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Cluster Resistance Training Results Higher Improvements on Sprint, Agility, Strength and Vertical Jump in Professional Volleyball Players

Kümeleme Set Direnç Antrenmanı Profesyonel Voleybol Sporcularında Sprint, Çabukluk, Kuvvet ve Dikey Sıçramada Daha İyi Gelişimler Sağlayabilir

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ABSTRACT Objective: The purpose of this study is to compare the effects of six-week traditional and cluster resistance training (CRT) on sprint, agility, maximal strength and vertical jump parameters in professional volleyball players. **Material and Methods:** Twenty-eight professional male volleyball players participated in the present study. Athletes were randomly assigned into two training groups: traditional resistance training (TRT) (n=14) and CRT (n=14) groups. Both training groups performed the resistance trainings during six-week on three nonconsecutive days (Monday, Wednesday and Friday). Subjects underwent countermovement vertical jump, agility t, 10-m, 20-m sprint, one repetition maximal (1RM) back squat (BS), bench press (BP), pull over (PO), military press (MP) and dead lift (DL) tests prior to and after six-week resistance training program. **Results:** Both training groups demonstrated statistically significant improvements in 1RM, sprint times, vertical jump displacement and agility t-test (p<0.05). As compared with the TRT group, the CRT group demonstrated large significant gains in 1RM BS (CRT: 4.76%±2.34% vs. TRT: 2.21%±1.57%; p=0.002, effect size (ES)=0.51), 1RM PO (CRT: 7.59%±4.57% vs. TRT: 3.96%±3.65%; p=0.004, ES=0.91), 1RM DL (CRT: 4.19%±2.76% vs. TRT: 1.79%±2.92%; p=0.024, ES=0.875) and 1RM BP (CRT: 5.82%±4.58 vs. TRT: 2.66%±3.51; p=0.033, ES=0.31). As compared with the TRT group, the CRT group demonstrated significantly higher gains in 20-m sprint (CRT: 6.48%±4.70% vs. TRT: 1.81%±1.04%; p=0.001, ES=1.93), agility t-test performances (CRT: 11.35%±3.89% vs. TRT: 2.28%±1.85%; p=0.000, ES=0.81) and vertical jump displacement (CRT: 6.21%±0.90% vs. TRT: 2.13%±0.61%; p=0.000, ES=5.45). **Conclusion:** This study suggests that CRT provides more advantages than TRT for professional volleyball players.

Keywords: Cluster resistance training; strength training; traditional strength training; volleyball players

ÖZET Amaç: Bu çalışmanın amacı, 6 hafta boyunca uygulanan geleneksel ve kümelenmiş direnç antrenmanların sprint, çabukluk, maksimal kuvvet ve dikey sıçrama performansı üzerine olan etkilerini kıyaslamaktır. **Gereç ve Yöntemler:** Yirmi sekiz profesyonel erkek voleybol oyuncusu bu çalışmaya katıldı. Sporcular, geleneksel direnç antrenman (GDA; n=14) ve kümelenmiş direnç antrenman grubu (KDA; n=14) olarak randomize bir şekilde 2'ye ayrıldı. Her iki grup direnç antrenmanlarını, 6 hafta boyunca ardışık olmayan 3 ayrı günde (Pazartesi, Çarşamba ve Cuma). Katılımcılara karşı hareket sıçrama, çabukluk t, 10-m, 20-m sprint, 1 tekrar maksimal (1TM) arka squat [back sguat (BS)] , "bench pres" (BP), "pull over" (PO), "military pres" ve "dead lift" (DL) testleri 6 haftalık antrenman öncesinde ve sonrasında uygulandı. **Bulgular:** Her iki antrenman grubu 1 TM, sprint zamanı, dikey sıçrama yüksekliği ve çabukluk t-test performanslarında istatistiksel olarak önemli gelişmeler gösterdi (p<0,05). GDA grubuyla kıyaslandığında, KDA grubu 1TM BS'de (KDA: %4,76±%2,34'e karşı GDA: %2,21±%1,57; p=0,002, "effect size" (ES)=0,51), 1TM PO'da (KDA: %7,59±%4,57'e karşı GDA: %3,96±%3,65; p=0,004, ES=0,91), 1TM DL'de (KDA: %4,19±%2,76'e karşı GDA: %1,79±%2,92; p=0,024, ES=0,875) ve 1TM BP (CRT: %5,82±4,58'e karşı GDA: %2,66±3,51; p=0,033, ES=0,31). GDA grubuyla kıyaslandığında, KDA grubu 20-m sprint (KDA: %6,48±%4,70'e karşı GDA: %1,81±%1,04; p=0,001, ES=1,93) ve çabukluk t-testi (KDA: %11,35±%3,89'a karşı GDA: %2,28±%1,85; p=0,000, ES=0,81) ve dikey sıçramada (KDA: %6,21±%0,90'a karşı GDA: %2,13±%0,61; p=0,000, ES=5,45) istatistiksel anlamda daha yüksek kazanımlar sağladı. **Sonuç:** Bu çalışma, profesyonel voleybolcularda, GDA yöntemine kıyasla daha iyi avantajlar sağlamaktadır.

Anahtar Kelimeler: Kümeleme direnç antrenmanı; kuvvet antrenmanı; geleneksel kuvvet antrenmanı; voleybol oyuncuları

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Training methods to improve strength and power with optimal load/stimulus based on scientific foundations have a significant place in our daily training programs. Traditionally, resistance training involves recurrent repetitions and consequently, traditional resistance trainings (TRT) cause metabolic fatigue.[1] Another approach to resistance training, which has recently been termed a cluster set offers many advantages and has been used to improve strength and power.[2] It employs short rest periods between repetitions to replenish phosphocreatine stores. It diminishes muscular fatigue and increases power output.[1] Cluster set allows greater power output to be attained with the same training volumes compared with traditional set configurations with because of the inter-repetition and inter-set rests.[3,4] As for its positive effects, it leads to less neuromuscular fatigue during resistance training than traditional set configurations, nervous systems increases the level of muscular contraction and prevents power losses.[5] A large part of the studies comparing traditional and cluster set configurations investigated the acute effect. A very few number of studies are intended to investigate long term effects of cluster set configuration.[2,6] Both training have provided positive improvements on power, strength, vertical jump and agility in long term training.[7-9] Some research groups reported that traditional sets lead to greater strength than cluster.[8,10] On the other hand, cluster set configurations can result in larger improvements in countermovement vertical jump (CVJ).[7,11] There are a limited number of studies in the literature which evaluated the effects of the long-term cluster set resistance training.[6] And a very few number of them focused on elite athletes.[4,8] However, no study has compared the effects of traditional and cluster resistance training (CRT) on professional volleyball athlete's strength and power performance. It is unknown to what extent cluster set configuration affects power and strength adaptations of professional volleyball players. Therefore, the aim of this investigation is to compare the effects of 6-week traditional and cluster set configurations on sprint, agility, maximal strength and vertical jump parameters in professional volleyball players.

MATERIAL AND METHODS

PARTICIPANTS

The investigation was approved by the Ege University Clinical Researches Ethics Committee (number: 18-8/39, date: 28.09.2011). Experimental method was designed according to the Declaration of Helsinki. Twenty-eight male professional volleyball players playing in professional volleyball league in Turkey (age: 27.4±1.51; height: 195.0±1.76 cm; weight: 93.8±1.49 kg) participated in the present study (Table 1). In average, the participants have accumulated 16 years of training time with a schedule of training six sessions per week. In addition, the time of the day allocated for testing was standardised to minimise the effect of circadian changes for each subject. No subjects had an injury in the last six months and suffered from muscular injury or any health problems restraining their physical movements.

DESIGN

A total of 28 professional volleyball players participated in the present study. Athletes were randomly assigned into two training groups: traditional strength training (TRT; n=14) and cluster set training (CRT; n=14) groups. Both training groups performed resistance trainings on three non-consecutive days (Monday, Wednesday and Friday). Volleyball players maintained their volleyball training routine (ball, technical and tactical trainings) on the days excluded by the resistance training days during 6-week resistance training program. Subjects underwent CVJ, one repetition maximal (1RM), agility t, 10-m and 20-m sprint tests before and after 6-week resistance training program. Traditional and cluster set configurations were matched and designed with the same exercises, intensities and volumes. One week prior to the initiation of the training programs, all athletes

TABLE 1: Subject characteristics.

	Traditional group (n=14)	Cluster group (n=14)	Total (n=28)
Age (year)	27.4±1.37	27.1±1.60	27.3±1.51
Height (cm)	194.4±1.89	195.7±1.49	195.07±1.76
Weight (kg)	93.6±1.25	94.14±1.65	93.9±1.49

were familiarized with the testing and training procedure. Across three non-consecutive days, anthropometric measures and performance tests were completed. On the first day, measurement of height (Seca 217, UK), body mass (DESIS Professional Weighing Centrum ELW) and 1RM pull over (PO) tests were completed. On the second day, each subject's 1RM back squat (BS) and military press (MP) were measured. On the third day, each subject's 1RM bench press (BP) and dead lift (DL) were assessed. On fourth day, CVJ (Just Jump, Probotics Inc, Huntsville, AL, USA), 10-m, 20-m sprint and agility t-test were completed. All those performance tests were repeated after the completion of 6-week training period. Tests were performed on an indoor volleyball court. All tests and resistance trainings were performed during the general preparation phase.

PROCEDURES

Training Programs

Half of the athletes performed TRT and the other half performed cluster sets on three days a week for six weeks. Resistance trainings were conducted on nonconsecutive days. Training sessions were monitored and supervised by the researchers and coaches to ensure that all training exercises were performed correctly. The training programs of both training groups consisted of a total five exercises; BP, MP, BS, DL and PO. Traditional sets were performed three sets with six repetitions at 85% of 1RM using an intra-set rest period of two minutes. Cluster sets were also performed with the same number of sets and repetitions and the same percentage of load with traditional sets. Unlike traditional sets, cluster sets were combined in three clusters, and each set was performed with two repetitions. Rest periods between intra-set and sets were respectively 20 seconds and 80 seconds.

Testing

Maximal strength, vertical jump, sprint and agility t-tests were performed across four non-consecutive days before and after the completion of the 6-week resistance training period. Additionally, all testing sessions were conducted at the same time of day to minimize the effects of circadian changes. Before physical tests, participants completed a standardized warm-up, which consisted of 8-min submaximal running, 5-min active stretching and specific warm-up exercises

Maximal Strength Assessment

Maximal strength of upper and lower body was assessed with the use of a series of 1RM tests using free weights. After a standardized warm-up, each participation completed a specific warm-up with a light load that allowed 5 to 10 repetitions. The load was then increased with the athlete performing 2-3RM. Then, participations fulfilled 1RM with each progressive increased resistance until volitional exhaustion was obtained.[12] Each set was separated with two minutes of rest.

Vertical Jump Assessment

Before the CVJ test, all subjects underwent a standardized warm-up and specific warm-up (five submaximal vertical jumps). After the completion of the warm-up protocols, each subject performed three maximal CVJ's, each separated by a 2-min rest period. The highest vertical displacement three maximal CVJ's was noted as a best score. A pressure sensing mat (Just Jump, Probotics Inc, Huntsville, AL, USA) was used for CVJ tests.[13]

Sprint Testing

All subjects performed 10-m and 20-m sprint tests with two repetitions.[14] Each repetition was separated by 2 minutes of rest. The fastest sprint time from 2 repetitions was selected for analysis in this study. 10-m and 20-m sprint tests were performed on an indoor running track. 10-m and 20-m sprint times were quantified by photocell timing gates (Sinar, Turkey).

Agility T-test

Agility t-test was used to determine the directional change. Before the initiation of the measurements, all subjects were familiarized with testing session by two repetitions.[15] All subjects performed agility t-test with three repetitions; each one is separated by 3 minutes of rest. The best one from three repetitions was selected for agility t-test.[15] Finishing times were recorded using photocell timing gates (Sinar, Turkey).

STATISTICAL ANALYSIS

A Shapiro-Wilk test of normality was performed to determine if the data were normally distributed. A 2×2 repeated-measures ANOVA was performed for all variables if there were significant differences between the 2 groups. Statistical significance was set at ≤ 0.05 for these analyses. Cohen's d was used as the measure of effect size. The Cohen's effect sizes (ES) were categorised as trivial (0-0.2), small effect (0.2-0.5), medium effect (0.5-0.8) and large effect (>0.8). Level of statistical significance was accepted as p≤0.05.[16] All statistics analyses were performed with the use of a statistics software package (SPSS version 16.0; SPSS, Chicago, Ill., USA).

RESULTS

STRENGTH MEASURES

Both training groups demonstrated significant improvements in 1RM tests (p=0.000 for 1RM BS, DL and BP; p=0.026 for 1RM PO). As compared with the TRT group, the CRT group demonstrated large significant gains in 1RM BS (CRT: 4.76%±2.34% vs. TRT: 2.21%±1.57%; p=0.002, ES=0.51), 1RM PO (CRT: 7.59%±4.57% vs. TRT: 3.96%±3.65%; p=0.004, ES=0.91), 1RM DL (CRT: 4.19%±2.76% vs. TRT: 1.79%±2.92%; p=0.024, ES=0.875) and 1RM BP (CRT: 5.82%±4.58 vs. TRT: 2.66%±3.51; p=0.033, ES=0.31) (Table 2).

VERTICAL JUMP

Both training groups demonstrated significant improvements in vertical jump displacement (p=0.000) (Table 3). Improvement in vertical jump displacement (CRT: 6.21%±0.90% vs. TRT: 2.13%±0.61%; p=0.000, ES=5.45) was larger than TRT group in CRT group (Table 3).

SPRINT AND AGILITY T-TEST

The TRT and the CTR group demonstrated a significant improvement in 10-m sprint performance (p=0.003). There was no significant difference between the groups in 10-m sprint performance (CRT: 3.72%±5.10% vs. TRT: 1.48%±3.13%; p=0.187, ES=0.55).

Additionally, significant improvements in the TRT and the CTR group were noted in 20-m sprint (p=0.000) and agility t-test (p=0.000) performances. As compared with the TRT group, the CRT group demonstrated significantly higher gains in 20-m sprint (CRT: 6.48%±4.70% vs. TRT: 1.81%±1.04%; p=0.001, ES=1.93) and agility t-test performances (CRT: 11.35%±3.89% vs. TRT: 2.29%±1.85%; p=0.000, ES=0.81) (Table 3).

DISCUSSION

The purpose of this study was to investigate the effects of 6-week traditional and cluster set configurations on strength, vertical jump, sprint and agility of

TABLE 2: Strength values.

Strength (kg)	Pre-test	Post-test	Change%	Effect size
1RM Back squat				
Traditional group	178.9±6.98	182.8±6.92	2.21±1.57	0.85
Cluster group	184.5±9.41	193.2±10.21	4.76±2.34*	2.00
1RM Bench press				
Traditional group	87.3±6.38	89.6±7.19	2.66±3.51	0.77
Cluster group	93.6±7.11	98.9±7.38	5.82±4.58*	1.33
1RM Dead lift				
Traditional group	107.8±6.56	109.8±7.87	1.79±2.92	0.62
Cluster group	114.5±8.33	119.3±9.47	4.19±2.76*	1.52
1RM Pull over				
Traditional group	68.7±5.16	71.4±5.34	3.96±3.65	1.07
Cluster group	70.2±7.16	75.3±6.71	7.59±4.57*	1.81

1RM: One repetition maximal; *Significant difference compared with traditional group (p<0.05).

TABLE 3: Sprint, agility t-test, and vertical jump displacement values.

Tests	Pre-test	Post-test	Change%	Effect size
10 m sprint time (s)				
Traditional group	1.73±0.08	1.71±0.05	1.48±3.13	0.478
Cluster group	1.73±0.11	1.67±0.11	5.10±3.72	0.756
20 m sprint time (s)				
Traditional group	2.98±0.10	2.93±0.11	1.81±1.04	1.80
Cluster group	3.15±0.14	2.95±0.09	6.48±4.70*	1.39
Agility t-test time (s)				
Traditional group	10.07±0.28	9.84±0.16	2.28±1.85	1.23
Cluster group	10.16±0.27	9.13±0.45	11.35±3.89*	3.37
Vertical jump (cm)				
Traditional group	66.27±1.28	67.68±1.07	2.13±0.61	3.63
Cluster group	65.99±1.67	70.09±1.71	6.21±0.90*	6.95

*Significant difference compared with traditional group (p<0.05).

professional volleyball players. According to our main results, both TRT and CRT groups demonstrated significant improvements after the completion of the 6-week resistance training program. As compared with TRT group, CRT group demonstrated higher significant gains in 1RM strength, sprint time (only in 20-m), vertical jump displacement and agility. Newton et al. showed that seven week TRT in women volleyball players over the competitive season caused a 5% decrease in vertical jump height.[17] The reason of it may be due to the fact that the volleyball players involved 3 games per week combined with volleyball practice sessions as well as strength and conditioning. As previously stated, the combination of playing games, skills practice, strength and conditioning have been reported to cause a significant reduction in jump performance over the course of the season. [18]

Zarezadeh Mehrizi et al. reported that when compared with traditional sets, 22 male soccer players demonstrated higher power improvements in countermovement jump with the cluster sets performed during three weeks and that higher gains in the development of 90° knee flexion were noted with traditional sets.[19,20] Asadi and Ramírez-Campillo reported that six week plyometric trainings performed with cluster set configurations resulted in greater improvements in countermovement jump, standing jump and agility t-test scores as compared with traditional training.[7] Hansen et al. reported that elite rugby players in TRT and CRT groups demonstrated gains in 1RM BS but TRT group demonstrated larger gains than CRT group after the completion of 8-week training program.[8] Considering the long term effect of both traditional and cluster trainings, they were found to demonstrate gains in strength, power, vertical jump and agility t-test. Arazi et al. reported that amateur female volleyball players demonstrated improvements in 1RM (BS, BP, MP, DL) with both traditional and cluster sets but they didn't affect their 20-m sprint performance.[11] In the same study, it was reported that cluster sets resulted in higher improvements in vertical jump performance.[11] Based upon the available literature, traditional sets lead to higher strength and sprint improvements than cluster sets and cluster sets results in larger gains in vertical jump. In our study, both training methods lead to improvements in strength, sprint, vertical jump and agility t-test. In contrast to literature data, cluster sets lead to greater gains in strength and sprint than traditional sets. Considering the characteristic features of volleyball, even 1-cm difference in vertical jump matters for a player to have an advantage over rivals, when attempting to block over the net. Considering the difference between cluster and traditional training methods, it is possible to say that CRT provides more advantages than TRT in the branch requiring explosive strength like volleyball. Additionally, Hardee et al. reported that cluster set configurations in the power clean maintain technique to a greater extent than a traditional set configuration on the effect of cluster set configurations on power clean technique.[21] They suggested that the rest period length between repetitions is a key factor in reducing fatigue and maintaining power development and technique proficiency.[21] Accordingly, considering cluster set configurations they may have a lower risk of injury as they maintain technique proficiency and delay the fatigue. As compared with cluster sets, in traditional sets elevated lactate production accompanied by the resynthesis of ATP and decrease in phosphocreatine stores causes more metabolic fatigue and thus TRT is thought to result in larger gains in strength.[1,6,10,22,23] They are just hypotheses since they haven't been discovered yet. Contrary to these findings, there are studies showing that high fatigue is not a stimulus for strength development.[20,24] Welsh and Rutherford applied isometric strength training from individuals over the age of 55 for six months with the continuous (traditional) and intermittent (cluster set configuration) contraction protocol, which is two different strength training method.[20] As a result of their study, it has been shown that change in metabolic products did not affect muscle growth.[20] Folland et al. showed that strength training performed in young individuals for 9 weeks by providing rest between each repetition (cluster set configuration) to avoid metabolic accumulation provides similar strength gains with the traditional strength training.[24]

As the CRT increases the synthesis rate of ATP, allows for replenishment of phosphocreatine and removes metabolic wastes, short intra-set rest periods are known to maintain movement velocity and to workout at higher intensity.[3] Thus, they are thought to lead to higher neuromuscular adaptations than TRT. They may be helpful to explain why the CRT group's performance in vertical jump and agility is better than the TRT group.

CONCLUSION

This study suggests that CRT provides more advantages than TRT for professional volleyball players. Instead of TRT, CRT may be used to improve maximal strength, short sprint, agility and vertical jump in general preparation phase by professional volleyball players.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Merve Cin, Bahtiyar Özçaldıran, Refik Çabuk, Onur Demirarar;* ***Design:*** *Merve Cin, Bahtiyar Özçaldıran, Refik Çabuk, Onur Demirarar;* ***Control/Supervision:*** *Merve Cin, Refik Çabuk, Onur Demirarar;* ***Data Collection and/or Processing:*** *Merve Cin, Refik Çabuk, Onur Demirarar, Bahtiyar Özçaldıran;* ***Analysis and/or Interpretation:*** *Refik Çabuk, Merve Cin, Bahtiyar Özçaldıran, Onur Demirarar;* ***Literature Review:*** *Refik Çabuk, Merve Cin, Onur Demirarar, Bahtiyar Özçaldıran;* ***Writing the Article:*** *Merve Cin, Bahtiyar Özçaldıran, Refik Çabuk, Onur Demirarar;* ***Critical Review:*** *Refik Çabuk, Merve Cin, Onur Demirarar, Bahtiyar Özçaldıran;* ***References and Fundings:*** *Merve Cin;* ***Materials:*** *Merve Cin, Bahtiyar Özçaldıran.*

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