 weeks.

Statistical Analysis

The collected data were analysed with application of SPSS package. The 't' test found out the individual effect from base line to post-test if any. Further Analysis of Covariance (ANCOVA) was used to determine the significant difference between the treatment means. Whenever the 'F' ratios were found to be significant, Scheffé's post hoc test was applied to test the significant difference between the paired adjusted means. 0.05 level of confidence was fixed to test the level of significance.

Results

Table.1 indicates the obtained 't' values on variables for the MPTWPT were 12.15 (Speed endurance), 71.41 (Upper body power); for the MPTWOPT were 7.51 (Speed endurance), 23.88 (Upper body power). Since these values were higher than the required table value of 2.09, it was found to be statistically significant at 0.05 level of confidence for degrees of freedom 1 and 19. And the obtained 't' ratio between pre and post-test of control group were 1.67 (Speed endurance), 0.45 (Upper body power) were lesser than the required table value of 2.09, found to be not statistically significant.

Table. 2 reveals the computation of 'F' ratios on pretest, posttest and adjusted posttest means of MPTWPT, MPTWOPT, and CG on speed endurance. The obtained 'F' ratio for the pretest means of MPTWPT, MPTWOPT, and CG on speed endurance was 0.26. Since the 'F' value was less than the required table value of 3.16 for the degrees of freedom 2 and 57, it was found to be not significant at 0.05 level of confidence. Further, the posttest 'F' ratio 71.17 after MPTWPT, MPTWOPT, and CG on speed endurance was higher than the required table value of 3.16 for the degrees of freedom 2 and 57, hence it was found to be statistically significant at 0.05 level of confidence. The obtained 'F' ratio for the adjusted post-test means of MPTWPT, MPTWOPT, and CG on speed endurance was 87.03. Since the 'F' value was higher than the required table value of 3.16 for the degrees of freedom 2 and 56, it was found to be statistically significant at 0.05 level of confidence.

Table.3 revealed that the mean differences between the paired adjusted post-test means of all groups on speed

Table 1. Computation of 't' ratio on speed endurance and upper body power of men team handball players

Variables	Pre – test mean	Pre – test S. D (±)	Post – test mean	Post – test S. D (±)	't' ratio
MPTWPT GROUP					
Speed Endurance (Scores in Seconds)	21.45	0.11	20.12	0.53	12.15*
Upper body power (Scores in centimeters)	287.55	2.01	320.10	1.25	71.41*
MPTWOPT GROUP					
Speed Endurance (Scores in Seconds)	21.46	0.09	20.99	0.33	7.51*
Upper body power (Scores in centimeters)	287.50	1.40	310.45	4.06	23.88*
CONTROL GROUP					
Speed Endurance (Scores in Seconds)	21.47	0.07	21.47	0.07	1.67
Upper body power (Scores in centimeters)	287.35	1.42	287.20	1.44	0.45

*Significant at 0.05 level for the degrees of freedom (1 and 19), 2.09

Table 2. Analysis of covariance on Pre, Post and Adjusted Posttest means on speed endurance of MPTWPT, MPTWOPT and Control Group (Scores in seconds)

Test	MPTWPT	MPTWOPT	Control Group (CG)	Source of variance	df	Sum of Square	Mean Square	F-ratio
Pre-test Mean	21.45	21.46	21.47	B / S	2	0.004	0.002	0.26
				W / S	57	0.476	0.008	
Post-test Mean	20.12	20.98	21.47	B / S	2	18.642	9.321	71.17*
				W / S	57	7.466	0.131	
Adjusted Post-test Mean	20.14	20.99	21.45	B / S	2	17.53	8.77	87.03*
				W / S	56	5.64	0.101	

*Significant at 0.05 level for the degrees of freedom (2, 57) and (2, 56), 3.16

endurance. The mean difference between MPTWPTG and CG, MPTWPTG and MPTWOPTG, and MPTWOPTG and CG were 1.31, 0.87 and 0.46 respectively. The values of mean difference of adjusted post-test means were higher than that of the required confidence interval value of 0.23. It is found to be significant at 0.05 level of confidence.

Figure 1 describes a bar diagram showing pre, post and adjusted post test means of maximal power training with plyometrics training group (MPTPG), Maximal power training without plyometrics training group (MPTWPG) and control group on speed endurance (Figure 1).

Table. 4 reveals the computation of 'F' ratios on pretest, posttest and adjusted posttest means of MPTWPT, MPTWOPT, and CG on upper body power. The obtained 'F' ratio for the pretest means of MPTWPT, MPTWOPT,

and CG on upper body power was 0.08. Since the 'F' value was less than the required table value of 3.16 for the degrees of freedom 2 and 57, it was found to be not significant at 0.05 level of confidence. Further, the posttest 'F' ratio 853.67 after MPTWPT, MPTWOPT, and CG on upper body power was higher than the required table value of 3.16 for the degrees of freedom 2 and 57, hence it was found to be statistically significant at 0.05 level of confidence. The obtained 'F' ratio for the adjusted post-test means of MPTWPT, MPTWOPT, and CG on upper body power was 848.26. Since the 'F' value was higher than the required table value of 3.16 for the degrees of freedom 2 and 56, it was found to be statistically significant at 0.05 level of confidence.

Table 5 revealed that the mean differences between the

Table 3. Scheffee's post hoc test for the differences between the paired adjusted post-test means of speed endurance

Maximal power training with plyometric training group (MPTWPTG)	Maximal power training without plyometric training group (MPTWOPTG)	Control group (CG)	Mean difference	Confidence Interval
20.14		21.45	1.31	
20.14	20.99		0.85	0.23
	20.99	21.45	0.46	

Scores in Seconds

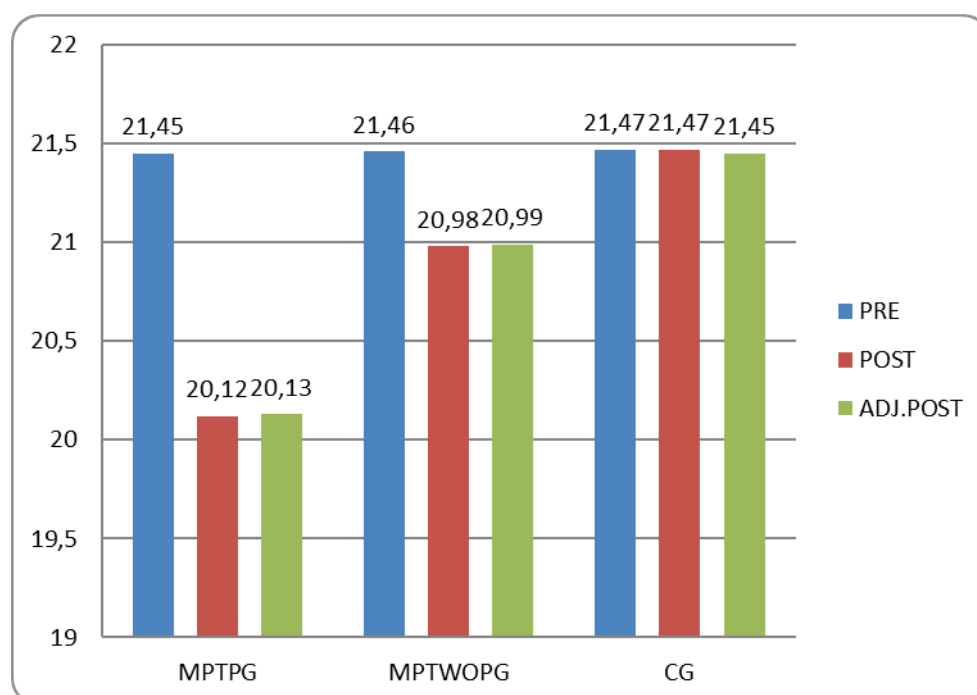

Figure 1. Speed Endurance.

Table 4. Analysis of covariance on pre, post and adjusted post test means on upper body power height of maximal power training with plyometrics training group (MPTPG), Maximal power training without plyometrics training group (MPTWOPG) and control group (Scores in centimeters)

Test	Maximal power training with plyometric training group (MPTPG)	Maximal power training without plyometric training group (MPTWOPG)	Control group (CG)	Source of variance	df	Sum of quares	Mean square	F-ratio
Pre-test mean	287.55	287.50	287.35	B .G	2	0.43	0.22	0.08
				W .G	57	152.50	2.68	
Post-test mean	320.10	310.45	287.20	B .G	2	11440.6	5720.32	853.67*
				W .G	57	381.95	6.70	
Adjusted post-test mean	320.08	310.44	287.22	B .G	2	11379.8	5689.90	848.26*
				W .G	56	375.65	6.71	

*Significant at 0.05 level for the degrees of freedom (2, 57) and (2, 56), 3.16

Table 5. Scheffee's post hoc test for the differences between the paired adjusted post-test means of upper body power

Maximal power training with plyometric training group (MPTPG)	Maximal power training without plyometric training group (MPTWOPG)	Control group (CG)	Mean difference	Confidence Interval
320.08		287.22	32.86*	
320.08	310.44		9.64*	2.32
	310.44	287.22	23.22*	

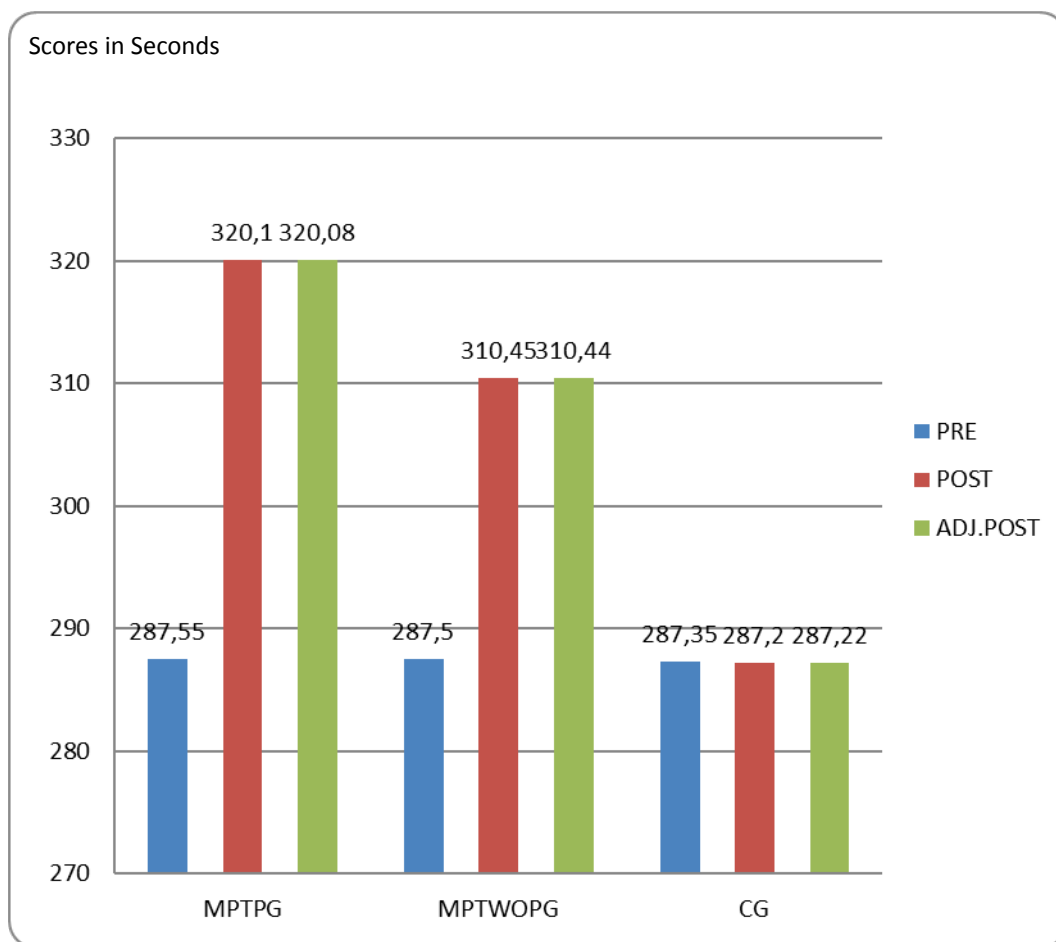


Figure 2. Upper Body Power

paired adjusted post-test means of all groups on upper body power. The mean difference between MPTWPTG and CG, MPTWPTG and MPTWOPTG, and MPTWOPTG and CG were 32.86, 9.64 and 23.22 respectively. The values of mean difference of adjusted post-test means were higher than that of the required confidence interval value of 2.32. It is found to be significant at 0.05 level of confidence.

Figure 2 describes a bar diagram showing pre, post and adjusted post-test means of maximal power training with plyometrics training group (MPTPG), Maximal power training without plyometrics training group (MPTWOPG)

and control group on upper body power (Figure2).

Discussion

In contemporary handball we can observe a very dynamic toughness of play. Strong body contact, heavy loads of technical executions and a faster speed of actions and tactical evolution are some of the new aspects in team handball now. As a consequence, the structure of training sessions included the power and strength training, which has been developed in order to cover the athletes' requested speed and power skills.

The present study has examined how the speed

endurance and upper body power are determined by the impact of maximal power training with and without plyometrics on college level men team handball players. The quest for the development of speed and power as a means of improvement in sports performance is never ending. Training methods to improve speed and power have run the gamut from heavy weight to light weight training to plyometrics where the acceleration and deceleration of the body is the overload. All these methods have produced results, although the results have not always been commensurate with the training time invested. Research has shown that in a maximal lift 23% of the movement is accounted for deceleration of the bar. In a lift at 81% of maximum the deceleration phase accounted for 52% of the concentric movement. This is one of the major limitations of maximal power training for the development of speed and power.

The results from the study are very encouraging and demonstrate the benefits of maximal power training and plyometric exercises over speed endurance and upper body power in team handball game. In addition, the results report improvements in fitness can occur in a little as 12 weeks of maximal power training and plyometrics which can be useful during the last preparative phase before the competition session for team handball players.

The results of the present study indicate that the maximal power training and plyometrics training programme are effective methods to improve speed endurance and upper body power in team handball.

The maximal power training with plyometrics improved the speed endurance and upper body power over 6.20% and 11.32% respectively.

The maximal power training without plyometrics improved the speed endurance and upper body power over 2.19% and 7.98% respectively.

However there were no statistically significant changes in speed endurance and upper body power of control group.

The factors to be noted in the present study is that, there is an improvement in speed endurance and upper body power for maximal power training with plyometrics than maximal power training without plyometrics. So the maximal power training with plyometrics training holds good to desired effect on selected parameters.

Transfer may be conceptually expressed as being a function of the following: gain in performance/gain in trained exercise [25]. Eight weeks of strength training with the squat exercise produced 21% gain in the one-repetition-maximum (1RM) squat. This change was accompanied by an improvement in vertical-jump (VJ)

performance of 21% and 40-m sprint performance of 2.3%. This example shows that training to improve leg strength as measured by a 1RM squat has excellent transference to VJ performance but considerably less to sprinting performance. Key issues involve determining the factors responsible for attaining high levels of transfer and whether appropriate training guidelines have been identified.

Lytle et al. [26] suggested that the incorporation of horizontal plyometric exercises may improve sprints times since the training would be more related to the performance measure. The present study had both training groups performing horizontal bounding and box jumping exercises for the entire plyometric phase of training.

The contact times during the initial acceleration phase of a sprint are similar to the contact times of the exercises employed [27]. Therefore, the greatest transfer of the plyometrics to sprinting likely occurred during the initial acceleration phase. This theory is supported by [28], who suggested that bounding may be considered a specific exercise for the development of acceleration because of the similar contact times of bounding and sprinting during the initial acceleration phase.

Ebeedi et al. [29] conducted a study to recognize the effect of ballistic training on some physical and skillful variables upon handball players. The most important result was that the proposed ballistic training led to improve physical variables such as (muscular ability- flexibility- fitness velocity) and the skillful ones (the velocity of dribbling, velocity of passing, pivot shot) of handball players.

Conclusions

Within the limitations and on the basis of the findings, it was very clear that twelve weeks of maximal power training with plyometrics training produced significant changes in the speed endurance and upper body power college level men team handball players.

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Conflict of interest

The authors declare no conflict of interest.

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Information about the authors:

Balaji Ethiraj: (Corresponding Author); <https://orcid.org/0000-0001-8532-3308>; balajiethirajcbe@gmail.com; C.B.M College; Coimbatore, Tamil Nadu, India.

Murugavel Kamatchi; <https://orcid.org/0000-0002-7953-1757>; melato_muruga@yahoo.co.in; Bharathiar University; Coimbatore, Tamil Nadu, India.

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