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Accentuated eccentric load training: traditional set versus cluster set

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Abstract

Background and Study Aim This study aims to comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outputs in accentuated eccentric load (AEL) training.

Material and Methods Thirty-two amateur male football players with at least 2 years of strength training history participated in the study ($\bar{X}_{age}$: 18,78 ± 0,83 years, $\bar{X}_{height}$:166,73± 8,61 cm., $\bar{X}_{body\ weight}$: 69,59± 6,03 kg.). Participants were randomly divided into two groups: CS (n=16) and TS (n=16). In both groups, the same "AEL Training" was applied and different set models were used. Augmented eccentric load (AEL) training was performed with 3 sets of 8 repetitions, 50% concentric and 80% eccentric of 1 Repetition Maximum (1-RM) and with a fast lifting tempo. The sets were completed with 20 seconds of rest after every two repetitions in the AEL-CS group and without any rest between repetitions in the AEL-TS group, and the training sessions were performed twice a week for 4 weeks. Countermovement jump (CMJ), 50cm drop jump-reactive strenght index (DJ-RSI) test, 1-RM strenght test, 10-20-30m sprint test and Illinois Agility Test (IAT) were performed on the athletes before and after the training.

Results When analysing the data obtained in this study, Skewness and Kurtosis values and Kolmogorov-Smirnov values were examined to determine homogeneity. In order to compare the pre-test and post-test averages between groups, ANOVA was used for Repeated Measures, and Sample T Test was used to compare the pre-test and post-test averages within groups. The statistical significance level was determined as $p<0.05$. When the groups were compared, the difference in the improvement rate averages was tested. At the end of the four-week study, drop jump-reactive strength index (DJ-RSI), countermovement jump (CMJ), Illinois Agility Test (IAT) 10-20-30m sprint values and 1-RM values were improved percentage-wise in both AEL-CS and AEL-TS groups. Between the groups, a significant difference was observed between DJ-RSI, CMJ, and 10-20-m Sprint Test results ($p<0.05$). When we compare the results within groups, it can be concluded that the AEL-CS group showed more improvement in terms of strength, change of direction (COD) skills and Sprint compared to the AEL-TS group.

Conclusions In conclusion, it can be advised to use cluster set in accentuated eccentric load training in order to improve strength, Sprint and COD skills.

Keywords: eccentric training, clustering, power, reactive strength index, vertical jump

Introduction

The most important determinants in resistance training aiming at the improvement of strength and power are the mode of the applied exercise, the intensity of the training and the lifting tempo [1]. The improvement in strength and power can be optimised by appropriate management of acute training variables such as sets, repetitions, rest (recovery) periods and exercise sequence [2]. However, when it comes to athletes with advanced training levels, different applications and different stimuli may be required to go beyond the force plateau. Periodization is recommended considering the nature of the sports branch in question [3, 4].

Coaches use different designs in their training programs to manage fatigue effectively, to unlock performance potential and to achieve more predictable results [5, 6]. The design of the training programme then serves to bring variety to a periodic training programme through the manipulation of one or more training variables (e.g., volume, intensity). Hodges et al. [7], who emphasised the importance of training variation, argued that a novel stimulus results in faster performance improvement, whereas monotonous training slows adaptation. For this reason, it is particularly important for coaches to consider numerous factors in order to maximise preparation and performance potential. Traditional strength training uses the same loads for the concentric and eccentric phases of an exercise. However, compared to concentric muscle movements, skeletal muscle is capable of producing up to 50% more force during maximal eccentric muscle movements [8]. Therefore, a more popular way of providing variation within a resistance training programme is the manipulation

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of exercise phase-specific overload. Recently, the method called accentuated eccentric load (AEL), in which the eccentric phase is applied with a higher load when compared to the concentric phase, has gained popularity [9].

AEL is an advanced training method that aims to benefit from the ability of the muscle to produce more force during eccentric muscle movements compared to isometric and concentric actions [8, 10]. This method is intended to be used during exercises that use eccentric loads that exceed the concentric load (e.g. back squat, bench press). Ideally, this is achieved by minimising disruption to the natural mechanics of the chosen exercise [9]. AEL has shown favourable effects on concentric performance in both upper [11, 12, 13] and lower trunk [13, 14, 15] exercises compared to traditional loading patterns [11, 15]; however, not all studies agree [12, 13, 14].

Recent literature on maximal strength has shown inconsistent results regarding acute responses and chronic adaptations in AEL training using supramaximal loads. Doan et al. [16] reported increases of 2.27-6.80 kg in bench press 1-RM in subjects using supramaximal AEL with 105% of concentric 1 RM during the eccentric phase compared to traditional loading. Ojasto et al. [11, 12] reported that subsequent 1-RM and concentric force production were significantly reduced when a series of supramaximal AEL (105-120%) eccentric overloads were used in the bench press [11]. The biggest reason for the inconsistent results of AEL training with supramaximal loads [11, 12, 17, 18] has been reported as fatigue caused by training with heavy loads [11, 17].

The inconsistent nature of the available evidence may be largely attributable to the variability of both eccentric and concentric loads, and the differences in application tools and exercise selection. Furthermore, since typically AEL requires time between repetitions in order to re-lift the load in eccentric training, it would be even more possible for inter-repetition recoveries to explain some of the aforementioned benefits of AEL [19].

Regardless of its potential impact on AEL, the inter-repetition recovery method, typically referred to as the cluster method, is an efficient programming method. Previous literature shows that various cluster method arrangements can compensate for the loss in movement speed and preserve power outputs [20, 21, 22]. Interestingly, the strengthening effects of the cluster method show effective results when applied to athletes with advanced training age [23]. This suggests that the cluster method can be performed in a more appropriate way [24]. Although some researchers suggest that this may also be true for AEL [9], such a hypothesis requires further study.

Purpose of the Study. Therefore, the main purpose of this study: To comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outcomes in AEL training using submaximal loads.

Materials and Methods

Participants.

While determining the sample size for experimental studies, it is stated that a sample size as small as 10-20 for simple experimental studies would be appropriate for the conduct of successful research. On the other hand, it is stated that the sample size should be 15 or more people in order for the results obtained in experimental studies to be valid [25, 26]. Therefore, the sample group in our study was planned to be 32 people. Gpower [27] is used to calculate the sample size from the determined population.

Thirty-two amateur male football players with at least 2 years of strength training history participated in the study ($\bar{x}_{age}$: 18,78 ± 0,83 years, $\bar{x}_{height}$:166,73± 8,61 cm., $\bar{x}_{body\ weight}$: 69,59± 6,03 kg.).

Criteria For Being Included In The Study:

(a) Absence of known cardiovascular, pulmonary, metabolic, bone or joint diseases;
(b) Absence of muscle and joint injuries in the last six months;
(c) Being a licensed football player.

Criteria For Being Excluded From The Study:

(a)Failure to attend two consecutive training sessions;
(b)Diseases and Injuries.

Before data collection, participants were informed about all study procedures and about the possible risks or benefits of participation. All participants signed an institutionally approved informed consent form. The study meets the requirements of the Declaration of Helsinki and is approved by the Marmara University Non-Interventional Clinical Research Ethics Committee (Protocol No: 09.2020.739)

Procedures

In order to comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outputs in accentuated eccentric load (AEL) training, CS and TS Protocol Groups were created. At the beginning of the study, each participant underwent a 1-RM (1 Repetition Maximum) strength Test. Then, the participants were divided into two groups: CS (n=16) and TS (n=16) by using a randomised method for the execution of the exercise protocol consisting of hip thrust and back squat exercises. After 48 hours from the 1RM test and after a four-week training period, the participants were subjected to a post-test 1RM strength test protocol 10-20-30 m sprint, drop jump-reactive strength index (DJ-RSI), countermovement jump (CMJ), Illinois Agility Test (IAT).The study plan is presented in table 1.

Research Design

Lifting tempo

Each of the four numbers associated with the exercise in the training programme indicates how long, in seconds, the specific "phase" (eccentric, isometric, concentric and cluster) should be performed. For example, a Back Squat might be performed at the following tempo: 6:0:0:0. The first number (6) represents the eccentric phase of the exercise. The second number (0) represents the isometric phase of the exercise. The third number (0) represents the concentric phase of the exercise. Finally, the last number (0) represents the number of repetitions that should be followed by a rest (Cluster Set) [28].

Training Program

This study is considered as intervention training and is integrated into the participants' on-going training programmes. Since the study group is chosen from the same team, there are no differences between the training programmes. All other elements of the resistance training programme used in the eccentric phase of the selected exercises, such as intensity of load, exercise selection, sets, repetitions, tempo and frequency, were the same between the groups. Only the AEL-CS group rested for 20 seconds after every two repetitions while performing the exercises [29].

After measuring the 1-RM strength value of all participants who performed back squat and hip thrust exercises, the participants were randomly divided into two groups: AEL Cluster Set (CS) (n=16) and AEL Traditional Set (TS) (n=16). After 48 hours following the 1-RM test, 50cm Drop Jump (DJ), Countermovement Jump (CMJ), 10-20-30 m Sprint Test, and Illinois Agility Test (IAT) were performed for both groups. After 48 hours following the tests, the training protocol, which was going to be applied

Table 1. The Study Plan

1 RM Test	**(After 48 Hours) Pre-Test**	**The Training Process 4 Weeks**	**1RM Test**	**(After 48 Hours) Pre-Test**
-Hip Thrust	-50cm-DJ-RSI	AEL-TS	-Hip Thrust	50cm-DJ-RSI
		-Hip thrust & Back Squat		
-Back Squat	-CMJ	-Concentric: 50% 1RM	-Back Squat	-CMJ
		-Eccentric: 80% 1RM		
	-10-20-30m Sprint	-8 Repetitions x 3 Set		-10-20-30m Sprint
		- lifting tempo: 0.0.0.0		
	-Illinois Agility Test	AEL-CS		-Illinois Agility Test
		Hip thrust & Back Squat		
		-Concentric: 50% 1RM		
		-Eccentric: 80%1RM		
		-8 Repetitions x 3 Set		
		- lifting tempo: 0.0.0.2		

AEL-TS: accentuated eccentric load traditional Set; AEL-CS: accentuated eccentric load cluster Set; DJ-RSI: drop jump reactive strength Index; CMJ: countermovement Jump; CON: concentric; ECC: eccentric

Table 2. Accentuated eccentric load traditional set training protocol

Back Squat (eccentric/concentric -80%-50% 1RM)				
1. Set	180 seconds of rest (recovery period)	2. Set	180 seconds of rest (recovery period)	3. Set
8 (repetitions)		8 (repetitions)		8 (repetitions)
5 Minutes of rest (recovery period)				
Hip Thrust (eccentric/concentric -80%-50% 1RM)				
1. Set	180 seconds of rest (recovery period)	2. Set	180 seconds of rest (recovery period)	3. Set
8 (repetitions)		8 (repetitions)		8 (repetitions)

two days a week and which would last for 4 weeks, was initiated in both groups. The training protocol is presented in table 2 and table 3.

For both groups, the load to be used during the training application was determined as Concentric 50% 1-RM and Eccentric 80% 1-RM for back squat and hip thrust exercises. The bar and the eccentric hook were adjusted in terms of height according to the lowest landing point of each participant during the back squat and hip thrust exercises [15]. Due to the angle of its base, the eccentric hook mounted on the bar (Figure 1) was designed to detach from the barbell at its lower part during the performance of the back squat and hip thrust exercises. Thus, the eccentric part of the exercise undergoes more load when compared to the concentric phase [16, 30].

The AEL-CS and AEL-TS training programme include the rapid execution of each phase (eccentric, isometric, concentric, cluster) according to the exercise tempo without any rests in between. For the back squat and hip thrust exercises, participants performed a fast eccentric phase with 1-RM 80% with 1-RM 50% already loaded on the bar and 1-RM 30% loaded on the eccentric hook. Immediately, after the eccentric hook was detached from the bar, a concentric phase with 1 RM 50% was quickly performed. Assistants started the second repetition by attaching the hook onto the bar within 3 seconds [19]. CS and TS groups performed the back squat and hip thrust exercises in 3 sets of 8 repetitions.

Table 3. Accentuated eccentric load cluster set training protocol

Back Squat (eccentric/concentric - 80%-50% 1RM)						
1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
3. Set 2 (repetitions)	20 seconds of Rest (Recovery Period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)
5 minutes of rest (recovery period)						
Hip Thrust (eccentric/concentric - 80%-50 % 1RM)						
1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)

Figure 1. Adjustable eccentric hook device

In the AEL-CS group, the sets were performed with 20 seconds of rest after every two repetitions, 120 seconds of rest between sets, for a total of three minutes, and five minutes of rest between exercises. In the AEL-TS group, the sets were performed without any rests between repetitions, with 180 seconds of rest between sets and five minutes of rest between exercises.

One repetition maximum (1-RM) strength test

Participants warmed up before the test by cycling for 5 minutes on a stationary bike. After a one-minute rest (recovery) period, participants familiarized themselves with the Back Squat and Hip Thrust exercises by performing 8-10 repetitions using a light load (~50% of the estimated 1-RM). After a three-minute recovery period, participants performed the exercise with a certain load (~80% of the estimated 1-RM) through the entire range of motion. After each successful performance, the weight was increased gradually until failure. Between each trial, participants rested for three minutes, and 1-RM was reached after 6 trials. And, the participant was allowed to rest for five minutes after each test. Exercises were alternated to facilitate recovery and reduce the effect of fatigue [31].

10-20-30 Meter sprint test

To measure speed performance, a 30 m Sprint Test was performed using sensor gates every 10 meters (0-10, 0-20 and 0-30 m). The Sprint Test was performed outdoors on a hard surface. Participants started running in a standing position at the Start Line, approximately 0.5 m behind the first gate. Photocells were placed 0.6 m above the ground (approximately at hip level) to capture the movement of the trunk instead of a false signal due to limb movements. Intermediate values were measured through 2 infrared photoelectric infrared gates (Fusion Sport Smart Speed) that were placed every 10 meters and recorded horizontal speed. Measurements were made in 2 trials. The participant was allowed to rest for five minutes between repetitions. The best time was recorded in seconds [32].

Illinois Agility Test

The participants' sudden change of direction speed performance was measured through the Illinois Agility Test. Participants were asked to run at maximum speed and this application was repeated twice. And, they were allowed to rest for three minutes between these two applications. The best value was recorded in seconds. Participants' running speed was measured via photocells (Smartspeed, Fusion Sport,) with a margin of error of 0.01/sec [33].

Drop Jump Test

The depth jump test was performed bilaterally from a height of 0.50 meters [34]. Participants completed the test by performing 3 maximal trials with a three-minute recovery between each trial.

Participants were instructed to perform depth jumps with hands on the waist and to step forward from the box before starting the movement. They were clearly asked to try to maximize their jump height while minimizing their ground contact time. Thus, a short ground contact time was prioritized. If trials were rejected due to severe failure of technique, the test was repeated. All jumps were recorded simultaneously via an iPhone 8plus Smartphone (Balsobre, Spain) with a 240 Hz High-Speed Video Capture feature [35, 36, 37]. Video footage was captured in the frontal plane, focusing on the toes of the jumping participant at a distance of approximately 1.5 meters. The recorded videos were analysed by using the MyJump Smartphone App [35, 36, 37].

Countermovement Jump Test

Participants were fixed with legs hip-width apart, hands on the hips. Later, they performed a quick squat to approximately 90^0 knee flexion and then

Table 4. Repeated Measures Anova Results Regarding The Difference Between RSI, CMJ, IAT, Speed And Maximal Strength Values Between Groups

Variable	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	$F_{(1-31)}$	P	η^2
DJ-RSI	Cluster Set	1.45±.246	1.62±.259	4.787	**.037***	0.13
	Traditional Set	1.33±.164	1.45±.157			
CMJ (CM)	Cluster Set	32.02±2.11	35.21±1.91	9.951	**.004***	0.24
	Traditional Set	29.88±2.56	31.80±2.72			
IAT (Seconds)	Cluster Set	15.74±.295	15.47±.312	.985	.329	0.03
	Traditional Set	15.70±.276	15.48±.283			
10 m Sprint (Seconds)	Cluster Set	1.87±.071	1.80±.081	4.235	**.048***	0.12
	Traditional Set	1.89±.113	1.86±.095			
20 m Sprint (Seconds)	Cluster Set	3.16±.139	3.07±.101	5.224	**.032***	0.14
	Traditional Set	3.20±.126	3.17 ±.97			
30 m Sprint (Seconds)	Cluster Set	4.42±.255	4.24±.176	3.468	.072	0.10
	Traditional Set	4.47±.202	4.36±.182			
1RM-BS (KG)	Cluster Set	91.43±14.28	106.93±16.24	2.134	.154	0.06
	Traditional Set	93.43±13.62	111.81±17.80			
1RM-HT (KG)	Cluster Set	80.62±15.28	95.93±14.96	2.152	.153	0.06
	Traditional Set	79.43±13.12	96.12±15.41			

DJ-RSI: drop jump-reactive strength index; CMJ: countermovement jump; IAT: illinois agility test; 1RM-BS: 1 repetition maximum back squat; 1RM-HT: 1 repetition maximum hip trust; SD: standard deviation, CM: centimetre; KG: kilogram; SN: seconds; *Statistically significant differences (P< 0.05).

a vertical jump upwards as fast as possible without waiting.

Attention was paid not to bend the knees during take-off and to ensure that both feet were within the contact area when landing. Three repetitions with three-minute recovery periods were performed and the best result was recorded. Participants, who performed the movement with a faulty technique, were made to repeat the test [38].

All jumps were recorded simultaneously via an iPhone 8plus Smartphone (Balsobre, Spain) with a 240 Hz High-Speed Video Capture feature [35, 36, 37]. Video footage was captured in the frontal plane, focusing on the toes of the jumping participant at a distance of approximately 1.5 meters. The recorded videos were analysed by using the MyJump

Smartphone App [35, 36, 37].

Statistical Analysis

In accordance with the sub-problems determined within the scope of the study, the collected data set was recorded electronically. When analysing the data obtained, Skewness and Kurtosis values and Kolmogorov-Smirnov values were examined to determine homogeneity. In order to compare the pre-test and post-test averages between groups, ANOVA was used for Repeated Measures, and Sample T Test was used to compare the pre-test and post-test averages within groups. The statistical significance level was determined as $p<0.05$. Statistical Analyses were performed using the SPSS 26.0 (Armonk, NY: IBM Corp, 2019) Package Program [39].

Results

After AEL training, a statistically significant difference was observed between AEL-CS and AEL-TS groups in terms of DJ-RSI, CMJ, 10m and 20m Sprint values ($P<0.05$). There was no significant difference between the groups in terms of pre-test and post-test values of the IAT, 30 m Sprint, Back Squat 1-RM and Hip Thrust 1-RM ($P>0.05$) (table 4).

As for the intra-group assessments, a statistically significant difference was observed between the pre-tests and post-tests, DJ-RSI, CMJ, 10m, 20m, 30m Sprints, IAT, Back Squat 1RM and Hip Thrust 1RM results of AEL-CS and AEL-TS groups ($P<0.05$). When analysed in terms of percentage improvement, the percentage improvement of the AEL-CS group in terms of DJ-RSI, CMJ, IAT, 10m, 20m and 30m Sprint measurements was higher than the AEL-TS group.

In 1RM measurements, it was observed that the percentage improvement rate was higher in the AEL-TS group compared to the AEL-CS group (table 5).

Discussion

This study aims to comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outputs in accentuated eccentric load (AEL) training. For this purpose, 10-20-30 Sprints, Illinois Agility Test (IAT), Drop Jump- Reactive Strength Index (DJ-RSI) Countermovement Jump (CMJ) and 1-RM Tests were applied in the form of pre and post-tests.

In this study, which was conducted with a standard method, it is revealed that maximal strength improvement was observed in both methods in terms of maximal strength improvement. But, the improvement differences between the two groups are not found to be statistically significant.

Maximal Strength (1-RM): In this study using submaximal loads (Eccentric: 85%-Concentric: 50% 1 RM), when intra-group changes were compared in terms of maximal strength improvement, pre-test and post-test evaluations were statistically significant in both groups ($p<0.05$). When we consider the intra-group percentage differences: In the AEL-TS group, *Back Squat* improvement was 20% and *Hip Thrust* improvement was 21%, while in the AEL-CS group, *Back Squat* improvement was 17% and *Hip Thrust* improvement was 19%. In this study, it is concluded that using the Cluster Set method in AEL Training is not superior to the Traditional Set method in terms of maximal strength improvement. Although it is seen that there is no superiority of the set methods used in this study, the results obtained are consistent with the results of studies [11, 40, 41] that recommend the use of submaximal loads in AEL Training for strength improvement.

Ojasto and Hakkinen [11] reported that maximal power and neuromuscular activity increased with submaximal AEL. The submaximal Loading Strategy is generally used in AEL Training when changes in explosive and plyometric performance are expected [39, 40, 41]. Many different Submaximal Load Methods were used in AEL studies (Eccentric/Concentric: 60/50% 1RM, 70/50% 1RM, 80/50% 1RM, 90/50% 1RM). However, there is no certainty about the optimal submaximal load (eccentric/concentric) ratio for performance improvement [11].

Power, sprint and change of direction: In our study, 10 m, 20 m, 30 m Sprint Test, Illinois Agility Test (IAT), Drop Jump Reactive Strength Index (DJ-RSI), Countermovement Jump (CMJ) Tests were used in order to assess explosive performance. It is observed that AEL Training with submaximal loads produced statistically significant improvements in both groups. When we consider the intra-group comparisons of the two different set methods used throughout the study, improvement is observed in all tests. These results support the studies indicating that using the submaximal load in AEL training improves explosive and plyometric performance [11, 40, 41].

Power (CMJ, DJ-RSI): When we compare the vertical jump performance of AEL CS and AEL TS groups under the roof of this study, we can say that the DJ-RSI and CMJ Test results were statistically significant both within and between the groups. When we compare the percentage improvements between the two groups, we observe that the percentage improvements of the CS group were 10% in the context of CMJ and 12% in the context of DJ-RSI, while the percentage improvements of the TS group were 6% in the context of CMJ and 9% in the context of DJ-RSI. In both measurements, the percentage changes were higher in the CS group compared to the TS group.

In their study to evaluate the effects of accentuated eccentric load on CMJ performance, Aboodarda et al. [42] showed that vertical ground reaction forces increased by 6.34%, the power output by 23.21%, impulse impact by 16.65% and jump height by 9.52% in the group where they used

Table 5. T-Test Results Regarding The Difference Between Pre-Test And Post-Test, RSI, CMJ, IAT, Speed And Maximal Strength Values Within Groups

Variable	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t	Improvement %	P
DJ-RSI	Cluster Set	1.45±.246	1.62±.259	-10.058	12	**.000***
	Traditional Set	1.33±.164	1.45±.157	-9.563	9	**.000***
CMJ (CM)	Cluster Set	32.02±2.11	35.21±1.91	-9.350	10	**.000***
	Traditional Set	29.88±2.56	31.80±2.72	-8.928	6	**.000***
IAT (Seconds)	Cluster Set	15.74±.295	15.47±.312	10.920	2	**.000***
	Traditional Set	15.70±.276	15.48±.283	5.834	1	**.000***
10 m Sprint (Seconds)	Cluster Set	1.87±.071	1.80±.081	3.696	4	**.002***
	Traditional Set	1.89±.113	1.86±.095	3.216	2	**.006***
20 m Sprint (Seconds)	Cluster Set	3.16±.139	3.07±.101	5.693	3	**.000***
	Traditional Set	3.20±.126	3.17±.97	2.736	1	**.015***
30 m Sprint (Seconds)	Cluster Set	4.42±.255	4.24±.176	6.522	4	**.000***
	Traditional Set	4.47±.202	4.36±.182	3.730	2	**.002***
1RM-BS (KG)	Cluster Set	91.43±14.28	106.93±16.24	-17.513	17	**.000***
	Traditional Set	93.43±13.62	111.81±17.80	-10.452	20	**.000**
1RM-HT (KG)	Cluster Set	80.62±15.28	95.93±14.96	-26.616	19	**.000***
	Traditional Set	79.43±13.12	96.12 ± 15.41	-22.550	21	**.000***

DJ-RSI: drop jump-reactive strength index; CMJ: countermovement jump; IAT: illinois agility test; 1RM-BS: 1 repetition maximum back squat; 1RM-HT: 1 repetition maximum hip trust; SD: standard deviation, CM: centimetre;KG: kilogram; SN: seconds; *Statistically significant differences (P< 0.05).

elastic bands providing additional load equivalent to 30% of body mass.

This time, in their study, where they employed a drop jump method, Aboodarda et al. [42] used elastic bands that provided an additional load equivalent to 30% of the body mass and obtained a higher The rate of force development (RFD).

Following a 4-week study by Bridgeman et al. [43] on two groups using Bodyweight and Bodyweight +20% Additional Load, although significant individual improvements in speed occurred in the AEL groups, the size of the improvement across all groups was small compared to the improvements seen in Vertical Jump Performance (2.2% at 10 and

2% at 30m).

Sprint and Change of Direction (COD): When we consider the results of the sprint test, we can say that the 10-20m test performance of the AEL-CS group was statistically better. On the other hand, there was no statistical difference between the 30m sprint and Illinois Agility Test results between the two groups.

Although the results of the 30m Sprint Test and IAT Test between the groups were not statistically significant, when we evaluate the percentage improvement values, the results of the 30m Sprint Test showed a 2% improvement in the AEL TS group and a 4% improvement in the AEL CS group. IAT Test results showed 1% improvement in the AEL TS group and 2% improvement in the AEL CS group. Although there were significant individual improvements in the speed of both groups participating in this study, the vertical jump performance was higher. These improvement values put forth similar results with the studies in the literature [44, 45].

On the other hand, in one of the limited studies on change of direction (COD) skills, Lockie et al. [44] applied a training program including speed and agility training elements that provided eccentric muscle movements in male (23 years old) and female (25 years old) athletes, who were recreationally engaged in team sports. As a result of this study, similar to our study, an improvement was observed in terms of COD speed performance after 6 weeks of training.

Hoyo et al. [45] examined the effects of a 10-week strength training program on the COD by designing AEL training differently. They used an iso-inertial flywheel training device to measure kinetic parameters during COD in 17-year-old young football players. The results obtained from this study reported significant improvements in COD speed kinetics after training.

Similarly, Tous-Fajardo et al. [46] examined the effects of an 11-week strength training program (applied on 17-year-old elite young football players) (including additional iso-inertial eccentric muscle movements and additional whole-body vibration) on COD Speed Performance compared to traditional combined training that includes plyometrics, linear velocity and weight-loaded exercises. The findings of this study show that strength training with AEL in combination with vibration stimuli improves change of direction (COD) speed performance more than traditional training does.

Spiteri et al [47] studied the relationship between eccentric force and COD performance and reported a strong correlation between them. The authors reported that the ability to tolerate larger eccentric loads may result in improved COD performance [47]. If we analyse the results of this current study, we see that the subjects in the AEL group had the greatest increase in Eccentric Peak Force (13.8% vs. 7.3%) and also the greatest improvement in COD Performance. In conclusion, while it is stated that different applications of the AEL method in COD training will provide improvements, we can say that, in our study, CS application also brought similar advantages.

When the effects of AEL training on the development of power [48, 49, 50], change of direction [45, 46, 47] and speed [43, 46, 47] are examined, it is seen that the use of AEL reveals better results than the traditional set method. Hansen et al. [51] showed that: following a training program involving squats or squat derivatives, when compared to the use of traditional sets [52, 53, 54], the use of cluster sets caused greater changes in post-activation strength development and peak velocity characteristics of the jump squat exercise.

As we also revealed in our study, cluster set practice stands out in many studies as a practice to improve speed and power characteristics [51, 55, 56]. In the limited number of studies using the cluster method in AEL training, we see that cluster set practice was used as an effective method, especially for speed and power improvement [51]. Acutely, such a method is reported to result in higher power outputs while exposing the athlete to less metabolic stress and fatigue [57].

On the other hand, recent AEL studies have found that the application of the cluster set method in a single repetition or in all repetitions of eccentric overloading significantly increases eccentric work (W_{Eks}) compared to the traditional loading [11, 16, 58, 59].

Wagle et al. [59] compared four different training methods 1. Traditional strength training (TST), 2: Traditional strength training with Cluster Sets (TSTCS), 3: Accentuated eccentric load Training Traditional Sets (AELTS), 4: Accentuated eccentric load Training Cluster Sets (AELCS). In the study, they used 1RM 80% as concentric load and 1RM 105% as eccentric load. When the four groups were compared, in terms of concentric outcomes, the Average Speed Average Power accentuated eccentric load Cluster (AELCS) group showed superior effects compared to the other groups ($p<0.001$), especially on Average Power and Average Speed.

Conclusions

In conclusion, this study revealed that the Cluster Set and Traditional Set methods produce similar results in terms of maximal strength improvement in AEL training using submaximal loads. And, the Cluster Set method is not superior to the Traditional Set method in terms of maximal strength improvement. It is also consistent with the studies that recommend the use of submaximal loads in AEL training because working with supramaximal loads causes fatigue [11, 17, 18]. To summarize the effect of using submaximal loads on

explosive power performance; when we analyse the results in terms of the percentage improvements of the pre-test and post-test measurements between the groups: Percentage improvements in DJ-RSI, CMJ, 10-20-30m Sprint, IAT measurements in AEL-CS Group were higher when compared to AEL-TS Group. As a result, the use of the Cluster Set method in accentuated eccentric load training can be recommended for the development of strength, change of direction (COD) skills and sprint.

Conflict of interest

The authors declare no conflict of interest.

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