International Journal of Physical Education, Sports and Health 2017; 4(2): 33-37

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2017; 4(2): 33-37

www.kheljournal.com
Received: 08-01-2017
Accepted: 09-02-2017

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Effects of maximal power training with and without plyometrics training on vertical jump height and maximum power of men team handball players

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Abstract
The study was designed to investigate the "Effects of maximal power training with and without plyometrics training on vertical jump height and maximum power of men team handball players". To achieve this purpose 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 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. The criterion variables were chosen namely vertical jump height and maximum power. The dependent variables were assessed before and after the 12 weeks of maximal power training with and without plyometrics. The collected data on vertical jump height and maximum power were analyzed with application of 't' test to find 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, scheffe'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

Keywords: Maximal power training, plyometrics, vertical jump height, maximum power, team handball

1. Introduction
The ability to generate maximal power during complex motor skills is of paramount importance to successful athletic performance across many sports. A crucial issue faced by scientists and coaches is the development of effective and efficient training programmes that improve maximal power production in dynamic, multi-joint movements. Such training is referred to as 'power training'.
According to Wilson (1994) [12], "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 should be obvious that the exercises must not be typical weight-training exercises where the bar reaches zero velocity at the end of the movement. This would be counterproductive to the stated goal of raising explosive power.
One solution is to think 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 resistance than body weight is used, but lighter than traditional weight training.
In selecting exercises for maximal power training, the key is to find those that allow for the production of the highest possible force throughout the entire range of motion. One of the best examples of this is the weighted squat jump. According to Baker (1995) [2], "The multiple repetition jump squats are associated with power outputs usually only generated by elite usually only generated by elite weightlifters during the second pull of the jerk thrust."

Maximal strength and power training programme improve in muscle strength, squat, sprinting, jumping (Bernardorequena *et al*., 2015) [3]. Maximal strength, maximal repetitive upper and lower body high power exercises programme improve in maximum power, maximum strength (Mikel *et al*., 2001) [10]. Combined maximum power and maximum strength with plyometrics training programme improve maximum power, lower body power (Fagan *et al*., 2000) [8].

In many sports and activities that require an explosive power from particular muscle contractions are rapidly followed by concentric contractions (Chu, 1992) [7]. Maximal Power performance has been shown to respond to training, which involves the athletes performing SSC movements with a stretch load greater and more rapid than to which they are accustomed. These activities have been termed "Plyometrics" and have been found in a number of studies, to be effective for increasing jumping ability (Adams *et al.,* 1992) [1].

Handball is a popular game throughout the world, was introduced in Germany by a gymnastics teacher, Max Heiser, in 1917. The game was primarily devised for girls and played 11-a-side on a football field. There are, however, authentic reports of a similar game, "Handbold" being played in Denmark as early as 1904.

Power is an important factor in handball, highlighted in game situations involving sprinting, changing of direction, jumping and physical contacts with the opponent. However, since the force actions are repeated several times during the game, the power resistance has to be trained (Buchheit, 2008) [4]. The vertical jump is a frequent movement, in both defensive (e.g. blocking, rebounding, and stealing) and offensive (e.g. passing, rebounding, and shooting) actions. The 8 week of plyometric training improves upper limb, lower limb regimen of adolescent handball players (Chelly *et al.,* 2014) [5].

During the game, tasks such as pushing and blocking require high power and strength levels in the limbs and trunk regions (Wallace and Cardinale, 1997) [11]. Reported that stronger players with higher body mass have an advantage in handball because the requirements of the game, such as throwing the ball with power and speed, are met through jumping and physical contact with the opponent. The increase in maximal upper-body strength and jumping power should give the whole team an advantage to sustain the forceful muscle contractions required during some handball game actions, such as hitting, blocking, pushing, holding, and jumping (Jensen *et al.,* 1997) [9].

The hypothesis argued in this paper is that team handball players can significantly increase the vertical jump height and maximum power by combining technical and tactical sessions with maximal power training with plyometrics over a consecutive 12 weeks period. Therefore, the object of this study 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.

2. Materials and Methods

2.1 Experimental Approach to the Problem

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. 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.

2.2 Design

The evaluated parameters were vertical jump height (Sergeant jump) and maximum power (1 RM Half Squat).The parameters were measured at baseline after 12 weeks of MPTWPT and 12 weeks of MPTWOPT and the effects of the training were examined.

2.3 Training Protocol

In each training session the training was imparted for a period 60 minutes. The maximal power training with and without 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.

2.4 Statistical Analysis

The collected data were analyzed with application of't' test to find 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, Schefft'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.

3. Results

3.1 Computation of 'T' Ratio on Vertical Jump Height and Maximum Power of Men Handball Players

Variables	Pre – test mean	Pre – test S. D (±)	Post – test mean	Post – test S. D (±)	't' ratio
MPTWPT GROUP					
Vertical Jump Height	42.58	0.30	46.09	0.77	19.49*
Maximum Power	86.7	2.54	104.9	1.89	39.87*
MPTWOPT GROUP					
Vertical Jump Height	42.6	0.35	43.32	0.36	7.30*
Maximum Power	86.4	1.9	93.1	2.38	14.41*
CONTROL GROUP					
Vertical Jump Height	42.40	0.29	42.32	0.29	1.73
Maximum Power	86.3	1.49	86.1	1.74	1.71

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

Table 3.1 indicates the obtained't' values on variables for the MPTWPT were 19.49 (Vertical jump height), 39.87 (Maximum power); for the MPTWOPT were 7.30 (Vertical jump height), 14.41 (Maximum 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 freedom1 and 19. And the obtained't' ratio between pre and post-test of control group were 1.73 (Vertical jump height) and 1.71 (Maximum power) were lesser than the required table value of 2.09, found to be not statistically significant.

3.2 Analysis of covariance on Pre, Post and Adjusted Post-test means on vertical jump height of MPTWPT, MPTWOPT and Control Group
(Scores in centimeters)

Test	MPTWPT	MPTWOPT	Control Group (CG)	Source of variance	df	Sum of Square	Mean Square	F-ratio
Pre-test Mean	42.58	42.60	42.4	B / S	2	0.51	0.26	2.58
				W / S	57	5.64	0.10	
Post-test Mean	42.09	43.32	42.32	B / S	2	152.25	76.13	283.56*
				W / S	57	15.30	0.27	
Adjusted Post-test Mean	46.06	43.29	42.37	B / S	2	143.23	71.62	276.84*
				W / S	56	14.49	0.26	

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

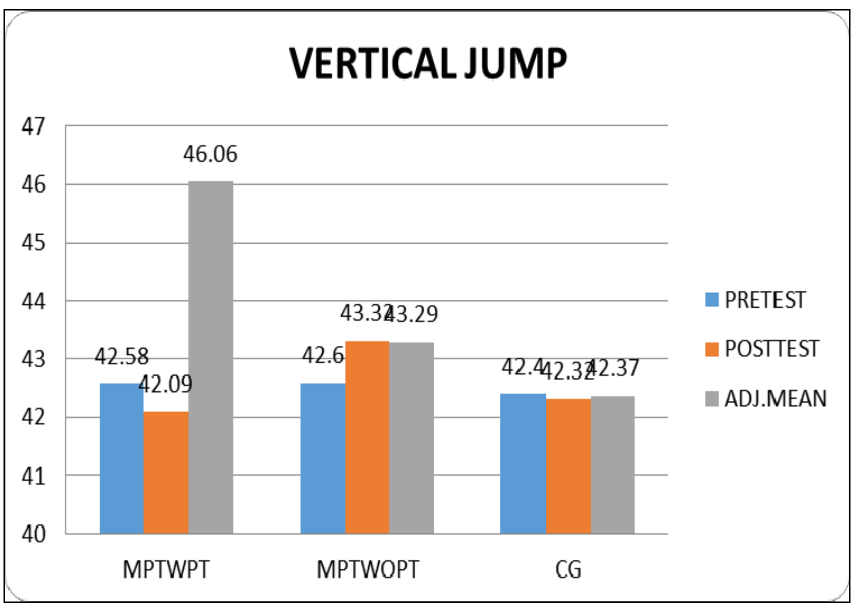
Table 3.2 reveals the computation of 'F' ratios on pretest, posttest and adjusted posttest means of MPTWPT, MPTWOPT, and CG on vertical jump. The obtained 'F' ratio for the pretest means of MPTWPT, MPTWOPT, and CG on vertical jump was 2.58. Since the 'F' value was less than the required table value of 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 283.56 after MPTWPT, MPTWOPT, and CG on vertical jump 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 vertical jump was 276.84. 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.

3.3 Scheffe's Post hoc test for the differences between the paired Adjusted Post-test means of vertical jump

MPTWPT	MPTWOPT	Control Group (CG)	Mean difference	Confidence Interval
46.06		42.37	3.69*	0.37
46.06	43.29		2.77*	
	43.29	42.37	0.92*	

* Significant at 0.05 level

Table 3.3 revealed that the mean differences between the paired adjusted post-test means of all groups. The mean difference between MPTWPTG and CG, MPTWPTG and MPTWOPTG, and MPTWOPTG and CG were 3.69, 2.77 and 0.92 respectively. The values of mean difference of adjusted post-test means were higher than that of the required confidence interval value of 0.37. It is found to be significant at 0.05 level of confidence.



3.4 Analysis of covariance on Pre, Post and Adjusted Post-test means on maximum power of MPTWPT, MPTWOPT and Control Group (Scores in kilograms)

Test	MPTWPT	MPTWOPT	Control Group (CG)	Source of variance	df	Sum of Square	Mean Square	F-ratio
Pre-test Mean	86.70	86.40	86.30	B / S	2	1.73	0.87	0.21
				W / S	57	233.20	4.09	
Post-test Mean	104.90	93.10	86.10	B / S	2	3611.2	1805.6	440.96*
				W / S	57	233.40	4.10	
Adjusted Post-test Mean	104.75	93.14	86.21	B / S	2	3485.64	1742.82	712.83*
				W / S	56	136.92	2.45	

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

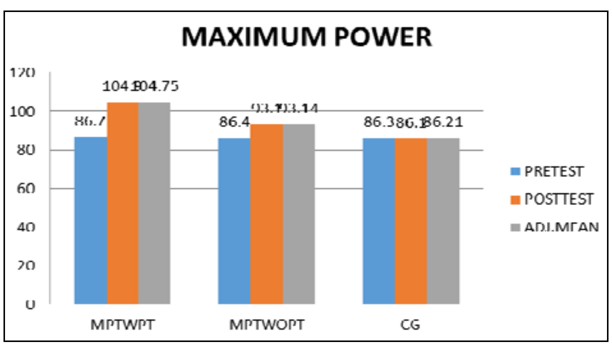
Table 3.4 reveals the computation of 'F' ratios on pre-test, post-test and adjusted post-test means of MPTWPT, MPTWOPT, and CG on maximum power. The obtained 'F' ratio for the pre-test means of MPTWPT, MPTWOPT, and CG on maximum power was 0.21. Since the 'F' value was less than the required table value 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 post-test 'F' ratio 440.96 after MPTWPT, MPTWOPT, and CG on maximum 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 maximum power was 712.83. 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.

3.5 Scheffe's Post hoc test for the differences between the paired Adjusted Post-test means of maximum power

MPTWPT	MPTWOPT	Control Group (CG)	Mean difference	Confidence Interval
104.75		86.21	18.54*	1.15
104.75	93.14		11.61*	
	93.14	86.21	6.93*	

* Significant at 0.05 level

Table 3.5 revealed that the mean differences between the paired adjusted post-test means of all groups. The mean difference between MPTWPTG and CG, MPTWPTG and MPTWOPTG, and MPTWOPTG and CG were 18.54, 11.61 and 6.93 respectively. The values of mean difference of adjusted post-test means were higher than that of the required confidence interval value of 1.15. It is found to be significant at 0.05 level of confidence.



Plyometric training has widely been used to enhance muscular power output, force production, velocity, and aid in injury prevention. The plyometric method is ranked among the most frequently used methods for conditioning in handball (Lehnert *et al.,* 2009). 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.

Maximal strength, maximal repetitive upper and lower body high power exercises programme improve in maximum power, maximum strength (Mikel *et al*., 2001) [10]. Combined maximum power and maximum strength with plyometrics training programme improve maximum power, lower body power (Fagan *et al*., 2000) [8].

4. Discussion

Power training has emerged as an important method in stimulating overall functioning capacity (Izquierdo *et al.,* 2001). Maximal strength and power training programme improve in muscle strength, squat, sprinting, jumping (Bernardorequena *et al*., 2015) [3]. To any sport that requires powerful, propulsive movements, such as football, volleyball, sprinting, high jump, long jump, and basketball, the application of plyometric or explosive jump training is applicable.

5. Conclusions

Twelve weeks of maximal power training with plyometrics training programme produced significant improvements in the vertical jump, and maximum power of men team handball players.

Maximal power training with plyometrics training protocol to bring out desirable changes over the above said parameters for handball players.

Thus continuous and systemic maximal power training with plyometrics training aimed at maximizing performance capacity should be applied to college level men handball players.

The proposed maximal power training with plyometrics training programme should be a part of physical preparation of handball players, because of their significant influence on raising the level of the player physically and skillfully. It is necessary to raise the awareness of the trainers with the importance of the maximal power training with plyometrics exercises in the direction of the skill because of their significant influence on raising the physical and skillful level of handball players. Studies should be conducted in the same area on different samples in terms of age and gender.

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