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Effects of Traditional and Cluster Resistance Training on Explosive Power in Soccer Players

Aliasghar Zarezadeh-Mehrizi[1*], Mohsen Aminai[1],
Mohammadtaghi Amiri-khorasani[2]

[1] *Department of Sports Physiology, Faculty of Physical Education and Sports Science, Shahid Bahonar University of Kerman, Kerman, Iran*
[2] *Department of Sports Biomechanics, Faculty of Physical Education and Sports Science, Shahid Bahonar University of Kerman, Kerman, Iran*

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Abstract

Purpose: The purpose of this study was to investigate the effects of traditional and cluster resistance training on explosive power in soccer players during pre-seasonal preparation.

Materials and Methods: 22 male, soccer players (mean age 24/68±3/13 years, mean height 176 ± 0.41cm, and mean body mass 71/05 ± 6/51 kg) were selected as available samples and performed a 10-week resistance training protocol that included three stages; [1] Hypertrophy (4 weeks), [2] Strength (3 weeks) and [3] Power (3 weeks). The subjects were evaluated after 4 weeks of hypertrophy phase for maximum strength and power. They were then divided into two squat training groups, with respect to their recorded one repetition maximum: [1] Traditional training (TT) group (N=11) and [2] Cluster training (CT) group (N=11). Each group performed strength and power trainings for 6 weeks. Data was analyzed using Repeated Measures (ANOVA) at a Significance level of (P<0.05).

Results: The statistical analysis showed that strength significantly increased in both groups but this increase was significantly higher in the traditional group compared to the cluster group (P <0.05). There was also a significant increase in the power of the cluster group which was greater than the traditional group (P <0.05).

Discussion and Conclusion: According to the current findings, we concluded that as CT probably increases power in the soccer players, it might be a convenient alternative for TT as a means of developing power in soccer players.

Key words: Soccer, Cluster training, Traditional training, Explosive power

Introduction

Strength and power are two important factors determining success in soccer players who need to perform quick and powerful runs and cutting maneuvers [1]. Therefore, developing strength and power is important in pre-seasonal preparation. Measuring power of lower extremity is important in assessing performance in soccer players [2]. Improving power of the lower extremity develops the player's ability to jump higher, which in turn increases chances of beating an opponent in striking an aerial ball [3]. Power could be developed in many ways including traditional and cluster weight training. In traditional weight training the athlete is required to perform each repetition with a continuous move with no rest between the repetitions in each set. Cluster training (CT) program is a way of altering the structure of a training set. In this type of training, there is 10–30 seconds rest between the repetitions [4]. In traditional training (TT) program, fatigue occurs between the repetitions [4]. Muscular power output reduces with fatigue, especially during high-intensity activities that require powerful muscle contractions [5]. As Fatigue reduces both force and velocity, it impairs power output in athletes. Therefore, training methods that cause less fatigue are more useful in the development of muscular power [6].

The concept of an inter repetition rest interval, or cluster training, was suggested as a method for allowing each repetition of the set to be performed with the highest quality. It was hypothesized that the cluster set configuration with 15–30 seconds of recovery between repetitions may result in some

⁎ Corresponding author E-mail:
zarealiasghar7@gmail.com

phosphocreatine (PCr) replenishment and therefore would allow the individual to experience partial recovery and perform each repetition with a higher power output[7]. In the Cluster set was used from maximum velocity and power in training. Furthermore, CT could be applied in periodization of training programs of a variety of different sports [7]. One of the key concepts in periodization of training programs is that programs be designed to introduce appropriate training variation in a logical and systematic way, in an attempt to stimulate improvements in some performance or physiological outcome. Training variations are essential because they stimulate recovery and adaptation, prevent overtraining and improve performance outcomes [8]. Variation can be introduced into a periodized training program in many ways. Some typical variations in a periodized program can be the result of manipulating factors such as the overall training load, number of sets, number of repetitions, set configurations, and the selected exercises [8]. Some researchers have studied the effects of CT on fitness performance. In one of the first studies on the topic, Byrd et al. [9] examined the effects of 10 weeks of resistance training with 3 different inter-repetition rest intervals (zero, 1, and 2 seconds) on total work output. In that study, it was determined that the 2 groups that had rest periods between repetitions were able to increase their overall work output. While the major focus of this study was cardiovascular adaptations, the results are important due to the relationship between total work and training adaptations.

In addition, Rooney et al. [10] examined the effects of implementing different set configurations across a 6- week training program on isometric and dynamic markers of elbow flexor strength. Subjects were divided into 3 groups: (a) a control group that did no training, (b) a traditional set protocol group, and (c) a cluster set protocol group who had a 30-second inter-repetition rest interval. Training was conducted 3 days per week with intensities and volumes varying from 6 sets of 6RM to 10 sets of 6RM loads. There were no differences in maximal isometric strength between the cluster and traditional groups. However, the traditional set configuration resulted in a significantly greater increase in dynamic muscular strength as compared to the cluster set protocol.

Lawton et al. [11] also compared upper body strength and power adaptations in the bench press movement between a cluster intervention and a TT structure over a 6-week training period in elite junior basketball players. This research showed that a traditional structure resulted in significantly greater gains in maximal strength compared to the cluster structure but there were no significant differences in power adaptation between the two interventions. Despite suggestions proposing the application of CT, no research has so far studied long-term effects of CT on the development of lower body power in soccer players. Therefore, due to importance of strength and power in soccer, this study was conducted to see whether applying CT and traditional resistance training program during pre-seasonal preparation time develop power to a similar level, and whether CT can induce the desired training variations and take the place of traditional resistance training program . Thus, the purpose of the present study was to investigate the effects of applying traditional and cluster resistance training during pre-seasonal preparation on explosive power in soccer players.

Material and Methods

This study was a quasi-experimental research including a pre-test and a post-test. The participants consisted of 22 malesoccer players (age: 24.68±3.13 years, height 176±0.41cm, body mass 71.68±6.85 kg) who had no history of main injuries. In this study 10 weeks of weight training was performed, which consisted of three stages: [1] hypertrophy (4 weeks), [2] strength (3 weeks), and [3] Power (3 weeks). Hypertrophy training involved two types of movements that were performed 4 times a week and for 4 weeks. In hypertrophy stage, two types of the movements (A and B) were used in order to involve both the lower and upper body muscles.. Muscles specially involved in soccer playing were mainly trained in the strength and power stages.

Type (A) movement included: squat, leg extension, leg curl, heel raise, French curl, barbell curl.

Type (B) movement included: Bench press, Incline bench press, Lat pull down, Behind the neck press with barbell, Overhead press with barbell.

The movements were performed in 3 sets of 60-80% of one Repetition Maximum (1RM), each set containing 9 repetitions with 60-90 seconds of rest between each two sets. The participants' strength and power levels were measured at the end of the hypertrophy stage.

Strength testing

Maximum strength was evaluated through predicting 1RM of squat movement. The subject performed each repetition with a 90° flexion of the knee. One repetition maximum was then calculated applying the following formula. Results from this calculation method has been shown to have a very high correlation (r = 0.97) with actual 1RM in the squat movement [12].

1RM =100× W/ [102.78- (2.78× R)]

RM: repetition maximum, W: weight, R: Repetition

Power testing

After a standardized warm-up, each subject performed 6 jump up squat movements at 30% of 1RM applying the technique described by Hori et al [13]. The jump up technique involved the subjects standing at a self-selected foot width with an Olympic bar placed on their upper trapezius immediately below C7. The subjects performed a countermovement to a self-selected depth and immediately preformed a maximal jump up. The subjects were instructed to keep the depth of countermovement consistent between the jumps for maximum height on each repetition. All the subjects were familiar with the jump up squat movement. A camcorder (Sony, DSR-PD175, Japan) fixed on the center of the external side of barbell bar was utilized to record the participants' movements. The software skill spector, (V.1.3.2, SB, Denmark, was used to measure the displacement of maximum height of land and velocity [velocity = displacement/time(s)]. Force was calculated applying the following formula: F = (m × g) + (m × a), where m = mass in kilograms, g = gravity (9.81m.s^2), and a = acceleration. Power was calculated multiplying force and velocity (P = F. V), [14].

After 4 weeks of hypertrophy, maximum strength and power was evaluated as described previously. Subsequently, subjects were classified according to their calculated 1RM. In this study the means of 1RM in squat movement was approximately equal in the two groups. Then the subjects were divided into 2 groups: [1] traditional group (n=11), [2] cluster group (n=11), and performed strength and power trainings for the next 6 weeks. The strength phase included: Squat, lunge, leg curl, French curl, and Bench press, which were performed based on the volume and intensities mentioned in Table 1. Each training session consisted of three steps: [1] Warm up [2] Basic training and [3] Cool-down. Both groups performed the first and the third stage in 10 minutes. Group differences were revealed in the first stage. Training protocols of the traditional and cluster groups are presented in Table 1.

Power training protocol included: Squat, jump up squat and bench press throw and was performed 3 times a week and for 2 weeks with determined volume and intensity (Table 2). Strength and power values were calculated the same as pre-test.

Table1: Strength phase

Groups	Period (week)	Number of sessions in a week	Sets	repetition	Interset rest (second)	Interrepetition rest (second)	(% 1RM) Intensity
Traditional	3	3	3	5	180s	0	85%
Cluster	3	3	3	5	120s	10-30	85%

Table2: Power phase

Groups	Period (week)	Number of sessions in a week	Sets	repetitions	Intra set rest (second)	Inter repetition rest (second)	Intensity(%1RM)		
							Squat*	Jump up squat	Bench press throw
Traditional	3	3	5	5	180s	0	*80%	30%	70%
Cluster	3	3	5	5	120s	10-30	*80%	30%	70%

Statistical analysis

The descriptive statistics including mean, standard deviation and the Kolmogorov Smirnov test for normality of data distribution was run. . Independent sample t-test was used to evaluate homogeneity of the groups at baseline. Repeated Measures ANOVA was applied to evaluate inter- and intra- group differences. All the statistical analyses were performed using SPSS software (version 16, SPSS, Inc., Chicago, IL). P-values less than 0.05 were considered as statistically significant.

Results

The strength and power values before and after the training process have been presented in table 3. No significant difference in strength and power was observed between the two groups before the training process and all variables were homogeneous. Maximum strength increased significantly in both groups after training ($P<0.05$), and it was significantly higher in traditional group compared to the cluster group ($P<0.05$). There was also an increase in power of both groups after exercise, but it was only significant in the cluster group ($p <0.05$). significant differences were found between the two groups after training ($P<0.05$). However the values were significantly higher in the cluster group compared to the traditional group ($P<0.05$).

Table3: Means and standard deviations of strength and power in traditional and cluster groups

Groups / Variation	Traditional		Cluster	
	Pretest	Posttest	Pretest	Posttest
Strength (kg)	129.99±21.21	165.30±22.81*†	130.19±20.16	146.59±13.39*
Power (w)	1857.83±554.59	1890.62±534.05	2236.55±562.39	2665.22±669.45*†

Significant pre-training to post-training difference within the groups *
†Significant post-training difference between traditional and cluster groups.

Discussion and Conclusion

Current findings showed a significant increase in post-test average maximum strength compared to pre-test average maximum strength in both groups ($P<0.05$). The comparison between the groups showed that strength improvement was significantly greater in the traditional group compared to the cluster group ($P <0.05$). It seems that strength adaptation benefits from the metabolites build-up. The literature suggests significant metabolite accumulation during heavy strength training protocols [15]. The importance of this metabolite accumulation to strength adaptation is unclear [16, 10] however, there is some evidence that metabolic fatigue is an important precursor to both neural [17, 18] and endocrine [18, 19] responses to training. Therefore, the probable reasons for the increase of maximum strength in traditional group may be due to fatigue- related conditions such as the production of metabolites that trigger muscular adaptations. TT was found to put the active muscles under tension for a longer time which in turn blocks the muscular blood supply for longer periods of time. An increase in enzyme activity and metabolite accumulation (such as Pi and ADP) occurs when rest periods between the training sets are reduced [20]. The result of a muscle remaining under tension for a longer time would be an increase in some metabolites levels (e.g. lactate, inorganic phosphate, creatinine, etc.), which in turn could trigger strength adaptation [20].

It is also important to mention that involvement of a great number of motor units is the key to strength development [21]. A motor unit begins firing in response to a submaximal contraction in an assigned order (size principle) so not all motor units are active at the same time [22]. Repeated sub-maximal contractions result in low-threshold motor units' fatigue; thereafter higher-threshold motor units must be activated in order to maintain force output [23]. As TT involves exercising to repetition failure, it is quite possible that this technique results in greater motor unit activation compared to Cluster training.. Therefore, it is possible that the recovery between the repetitions in CT decreases metabolites accumulation and results in lower strength adaptation compared to TT.

Also the results of the present study showed that post-test mean power values in the cluster group were significantly greater compared to the traditional group (p <0.05). 15 -30 Seconds of rest between the repetitions helps re-synthesizing some of the depleted phosphocreatine (PCr) in the muscle cell, and thus reduces fatigue [7]. Bogdanis et al. demonstrated that PCr re-synthesis is important in the recovery of power during repeated bouts of sprint exercise. Significant correlations were found between the re-syntesis of pcr and the percentage of mean power restoration during the initial 6 seconds of exercise and after 1.5 and 3 minutes of recovery [24]. Furthermore, studies demonstrated PCr synthesis half-time to be 21-22 seconds, and that occlusion of the blood circulation to a fatigued skeletal muscle inhibits pcr re-synthesis. Therefore, it is speculated that an inter-repetition rest of at least 20 seconds may allow for partial pcr re-synthesis and maintenance of power, force, and velocity [25]. This notion is supported by Pereira et al. [26] who demonstrated that rest interval lengths of 14 to 17 seconds were sufficient to maintain jumping performance during 30 maximal volleyball spikes. Whereas, a rest interval length of 8 seconds resulted in increased blood lactate concentrations and decreased countermovement jump performance [26]. Maximal contractions resulted in significant decreases in both adenosine triphosphate (ATP) and PCr concentration. Decreases in both ATP and PCr were associated with significant elevations in lactate concentrations, which corresponded to substantial decreases in the amount of force that can be generated [27]. Inclusion of 15 seconds of recovery resulted in an increase in maximal force–generating capacity that corresponded to 79.7± 2.3% of initial capacity [27]. Increased lactate level resulting from short rest intervals, is generally associated with negative effects on muscle contraction. Leading to impaired ATP production caused by changes in contractility, lactate accumulation ultimately alters function [27]. However CT is beneficial for ballistic or explosive power development [10]. There are studies that show the effects of TT and CT on muscular power. For example, Keir et al. studied the effects of 8 weeks of traditional and cluster training on power output of rugby players [28]. After 8 weeks of training, there was no significant difference between the two groups regarding the amounts of power exerted. These results are in contrast with the results of the present study [28]. This inconsistency may be due to differences in the training protocols of the cluster groups. In Keir study, the cluster movements were not performed in the first week, and it was only after the first week that the subjects started partial application of cluster training protocol. Also the cluster training protocol usually did not have a rest between each two movements and rest intervals were only provided after two or three movements. But the cluster training protocol of the present study contained 10-30 seconds of rest between each two repetitions in all the movements so that the subject could perform each repetition with approximately maximum power.

As research has not investigated the effects of PCr re-synthesis and metabolite accumulation in CT on strength and power adaptation, there is a need for further research onmechanisms of maintaining power during CT.

In conclusion, this study showed that TT outperformed CT in improving strength but CT resulted in greater power development. Therefore, based on the results of the present study it is recommended that CT could be an alternative for TT in power development training programs.

References

1. Amiri-khorasani M, Sahebozamani M, GahremanTabrizi K, Yusof A (2011). Acute effect of different stretching methods on ilinois agility test in soccer players. J Strength Cond Res 24:2698–2704.
2. Pereira R, Pereira L, Thiebaut A, Sampalo-Jorge F, & Machado M (2009). Jump test: Comparison of the performance with the classic method and through the foot switch. Fit Performance Journal 8:73-80.
3. Castagna C, Impellizzeri F, Chamari K, Carlomagno D (2006). Aerobicfitness and yo-yo continuous and intermittent tests performances in soccer players: A correlation study. Journal of Strength and Conditioning Research 20: 320-325.
4. Haff GG, Whitley A (2003). Effects of different set configurations on barbell velocity and displacement during a clean pull. J Strength Cond Res 17: 95-103.
5. Jones DA, de Ruiter CJ, and de Haan A (2006). Change in contractile properties of human muscle in relationship to the loss of power and slowing of relaxation seen with fatigue. J Physiol 576: 913-922.
6. Fitts RH (1994). Cellular mechanisms of muscle fatigue. Physiol Rev 74: 49-94.
7. Haff GG, Hobbs RT, Haff EE, Sands WA, Pierce KC, and Stone MH (2008). CT: a novel method for introducing training program variation. Nat Strength Cond Assoc J 30: 67-76.

8. Plisk SS and Stone MH (2003). Periodization strategies. Strength Cond 25: 19–37.
9. Byrd R, Centry R and Boatwright D (1988). Effect of inter-repetition rest intervals in circuit weight training on PWC170 during arm-cranking exercise. J Sports Med Phys Fitness 28: 336–340
10. Rooney KJ, Herbert RD, and Balnave RJ (1994). Fatigue contributes to the strength training stimulus. Med Sci Sports Exerc 26: 1160–1164.
11. Lawton T, Cronin J, Drinkwater E (2004). The effect of continuous repetition training and intra-set rest training on bench press strength and power. J Sports Med Phys Fitness 44:361–367.
12. Dale A, Lesuer, James H, Mccormick, Jerry L, Mayhew Ronald L, Wasserstein, and Michael D (1997). The accuracy of prediction equations for estimating 1-RM performance in the bench press, squat, and deadlift. Journal of strength and conditioning Research 11: 211-213.
13. Hori N, Newton RU, Andrews WA (2007). Comparison of four different methods to measure power output during the hang power clean and the weighted jump squat. J Strength Cond Res 21: 314–320.
14. Lawton TW, Cronin JB, and Lindsell RP (2006). Effect of interrepetition rest intervals on weight training repetition power output. J Strength Cond Res 20: 172–176.
15. Crewther B (2004). The mechanical, hormonal and metabolic responses to two resistances loading schemes. In: Sport and Health Sciences. Auckland, New Zealand: AUT University
16. Folland JP, Irish SC, Roberts JC (2002). Fatigue is not a necessary stimulus for strength gains during resistance training. Br J Sports Med 36: 370–374.
17. Takarada Y and Ishii N (2002). Effects of low-intensity resistance exercise with short interset rest period on muscular function in middle-aged women. J Strength Cond Res 16: 123–128.
18. Takarada Y, Nakamura Y, Aruga S (2000). Rapid increase in plasma growth hormone after low intensity resistance exercise with vascular occlusion. J Appl Physiol 88: 61–65.
19. Kraemer WJ, Staron RS, Hagerman FC, Hikida RS (1998). The effects of short-term resistance training on endocrine function in men and women. Eur J Appl Physiol 78: 69–76.
20. Dudley AG (1988). Metabolic consequences of resistive. Type exercise. Med Sci Sports Exerc: 20:158-61.
21. Vandenburgh HH (1987). Motion into mass: how does tension stimulate muscle growth? Med Sci Sports Exerc: 19:S142-9.
22. Henneman E, Somjen G, Carpenter OD (1964). Functional significance of cell size in spinal motoneurons. J Neurophysiol 28:560-80.
23. Sale DG (1987). Influence of exercise and training on motor unit activation. In: Pandolt KB. Editor. Exercise and sport sciences reviews. Publisher: McMNillan Company, pp: 95-151.
24. Bogdanis GC, Nevill ME (1995). Recovery of power output and muscle metabolites following 30 s of maximal sprint cycling in man. J Physiol 482 (Pt 2): 467-480.
25. Justin P, Hardee Marcus M, Lawrence AC (2011). Effect of inter-repetition rest on power output in the power clean. Journal of Strength and Conditioning Research. DOI: 10.1519/ JSC. 0b013e3182474370.
26. Pereira G, Almeida AG (2008). The influence of resting period length on jumping performance. J Strength Cond Res 22: 1259-1264.
27. Sahlin K and Ren JM (1989). Relationship of contraction capacity to metabolic changes during recovery from a fatiguing contraction. J Appl Physiol 67: 648–654
28. Keir T, John B (2011). Does cluster loading enhance lower body power development in preseason preparation of elite rugby union players? J Strength Cond Res.