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Effect of Combined Plyometric-Sprint and Combined Plyometric-Resistance Training Protocols on Speed, Explosive Power and Change of Direction

Hassan Almoslim

KFUPM, Dhahran, Saudi Arabia;
almoslim@kfupm.edu.sa

Abstract

Background/Objective: The objective of the current investigation was to distinguish the impact of six weeks of combined plyometric-resistance and combined plyometric-sprint trainings on the fitness elements among male students. **Methods/Statistical Analysis:** 143 males aged 18 to 22 years were categorized into 3 groups, Plyometric-Sprint Training (PST, n = 48), Plyometric-Resistance Training (PRT, n = 47) and a Control Group (CG, n = 48). The experimental groups trained for 40 min per workout 2 days a week, for 6 weeks. Before and after training, tests were assessed on body composition, speed, power and agility. ANOVA and paired t-tests were used for analysis. **Findings:** The outcomes of all the components of this investigation showed that both the PSTand the PRT revealed significantly greater reduction in the mean values than the CG (P<0.05), but no change was recorded between them in 30 m, 40 m and a 50 m run (P>0.05). However, in the Illinois agility test and standing long jump, the PST significantly exhibited greater declines in mean different values than the PRT (P<0.05). **Applications/Improvements:** PRT and PST protocols have effectiveness for acceleration, speed, power and agility. PST showed reduction in agility and an increment in explosive power than PRT, but had same speed.

Keywords: Agility, Plyometric, Power, Resistance, Speed

1. Introduction

Plyometric workout refers to those activities that permit a muscle fiber to create the greatest power at the least possible time. The sporting community acclaimed the benefits of plyometric training and incorporated in their protocols to enhance the performance in sports[1]. These benefits are increases of strength[2,3], explosive power[4,5], running economy[6], a decrease in agility times[7,8] and ground contact times[9]. Further, several studies reported reductions in 30 m sprint times[10,11], in 40 m sprint times[12] and at 50 m sprint times[13] after the plyometric training program.

Resistance protocol is a style of workout focussing on the usage of resistance to persuade muscular shortening, which forms the power, muscular endurance and size of voluntary muscles. Keeping this in mind, trainers, competitors and physical education personnel have realized that resistance training methods became one of the best significant factors causing performance and resulting to the accomplishment in the particular actions in the competition or even improving health statue of a person. In addition, resistance training when integrated with plyometric training became the best common technique to progress in the areas of explosive power, maximum strength and speed. Trainers always pool various approaches of activity like plyometric drills, weight exercises and speed to make their performers ready for races so that their achievement is enhanced in sport. It is observed that combined plyometric and resistance training greatly enhances fitness components like speed[14], explosive power[15–17]and change of direction[18]. It is seen that there was a controversy in the literature with regard to 30 m sprint time in which[19,20] observed no remarkable outcomes. The combined plyometric and resistance training also has meaningful benefits in body composition elements[2,21].

Galileo defined speed as the distance covered per

* Author for correspondence

unit of time[22]. Speed exercise is the action of sprinting over a short distance at or nearby constant phase. It is utilized in several sports that include running, normally as a method of rapidly accomplishing an objective or avoiding or grasping a challenger. Speed obviously surges the body's ability to cope with fatigue, power, improving the ability of the heart and muscle strength exercise regimen simple to finish. It activates the production of high level of growth hormone; this will support you to be lean, strong and healthy. Besides, it boosts testosterone levels; both men and women need ideal testosterone level in their bodies which help to aid in mental and physical energy, adding lean muscle, reducing undesirable fat. In addition, it also improves insulin sensitivity and permits hours of continued fat burn even after the workout is finished. When this kind of exercise technique is joined with the plyometric training it will create a significantly greater drop in the acceleration time[23,24] and change of direction time[5,25]. It is observed from the literature that several investigations studied the effect of united plyometric and weight exercise technique, but, little research has examined the impact of joining plyometric and sprint exercise protocols. For our information, nota single research was founded in the literature comparing two united groups of Plyometric-Resistance Training and Plyometric-Sprint Training protocols. Therefore, the objective of this study was to distinguish the impact of 6 weeks of pooled plyometric and resistance regimens and pooled plyometric and sprint workout on selected fitness components between male students.

2. Method

2.1 Subjects

One hundred forty three male students aged 18 to 22 years from KFUPM undertaking the college course were chosen as participants for this investigation. Only the normal body weight participants were allowed to take part in the current research project. They were separated into 3 groups. Combined Plyometric-Sprint Training Group (CPSTG, n = 48), Combined Plyometric-Resistance Training Group (CPRTG, n = 47) and a Control Group (CG, n = 48). The Control Group was informed to keep their routine daily exercises and to keep away from additional severe sports performance throughout the study. The resistance training was to be performed in 80–95 % of 1RM. The willingness of the subjects was ascertained for their voluntary participation during the training program and they were informed to pull themselves out when they found out that they were not comfortable.

2.2 Body Composition

The body composition variables that measured before and after the training program to study the impact of combined plyometric-resistance regimens and combined Plyometric-Sprint Training protocols were age, body mass, height, body mass index, % body fat and fat free mass. Before and after training, the participants were weighed (SECA medical balance-Germany) to the closest 0.1 kg while wearing shorts and shirt. Height was assessed by a Stadiometer to the nearest cm. Body mass index was assessed by body mass (in kg) over the height (in m^2). Percent body fat was gauged by using skin fold caliper (Harpenden) at four locations (biceps, triceps, subscapular and abdomen)[26]. The fat free mass was calculated by multiplying the body mass of % body fat, then subtracting the result from the body mass values.

2.3 Fitness Components

The fitness components measured before and after the training period were 30 m, 40 m, 50 m, Illinois agility test and standing long jump.

2.4 Training Program

The program comprised of three study groups called combined Plyometric-Resistance Training group and combined Plyometric-Sprint Training group and a control group. The experimental groups trained for 40 min per workout 2 days a week, for a total period of 6 weeks. The Control Group was not allowed to take part in the schedule, but was continuing its routine activity. All participantswere familiarized with the plyometric drills, the resistance exercises (CPRTG), the sprint distances (CPSTG) and test procedures before the start of the training period.

2.5 Plyometric-Sprint Training

The exercises employed in the plyometric-sprint mode were single leg hop, double leg hop, frog jump (plyometric), 20 m, 30 m and 40 m distances (sprint). On day 1 and 2 of each training week, the subject performed 10 frog jump followed by 20 m sprint for 3 sets, 10 single leg hops (10 each leg) followed by 30 m sprint for 3 sets and 10 double leg hop followed by a 40 m sprint for 3 sets. Two minute rest period was allowed between sets and 1 min rest between each training unit. The subjects of the training groups performed plyometric drills with full height and distance and the speed distances at maximum or near maximum.

2.6 Plyometric-Resistance Training

The resistance training consisted of seated leg press and seated horizontal calf raises. 1 RM test, 80, 85, 90 and 95 % of 1RM were calculated for all subjects. In week number 1 and 2 of training, the participants of CPRTG exercised the resistance training drills at 80% of 1RM for 3 sets from 8 to 10 repetitions. The intensity of training increased by 5% in week 3, 4 and 5 and the number of repetitions decreased by 2 in each following week while, the number of sets was constant. During week 6, the intensity of exercise was decreased to 70% of 1RM for the aim of preparing the muscle for the post-tests measures which done in the week after. The recovery periods between sets that allowed for each subject were increased from 1 to 3 minutes in accordance with the increase of the intensity of training. The plyometric training drills mentioned above, were performed immediately after the completion of the resistance exercises.

2.7 Statistical Analysis

The data were analyzed by the usage of SPSS version 16.0 software which utilized as the statistical tool for this study. Mean and standard deviations were assessed for all study components. Paired t-tests were employed to distinguish pre and post-testsfor speed, agility and explosive power separately. ANOVA was used to differentiate all experimental groups at pre-test and the mean difference (post-test minus pre-test) values for the dependent variables. When remarkable changes among groups existed, the posthoc test (scheffe) was used. If there was a meaningful change among groups on pre-test, the ANCOVA was taken place. The alpha was stable at 0.05.

3. Results

The result of body mass in Table 1 showed that there was no change between groups after training (P>0.05). With regard to the percent body fat, the CPSTG reported significantly greater decrease in mean values than the CG (P<0.05). In fat free mass, the CPSTG illustrated remarkably greater increase in mean different values than the CPRTG and the CG (P<0.05).

Table 1. Illustrates the physical characteristics measured at pre, post and post minus pre-tests (mean differences) for three groups

CPSTG	CPRTG	CG			
(n = 48)	(n = 47)	(n = 48)			
Variables	**Tests**	**Mean SD**	**Mean SD**	**Mean SD**	**P-Values**
Age (y)	Pre	19.77±0.77	19.72±0.54	19.52±0.54	0.124
Height (m)	Pre	1.70±0.06	1.73±0.06	1.69±0.05	0.009*
	Pre	61.88±9.17	65.98±7.38	62.26±7.30	0.025*
BM (kg)	Post	63.47±8.79	66.64±7.14	63.40±7.30	0.073
	Post-Pre	1.59±2.05	0.66±1.34	1.14±1.83	0.137
	Pre	21.17±2.35	21.92±1.68	21.65±1.80	0.171
BMI (kg/m^2)	Post	21.89±2.26	21.99±1.76	22.06±1.80	0.912
	Post-Pre	0.71±0.75	0.09±0.69	0.36±0.75	0.000*
	Pre	14.35±3.86	14.86±3.55	14.46±3.77	0.790
BF (%)	Post	14.14±3.82	15.04±3.57	15.19±3.90	0.350
	Post-Pre	-0.20±1.15	0.18±1.11	0.72±1.09	0.000*
FFM (kg)	Pre	53.07±6.30	56.03±5.31	53.27±5.09	0.018*
	Post	54.52±6.23	56.48±5.16	53.59±5.07	0.036*
	Post-Pre	1.38±1.56	0.45±1.24	0.32±1.78	0.002*

Pre: before, Post: after, n: number of subjects; SD: Standard Deviation; m: meters, Post-Pre: mean differences, CPSTG:Combined Plyometric-Sprint Training Group, CPRTG:Combined Plyometric-Resistance Training group, CG: Control Group, y: years.*: remarkable

Table 1 indicated that at 30 m sprint time, the CPSTG and the CPRTG displayed significantly greater drop in mean values than the CG (P<0.05) but no change was exhibited between them (P>0.05) after training. Paired t-tests revealed that the mean value of the CPSTG reduced remarkably by 4.6% (4.80 ± 0.30 to 4.59 ± 0.27 sec, P<0.001) and the CPRTG decreased meaningfully by 4.5% (4.82 ± 0.35 to 4.61 ± 0.34 sec, PV0.001).

At the 40 m sprint times, ANOVA indicated that the CPSTG and the CPRTG revealed significantly greater reduction in mean different values than the CG (P<0.05) after training. But both the training groups reported no change (P>0.05). Paired t-tests illustrated that the CPSTG showed remarkable reduction of 4.4% (6.12 ± 0.41 to 5.86 ± 0.45 sec, P<0.001) and the CPRTG presented a significant decrease of 5% (6.05 ± 0.44 to 5.76 ± 0.41 sec, P<0.001) as exhibited in Table 2.

At the 50 m sprint time, ANOVA revealed that the CPSTG and the CPRTG exhibited significantly greater mean different values than the CG (P<0.05) but there was no change among them (P>0.05). Paired t-tests indicated that the CPSTG decreased remarkably by 3.8% (7.50 ± 0.51 to 7.22 ± 0.52 sec, P<0.001). The CPRTG also dropped meaningfully by 4.6% (7.29 ± 0.42 to 6.97 ± 0.40 sec, P<0.001) as shown in Table 2.

It can be seen from Table 3 with regard to the Illinois agility test that the ANOVA for the CPSTG significantly recorded greater reduction in mean different values than the CPRTG and the CG (-0.76 ± 0.52, -0.43 ± 0.31, 0.01 ± 0.07 sec, P<0.05). Paired t-test showed that the CPSTG had a remarkable reduction of 4.2% (18.19 ± 1.01 to 17.42 ± 1.01 sec, P<0.001). The CPRTG also reduced significantly by 2.5% (17.63 ± 1.07 to 17.20 ± 0.96 sec, P<0.001). With regard to the standing long jump, ANOVA illustrated that there were significant changes among the experimental groups and the CG (P<0.05). But the CPSTG showed a remarkably greater increment in mean different values than the CPRTG and the CG (14.04 ± 9.59, 10.21 ± 7.80, -1.69 ± 2.34 cm, respectively). Paired t-test reported that the CPSTG had a meaningful rise of 7.4% (193.15 ±

Table 2. Displays speed times measured at pre, post and post minus pre for three groups

CPSTG (n = 48) Variables	CPRTG (n = 47) Tests	CG (n = 48) Mean SD	Mean SD	Mean SD	P-Values
	Pre	4.80 ± 0.30	4.82 ± 0.35	4.60 ± 0.23	0.000*
30 m	Post	4.59 ± 0.27	4.61 ± 0.34	4.62 ± 0.22	0.854
(sec)	Post-Pre	-0.21 ± 0.17	-0.21 ± -0.15	0.02 ± 0.08	0.000*
	Pre	6.12 ± 0.41	6.05 ± 0.44	5.97 ± 0.33	0.200
40 m	Post	5.86 ± 0.45	5.76 ± 0.41	5.99 ± 0.33	0.025*
(sec)	Post-Pre	-0.24 ± 0.27	-0.29 ± 0.29	0.01 ± 0.07	0.000*
	Pre	7.50 ± 0.51	7.29 ± 0.42	7.28 ± 0.42	0.035*
50 m	Post	7.22 ± 0.52	6.97 ± 0.40	7.29 ± 0.41	0.002*
(sec)	Post-Pre	-0.28 ± 0.22	-0.32 ± 0.20	0.01 ± 0.07	0.000*

*: significant

Table 3. Represents Illinois agility times and standing long jump distances measured at pre, post and post minus pre for three groups

CPSTG CPRTG CG (n = 48) VariablesTests	(n = 47) Mean SD	(n = 48) Mean SD	Mean SDP-Values
	Pre	18.19 ± 1.01	17.63 ± 1.07	17.25 ± 0.900.000*
Illinois Agility	Post	17.42 ± 1.01	17.20 ± 0.96	17.27 ± 0.900.501
(sec)	Post-Pre	-0.76 ± 0.52	-0.43 ± 0.32	0.02 ± 0.070.000*
	Pre	193.15 ± 27.26	192.57 ± 28.82	201.40 ± 23.440.197
Standing Long	Post	207.49 ± 25.62	202.79 ± 25.29	99.71 ± 23.390.309
Jump (cm)	Post-Pre	14.04 ± 9.59	10.21 ± 7.80	-1.69 ± 2.34 0.000*

*: significant

27.26 to 207.49 ± 25.62 cm, P<0.001). The CPRTG also increased significantly by 5.3% (192.57 ± 28.82 to 202.79 ± 25.29 cm, P<0.001).

4. Discussion

This study used a training protocol of six weeks duration with 2 training sessions per week. This is in conformity with previous studies undertaken by[3,8,14,17,27–29] who investigated the influence of plyometric, sprint, weight and combined training in male subjects. The purpose of the present investigation was to distinguish the effect of combined Plyometric-Sprint Training and combined Plyometric-Resistance Training on fitness variables of college male subjects.

Our finding of % body fat indicated that the CPSTG had a meaningful decrease of 1.4%. This result agreed with the research of[2,30] who indicated meaningful decreases by (5.4% and 16.4%, respectively). In contrast, our finding was opposed by two investigations of[31,32]. The amount of reduction of body fat percent in our study is approximately smaller than both[2,30] and this may be due to the fact that both studies used heavier subjects of 77 and 81 kg, respectively, versus 64 kg subjects in this study. It is a well-known fact that the heavier subjects tend to lose weight greater than the lighter ones specially as the training durations of both investigations were longer (30 and 36 training sessions) than the present study (12 training sessions). Their subjects were active physical education students and elite handball players in comparison with moderately active male students who exercise twice a week in the present study.

In FFM the CPSTG had meaningfully greater mean (2.5%) than the CPRTG. It seems that the subjects of CPSTG gained more muscle in respect with the CPRTG which may be due to the fact that sprinting may be aiding the growth of new muscle tissue throughout the rest of the body more than the strength training. This result corresponds to[2,31] who recorded significant increases of 2.1% and 2.3%, respectively. These increments of FFM are similar to our study outcome. A controversy was shown as two of the investigations[30,32] are against the findings of our study. [30]Study reported a reduction by less than 1% in sprint training group while [32]showed no change after training.

Our results of speed showed that both training groups had a meaningful training impact greater than the CG, but no changes were observed between them. Our outcomes agree with several research studies of[4,11,12,24,31,33–35] who reported decreases between 1-5 %.

The result of[33] in 30 m is greater than our finding and this may be due to the use of elite hand ball players who trained harder (plyometric circuit exercises) and longer (90 min) than our subjects. The similar decrease in speed time between both training groups was affected by the condition that plyometric exercises increases the velocity of transforming outward contraction into inward and the resulted tension in the muscle raises as does the power created by the muscle, thereby reducing the time of speed. The other factor that may be interpreted for the identical result of both training groups in the present study was that the effectiveness of strength and sprint protocols may have similar training effect on the acceleration phase in the 30 m run speed. [34]Indicated that the highest increases in power takes place at or close by the speed of muscle contraction of the training. The extreme relocation of the plyometric to sprinting was probable to occur throughout the primary acceleration stage. This idea was reinforced by[36] who advised that bounding may be deliberated as a precise drill for the acceleration of development because of the similar contact times of bounding and sprinting throughout the primary acceleration stage.The acceleration period is greatly reliant on reaction time and the competitor's capability to produce energy and strength throughout propulsion[37].

In a 40 m sprint, our outcome showed a greater training impact on speed time than[4,12,34]. But, [31]reported a greater decline of (5.6%) than the present investigation. However, [38,39]recorded not training effect on speed time. [37,40]Confirmed that the hip and ankle extensors were the most contributors part of the body on the constant stage (40 m speed) which may gain power by sprinting and plyometric training. The elasticity of the plantor flexor muscles has high influence on the achievement of 40 m sprint distance[31]. The strength production of the hip flexor muscles is the most significant parts of the body, contributing in the maximum speed stage[32]. The possible mechanisms of the development in sprint performance can be understood via the neuromuscular deviations that comprise temporal sequencing of muscle activation, better enrolment of the quickest motor divisions, improved nerve transmission speed, rate or point of muscle connection and raised capacity to keep muscle enrolment and quick firing during the run[41].

Previous studies stated that neuromuscular adaptations occur after the plyometric training resulting in gains in speed performance. [4]Discussed that a number of factors such as muscle length, strength, age, gender, temperature, body shape, force and flexibility can have profound impacts on speed[42]. They stated that the strength of the knee extensors[43,44] and the hip flexors[45] may be the most important factors during this phase.

In 50 m sprint, our results correspond with[35]. Significant hypertrophy can be induced by performing plyometric training alone as reported by[46]. Our subjects performed 12 training sessions by plyometric drills and used short sprint sessions. These training modes strengthened the hip and knee extensors and contributed in the training effects of improved performance among the subjects. It can also be due to the decrease in ground contact times of less than 200 milliseconds at an acceleration phase to less than 100 milliseconds at a constant pace[47].

In agility, the CPSTG had more training impactthan the CPRTG and the CG. The CPSTG and the CPRTG had a remarkable reduction of 4.4% and 2.5%, respectively. The agility is the capability of the body to change direction; and depends on acceleration and deceleration phases of speed[47]. Two studies investigated the Illinois agility test[3,9]. They revealed meaningful effect by 1.7 and 3 %, respectively. [3]Compared plyometric and control group and illustrated a remarkable effect for plyometric group. [9]Also compared plyometric and a Control Group and found a remarkable change among the plyometric and the Control Group; the training group decreased by 3%. Our result's reduction is greater than both[3,9] studies. [9]Used mixed gender subjects and small sample size in each group (n = 14) and [3]used heavier highly trained male soccer players (75 kg) and small sample size (n = 12) per group. While male subjects and larger sample sizes were used in this study, which may explain the greater reduction in the agility. However, the findings of our study were in controversy of the investigations of[48–51]. The improvement in agility can be attributed to suitable motor recruitment or neural adaptation[9], muscle hypertrophy[46] and Knee extensor strength[37,43]. The improvement of coordination among the central nervous system signals and the proprioceptive feedback induce neural adaptation[52]. [4]Indicated that maybe neuromuscular adaptations caused by plyometric exercises affect muscle spindles, Golgi tendon, tendons, joints, balance and body position controlling favorably and this led to the improvement of agility.

In standing long jump,the current study indicated that the CPSTG recorded a greater increment than the CPRTG and the CG while the CPRTG showed a greater increase than the CG. The CPSTG increased by 7.4% and the CPRTG by 5.3%. The finding of our study is similar to the investigation of [17]but in contrast with[15,31,53,54]. The result of within group in this investigation is corresponding with the outcomes of[15,17,31,53,54] who reported remarkable increments between 2.8 to 14 %. The significant improvement in SLJ may be due to the fact that during the propulsive phase, the contributions of the hip, knee and ankle muscles were 46, 4 and 50%, respectively as indicated by[31] who insured the greater contributions of the plantar flexor muscles. It also belongs to the coordination[55] and the neuromuscular adaptations that have induced by plyometric training which boosts power production as indicated by[42].

5. Conclusion

It was found that six weeks of combined Plyometric-Resistance Training and combined Plyometric-Sprint Training modes have remarkable influence with regard to acceleration, maximum speed and deceleration, explosive power and change of direction when the post-tests were compared with the pre-tests. However, the training program had more effect for the CPSTG than the CPRTG in agility and standing long jump, but has similar consequences in speed constituents.

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