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The Effect of Plyometric Exercises Using the Cluster Set Method on Certain Physical and Physiological Parameters in Female Handball Players

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Abstract

This study investigated the effects of six weeks (three days per week) of plyometric training using traditional set (TS) and cluster set (CS) methods on several physical and physiological parameters in female handball players from the 2nd League. Twenty-three female athletes aged 12-15 participated, with 12 in the traditional set group (TSG) and 11 in the cluster set group (CSG). Pre- and post-tests measured physical characteristics (age, height, weight), vertical jump (VJ), standing long jump (SLJ), reactive agility test (RAT), 10m-30m speed test (ST), Pediatric RAST (PRAST) test, leg strength (LS), and back strength (BS). Data were analyzed using SPSS 22.0, with a significance level of $p<0.05$. Shapiro-Wilk's test assessed normality. Paired t-tests or Wilcoxon tests compared pre- and post-test results within groups, while independent samples t-tests or Mann-Whitney U tests compared groups. The difference between pre- and post-test scores was used to evaluate training effects. Results showed no significant changes in VJ, 30m speed, fatigue index, and leg strength in the TSG. However, the CSG showed significant improvements in VJ, reactive agility (RAT), 10m and 30m speed, and leg strength. Percentage changes (PC) were also higher in the CSG compared to the TSG. In conclusion, the CS method appears to be an effective training approach for improving the performance of these young female handball players.
Keywords: Handball, Cluster Set Method, Plyometric Training, Strength.

Özet

Kadın Hentbolcularda Cluster Set Yöntemi ile Uygulanan Pliometrik Çalışmaların Bazı Fiziksel ve Fizyolojik Parametreler Üzerine Etkisi

Bu çalışmanın amacı 2. Ligde oynayan kadın hentbolcuların pliometrik antrenmanlarında geleneksel set yöntemi (GSY) ve cluster set yöntemi (CSY) uygulanarak 6 hafta (haftada 3 gün) sonunda pliometrik antrenmanların bazı fiziksel ve fizyolojik parametreler üzerine etkisi incelemektir. Çalışmaya 12-15 yaşlarında 12 kişi geleneksel set grubu (TSG) ve 11 kişi cluster set grubu (CSG) olmak üzere toplam 23 kadın sporcu katıldı. Araştırma kapsamında, TSG ve CSG fiziksel özellikleri (yaş, boy uzunluğu, vücut ağırlığı), dikey sıçrama (DS), durarak uzun atlama (DUA), reaktif çeviklik testi (RÇT), 10m-30m sürat testi (ST), Pediatrik RAST (PRAST) testi, bacak kuvveti (BK), sırt kuvveti (SK) ön test ve son test şeklinde ölçümleri alındı. Verilerin analizinde SPPS 22.0 programı kullanıldı. İstatistiksel işlemlerde güven aralığı $p<0,05$ kabul edildi. Çalışma sonucunda bulunan tanımlayıcı istatistiklerin normal dağılım olup olmadığı Shapiro Wilk's testi ile anlaşıldı. Grupların ön test ve son test sonuçları arasındaki farklılığı belirlemek için normal dağılıma uygun değişkenlerde eşleştirilmiş t-testi, uymayanlarda ise Wilcoxon testi uygulandı. Gruplar arası farklılıkların normal dağılıma uygun değişkenler için Bağımsız örneklem t-testi, uygun olmayanlar için Mann Whitney U testi uygulandı. Antrenman verilerini değerlendirmek için ön test son test arasındaki fark alındı. İncelenen parametrelere bakıldığında GSY'de göre DS, 30m Sürat, Yorgunluk ind., ve Bacak kuvvetinde (anlamlı değişiklik yok iken, CSG de DS, Reaktif çeviklik, (RÇ), 10 m ve 30 m Sürat ve Bacak kuvvetinde anlamlılık görülmüştür. Yüzdesel değişimlerde ise CSG'nin TSG ye göre daha yüksek olduğu gözlemlenmiştir. Sonuç olarak; CSY'nin sporcuların gelişim seviyelerinde etkili bir yöntem olduğu düşünülmektedir.

Anahtar Kelimeler: Hentbol, Cluster Set Yöntemi, Pliometrik Antrenman, Kuvvet.

INTRODUCTION

Sports are physical and motor activities performed individually or in teams, governed by specific competition rules and undertaken without personal gain (31). Studies have shown that strength, as a physical attribute, significantly impacts performance in various sports disciplines. Applying scientific methods to enhance athletes' performance has facilitated substantial advancements. Improvement in technical skills, speed, anthropometric measurements, and physiological conditions is essential across all sports disciplines (9).

Handball is a sport that involves various movements performed simultaneously, intending to gain a competitive edge over opponents (3). The game has evolved from a slow-paced activity to a fast and modern sport due to changes in the rules. Athletes now execute a wide range of movements, such as running, passing, and changing direction quickly (6). Over the years, modern training methods have been adopted to achieve higher performance levels (37).

To attain optimal performance in handball, a widely practiced and widespread sport, it is essential to enhance training characteristics, thoroughly understand the impact of training on the body, and develop the motor abilities of the athletes (34).

In handball, various methods enhance anaerobic performance during training, which demands general and specific endurance, short and long-distance sprints, pushing, blocking, jumping, and accurate shooting. One of these methods is plyometric training, which is recognized for improving movement speed, force adaptation, and muscle strength through various exercises (18). Plyometric training for strength development enhances intramuscular coordination and neuromuscular harmony. It provides a protective effect against injuries and improves athletic performance by ensuring joint stabilization (25). Numerous studies have been conducted on plyometric training, and it has been concluded that these studies positively affect anaerobic power and explosive strength (26).

Recent research indicates that the developmental values derived from the effects of applied training on physical and physiological parameters can be measured, and test results can be obtained. Integrating modern scientific advancements and technological devices into sports illustrates the physiological changes induced by plyometric training on athletes and the impacts of these changes. Furthermore, this integration reveals that some practices previously considered correct contain incomplete information and that more accurate effects can be achieved through scientific advancements (24).

In addition to traditional training methods, recent years have seen the emergence of new approaches. One notable example is the cluster set method (CSY), which has garnered attention in contemporary research and training applications. Unlike the traditional set method (GSY), which involves continuous application with long rest breaks between consecutive repetitions, the CSY method employs shorter, more frequent rest intervals within sets. Research indicates that strength development is less pronounced with low set numbers in GSY training, whereas higher set numbers result in more significant strength gains (5). In addition to GSY, changes in the application of sets developed by researchers have proven effective in contributing to strength development. This new method, known as CSY (Cluster Set Method), involves dividing sets into smaller subsets with short rest intervals between them (16). These rest periods, typically ranging from 10 to 30 seconds, are intended to allow the practitioner to reach the desired level between repetitions and to achieve a higher performance level in subsequent repetitions, with these developments, new the method is called CSY (5, 16). These methods enhance strength development and athletic performance (32).

This study aimed to investigate the effects of six weeks of plyometric training, using traditional and cluster set methods, on various physical and physiological parameters such as vertical jump height, speed, agility, and strength in female handball players aged 12-15 years.

METHOD

Research Model

The study was designed to span six weeks, with training sessions conducted three days per week. Measurements were obtained using an experimental modeling method, including pre-test and post-test assessments. A total of 23 participants were randomly assigned to two distinct groups, with one group undergoing GSY and the other CSY.

The groups continued their training in a designated gymnasium and at scheduled times under the supervision of a trainer. The athletes performed the prescribed plyometric exercises three times a week, with at least one rest day following each training session, for six weeks, divided into GSY and CSY groups.

Research Group

The study sample comprised 23 female athletes, aged between 12 and 15 years, all of whom held an athlete license with Kastamonu Esan Akü Merkez Secondary School Sports Club and participated in handball at the 2nd League level. Of these, 12 were assigned to the GSY (control) group and 11 to the CSY (experimental) group.

Implemented Training Program

In the TSY and CSY training programs, athletes followed a prescribed number of sets and repetitions during the first four weeks. In the final two weeks, the number of sets remained constant while the number of repetitions was increased according to the principle of progressive overload. This approach led to an intensified training regimen in the latter part of the program.

Traditional Set Method

The six-week plyometric training program (18 sessions) employed a traditional set (TS) methodology. During the initial four weeks, each exercise consisted of three sets of nine repetitions. Weeks five and six incorporated a progressive overload paradigm, maintaining three sets per exercise but increasing the repetitions to twelve. Inter-exercise rest intervals were standardized at 60 seconds, with a 120-second rest period specifically designated for half burpees.

Cluster Set (Dividing Set into Sets) Method

The CSY strength training program was conducted over six weeks, encompassing 18 training days. During the program, exercises were organized into three sets with three repetitions, following the details specified in Table 3 and Table 4. Rest periods within sets were set at 10 seconds, with transition times between movements established as 40 seconds. For half burpees, rest periods within sets were 20 seconds, and transition times between movements were 80 seconds. Athletes monitored their training intensity using heart rate measurements, calculated with the formula:

Heart Rate=(220−Age)×(Percentage of Intensity).

Measurement Instruments

Data were collected using pre- and post-tests administered to all participants before and after the six-week training program. Participants' ages were obtained from their national identity cards. Height was measured using a stadiometer. Body weight was measured using electronic scales, with participants wearing only sports shorts and a t-shirt and barefoot. Vertical jump, T-test agility, 10m-30m speed and acceleration, reactive agility, and the Pediatric RAST (Running-Based Anaerobic Sprint Test) were assessed using a Newtest Powertimer 300. Leg strength was measured using a Takei (Tkk-5402 Back-D/JAPAN) brand dynamometer, and standing long jump was also assessed.

Ethical approval and institutional permission

Approval was obtained from the Kastamonu University Medical Faculty Clinical Research Ethics Committee for conducting the study. Before commencing the study, participants were provided with an 'Informed Consent Form' and a 'Parental Consent Form' detailing the study's scope and information, which they were asked to complete. Our descriptive study was approved by the Non-Interventional Clinical Research Ethics Committee of Kastamonu University Faculty of Medicine (Decision No: 2022-KAEK-129).

FINDINGS

A total of 23 female athletes aged 12-15 participated in the study, 12 of them in the traditional set group and 11 people in the cluster set group. The participants' height was determined as 156.08±5.02, and their body weight was determined as 53.92±7.16.

Table 1. In-group vertical jump change results

		n	X±ss	t	p
TSG - VJ (cm)	Pre-test	12	27,52±3,61	-0,62	0,55
	Post-test		27,80±3,97		
CSG - VJ (cm)	Pre-test	11	27,36±5,63	-2,42	**0,04***
	Post-test		28,77±4,42		

(p<0,05)

*TSG; Traditional set group, CSG Cluster Set Group, VJ: Vertical Jump

CSY VJ measurements showed 27.36±5.63 cm in the pre-test and 28.77±4.42 cm in the post-test and a statistically significant difference between the pre-test and post-test values (p<0.05).

Table 2. Intra-group reactive agility test change results

			n	X±ss	t	p
TSG	RAT (sn)	Pre-test	12	2,49±0,23	3,87	**0.00***
		Post-test		2,18±0,27		
CSG	RAT (sn)	Pre-test	11	2,49±0,24	6,43	**0.00***
		Post-test		2,01±0,19		

(p<0,05)

*TSG; Traditional set group, CSG Cluster Set Group, RAT; Reactive Agility Test

When looking at the reactive agility intra-group test results in both groups; significant differences were observed (p<0.05).

Table 3. Reactive agility test change results between groups

		TSG (n=12)	CSG (n=11)	t	p	TSG Change %	CSG Change %
RAT (sn)	Pre-test	2,49±0,23	2,49±0,24	-0,21	0,98	%14,22	**%23,88**
RAT (sn)	Post-test	2,18±0,27	2,01±0,19	1,77	0,09		

When the percentage change in the findings is examined, it is seen that the increase in CSG is higher than in TSG.

Table 4. Intra-group speed test change results

			n	X±ss	t	p
TSG	ST 10 m (sn)	Pre-test	12	2,10±0,24	4,59	**0,00***
		Post-test		1,77±0,28		
	ST 30 m (sn)	Pre-test	12	5,29±0,53	5,27	**0,00***
		Post-test		5,19±0,48		
CSG	ST 10 m (sn)	Pre-test	11	2,12±0,27	1,94	0,08
		Post-test		1,72±0,24		
	ST 30 m (sn)	Pre-test	11	5,26±0,36	2,74	**0,02***
		Post-test		5,11±0,36		

(p<0,05)

*TSG; Traditional set group, CSG Cluster Set Group, ST; Speed Test

When the 10 m speed within-group test results were examined in both groups; significant differences were observed. When the 30 m within-group test results were examined, there was no significant difference in TSG, but a significant difference was observed in CSG ($p<0.05$).

Table 5. Speed test change results between groups

		TSG (n=12)	CSG (n=11)	t	p	TSG	CSG
						Change %	
ST 10 m (sn)	Pre-test	2,10±0,24	2,12±0,27	0,53	0,14	%18,64	**%23,25**
	Post-test	1,77±0,28	1,72±0,24	0,41	0,69		
ST 30 m (sn)	Pre-test	5,29±0,53	5,26±0,36	0,16	0,88	%1,92	**%2,93**
	Post-test	5,19±0,48	5,11±0,36	0,45	0,66		

When the interaction between the groups is examined; while there is no significance in the speed test results, it is seen that CSG is higher than TSG in percentage changes($p<0.05$).

Tablo 6. Intra-group PRAST test change results

			n	X±ss	t	p
TSG	Minimum (watt)	Pre-test	12	1424,51±441,49	-2,64	**0,02***
		Post-test		1688±576,41		
	Maximum (watt)	Pre-test	12	2522,37±797,65	-4,49	**0,00***
		Post-test		3427,81±1147,28		
	Mean (watt)	Pre-test	12	1818,32±564,08	-3,95	**0,00***
		Post-test		2264,16±677,15		
	Fatigue Index (watt)	Pre-test	12	34,82±9,71	-1,41	0,22
		Post-test		50,43±19,36		
CSG	Minimum (watt)	Pre-test	11	1351,74±304,91	-2,17	0,06
		Post-test		1600,62±502,55		
	Maximum (watt)	Pre-test	11	2222,64±574,95	-4,05	**0,00***
		Post-test		3788,82±1317,91		
	Mean (watt)	Pre-test	11	1721,60±401,52	-9,03	**0,00***
		Post-test		2485,25±565,11		
	Fatigue Index (watt)	Pre-test	11	41,77±18,29	-3,06	**0,02***
		Post-test		75,20±15,95		

($p<0,05$)

*TSG; traditional set group, CSG Cluster Set Group, PRAST; Pediadric Rast Test

When PRAST results are examined, TSG' While significant differences were observed in Min, Max and Mean values, no significance was observed in the fatigue index. When the CSG results are examined, while the min value is not significant, significance is observed in max, mean and fatigue index.

Table 7. PRAST test change results between groups

		TSG (n=12)	CSG (n=11)	t	p	TSG Change %	CSG Change %
Minimum (watt)	Pre-test	1424,51±441,49	1351,71±304,91	0,46	0,65	%18,49	%18,47
Minimum (watt)	Post-test	1688±576,41	1600,62±502,55	0,39	0,70		
Maximum (watt)	Pre-test	2522,37±797,65	2222,64±574,95	1,02	0,32	%35,89	**%70,46**
Maximum (watt)	Post-test	3427±1147,28	3788,82±1317,91	-0,70	0,49		
Average (watt)	Pre-test	1818,32±564,08	1721,60±401,52	0,47	0,64	%24,51	**%44,35**
Abvarage (watt)	Post-test	2264,16±677,15	2485,25±565,11	-0,85	0,41		
Fatigue İndex (watt)	Pre-test	34,82±9,71	41,77±18,29	1,29	0,21	%44,83	**%80**
Fatigue İndex (watt)	Post-test	50,43±19,36	75,20±15,95	-2,53	**0,03***		

(p<0,05)

When the percentages of interaction between groups are examined, there is no percentage difference between TSG and CSG in Min values, while percentage differences are seen in max, mean and fatigue indices.

Table 8. Leg strength test change results within the group

		n	X±ss	t	p
TSG - LS (cm)	Pre-test	12	86,25±12,78	-1,61	0,14
	Post-test		92,33±18,25		
CSG - LS (cm)	Pre-test	11	72,52±12,71	-3,69	**0,00***
	Post-test		87,27±24,06		

(p<0,05)

*TSG; traditional set group, CSG Cluster Set Group, LS; Leg Strenght

When looking at the leg strength values within the group, no significant difference was observed in TSG, while a significant difference was observed in CSG results.

Table 9. Leg strength test change results between groups

		TSG (n=12)	CSG (n=11)	t	p	TSG Change %	CSG Change %
LS (kg)	Pre-test	86,25±12,78	72,52±12,71	2,58	**0,02***	%7	**%20**
LS (kg)	Post-test	92,33±18,25	87,27±24,06	0,57	0,57		

(p<0,05)

When looking at the percentage interaction between groups; It is observed that Csg results are higher.

DISCUSSION AND CONCLUSION

This study examined the impact of plyometric exercises, applied to both GSY and CSY groups for 6 weeks (3 days a week) and regular handball training, on various physical and physiological fitness parameters in female handball players aged 12-15. The results, derived from measurements of 23 athletes (11 in CSY and 12 in GSY), were analyzed by comparing data within and between groups.

Before the training period, the groups were homogeneous, with no significant differences in age, body weight, or height. In addition to anthropometric measurements, various tests, including VJ, SLJ, RAT, 10 m and 30 m ST, PRAST, LS, and BS, were conducted before and after the training.

A literature review revealed a scarcity of studies focusing on the effects of plyometric training in the handball branch for the CSY method. This highlights a gap in research, suggesting the need for further investigation into the benefits and efficacy of plyometric training, specifically within this context.

When we look at the studies examining the relationship between plyometric training and VJ in the literature,

Diallo et al. (7) investigated the effects of plyometric training on VJ performance. The study was conducted with 20 boys aged 12-13 years, and significant differences in VJ results were found in the experimental group. In their study, Lawton et al. (21) showed 26 young male basketball players and football players were made to bench press with a maximum of 6 repetitions with weights. It was stated that the findings obtained in CSG showed more improvement than those obtained in TSG. It was stated that CSG reached a more anaerobic level than TSG in repeated squat jumps.

In the study by Ateş and Ateşoğlu (2), the effects of plyometric training on physical and physiological parameters were examined in male football players aged 16-18. A total of 24 players participated, divided into a control group (CG) with 12 players and a workout group (WG) with 12 players. Over 10 weeks, with training sessions held twice weekly, the CG underwent standard football training, while the WG received additional plyometric training. The results indicated that the WG experienced positive improvements in vertical jump (VJ) values compared to the CG.

In a review study by Eduardo et al. (10), 56 studies were analyzed to assess the effects of plyometric training on vertical jump (VJ) development. The review concluded that plyometric training positively enhances VJ performance, as evidenced by evaluating the studies included.

Hansen et al. (17) examined the strength development of elite-level rugby players during the pre-season preparation period. 18 athletes were divided into two groups as TSG (n = 9) and CSG (n = 9). Both groups underwent 8-week lower body resistance training. According to the findings, while the two groups had a significant difference in strength and jump development, no statistical difference was found between the groups.

In their study, Moreno (28) performed two different applications of the acute effect of CSG in plyometric training. In the first application, CSG was performed as 30 seconds rest and 4 sets of 5 repetitions, and the second CSG was performed as 10 seconds rest and 10 sets of 2 repetitions. TSG was trained with 90 seconds of rest and two sets of 10 repetitions. The results related to VJ parameters were analyzed. According to the findings, it was concluded that the second CSG method performed more VJ than the first CSG and TSG.

In a study by Morales et al. (27), 19 male athletes were divided into CSG and TSG groups. The study investigated the effects of the training methods on strength development in both groups. The findings suggested that the CSG approach was more effective for strength and power development. Specifically, the speed loss between the first and sixth repetitions was 0.5% for the CSG group, compared to 3.5% for the TSG group.

Bavlı (4) investigated the impact of plyometric exercises on vertical jump (VJ) development in basketball training. The study included 24 male basketball players with an average age of 20.7±2.6 years, divided into a control group (CG, n=12) and a workout group (WG, n=12). The WG performed plyometric exercises for 30 minutes following their basketball training, while the CG participated only in basketball training. VJ measurements were recorded before and after the study. The results indicated a statistically significant improvement in VJ development for athletes who engaged in plyometric exercises.

Our research analyzed the VJ change results for the GSY and CSY groups. No statistically significant difference was found within or between the GSY groups. However, a statistically significant difference was observed within the CSY group ($p<0.05$). Between the groups, VJ improvement was 1.01% for GSY and 5.15% for CSY. Literature indicates that plyometric training generally leads to positive increases in VJ development, though some studies report no differences between groups. Our findings suggest that CSY plyometric training had a more substantial effect on VJ development than GSY.

When the studies in the literature examining the relationship between plyometric training and RAT are examined;

In the study by Dönmez (8), five female and 15 male athletes aged 18-21, all licensed and engaged in wushu, participated. The study investigated the effects of plyometric training on jumping and agility parameters. After eight weeks of plyometric training, statistically significant differences were observed in the male group's reactive agility test (RCT) results. The study concluded that plyometric training positively influenced agility performance in both men and women.

Matlak et al. (23) investigated the effects of reactive agility training (RTT) on performance in 15 amateur football players, finding a significant improvement in RTT performance. In a separate study by Erdem and Yazar (11), 40 athletes aged 16-17 years were divided into two groups: a control group (CG) that continued traditional football training and a workout group (WG) that underwent futsal-specific training for eight weeks (3 days a week). Data analysis using the reactive agility test (RCT) showed that the WG, which engaged in futsal-specific training, exhibited more substantial positive development than the CG.

Topal (35) explored the effects of two different resistance training programs combined with plyometric training on performance parameters in basketball. The study involved 40 male basketball players aged 15-18. Reactive agility test (RCT) parameters were measured before and after the training. The findings indicated that both plyometric and resistance plyometric training were effective in improving reactive agility. Our research examined the RCT change results for GSY and CSY groups. A significant difference was found within the CSY group, but no statistically significant difference was observed. Between-group analysis showed a 14.22% increase in the GSY group and a 23.88% increase in the CSY group. Literature suggests that plyometric training enhances RCT performance. Our findings indicate that the CSY group's improvement was greater than the GSY group's.

When examining the literature on the relationship between plyometric training with Cluster Set Group (CSG) and short-distance speed tests, including the 10-meter (ST 10 m) and 30-meter (ST 30 m) speed tests:

Iacono et al. (19) reported that their study significantly improved the 10-meter speed test (ST 10 m) results among elite handball players who underwent high-intensity interval training. This indicates that high-intensity interval training effectively enhances short-distance speed performance.

In his study, Öner (30) investigated the effects of plyometric and resistance training on motor skills and performance in female tennis players. The study involved 36 participants aged 11-13, divided into three groups: a control group (CG, n=12), a resistance training group (DA, n=12), and a plyometric training group (PA, n=12). The CG continued their regular tennis training, while the DA and PA groups received additional resistance and plyometric training for 10 weeks (3 days a week) before their tennis sessions. Pre- and post-test measurements for the 10-meter speed test (ST 10 m) were conducted. The results showed that the ST 10 m averages were significantly higher in both the DA and PA groups compared to the CG. The study suggests that speed performance can be enhanced through both resistance and plyometric training.

In his study, Erol (12) conducted quick strength and plyometric training with a total of 28 basketball players aged 16 to 18, divided into a workout group (WG, n=14) and a control group (CG, n=14) over eight weeks. Pre- and post-test measurements were taken, revealing a statistically significant improvement in the WG's 30-meter speed test (ST 30 m) times. Similarly, Samur (33) investigated the effects of plyometric training on male volleyball players' vertical jump strength and performance. The study found a statistically significant improvement in ST 30 m performance for the workout group, with pre-test values of 4.36 ± 0.06 seconds and post-test values of 4.30 ± 0.05 seconds.

In the study of Gençay (14), when the averages of the ST 30 m results were compared in the measurements taken before and after the training of 15 athletes who participated in an 8-week plyometric training program, it was found that there was a statistically significant improvement in the athletes who performed plyometric training.

In his study, Turgut (36) investigated the effects of 8 weeks of plyometric training on balance, sprint, and anaerobic power performances in 40 male handball players aged 15-18. The study involved a workout group (WG, n=20) and a control group (CG, n=20). The WG participated in plyometric training before their regular handball sessions for eight weeks (3 days a week), while the CG continued their regular handball training.

The results indicated a notable improvement in sprint performance. Specifically, the 30-meter speed test (ST 30 m) times improved from 6.08 seconds in the pre-test to 5.28 seconds in the post-test. The study concluded that plyometric training effectively enhanced sprint performance and could be valuable to athlete development.

In our research, when examining the changes in the 10-meter (ST 10 m) and 30-meter (ST 30 m) speed test results for both the TSG and CSG groups, significant improvements were observed within each group. However, no statistically significant difference was found between the two groups.

Analysis revealed that the cluster set group (CSG) demonstrated greater percentage increases in speed compared to the traditional set group (TSG). Specifically, the CSG showed a 23.25% improvement in the 10-

meter sprint test, exceeding the TSG's 18.64% improvement. Similarly, while the TSG showed a 1.92% increase in the 30-meter sprint test, the CSG exhibited a larger improvement of 2.93%.

Literature supports that plyometric training can enhance speed test performance. Our findings align with these studies, indicating that the CSG group's improvement was greater than the TSG group's, reflecting a more pronounced benefit from plyometric training.

When we look at the studies in the literature examining the relationship between plyometric training and PRAST,

Ara et al. (1) discovered that boys who engaged in regular sports activities before adolescence exhibited higher anaerobic capacity and power values than those who did not participate in sports.

Similarly, Obert et al. (29) reported a 23% increase in maximum anaerobic power values in pre-adolescent children following 13 weeks of aerobic training.

In the study by Kurban and Kaya (20), boys aged 10-13 underwent eight weeks of basic technical football training. The results indicated improved anaerobic power values, demonstrating that the technical training positively impacted their performance.

Löklüoğlu (22) examined the anaerobic performances of children and adolescents involved in various sports. The study included 104 athletes aged 10-16 from different sports disciplines. The findings highlighted the high reliability of the RAST and PRAST anaerobic performance evaluations for children and adolescents.

Our research analyzed the changes in PRAST results for both TSG and CSG. Statistically significant differences were observed in the fatigue (post-test) values within and between the groups, except for the minimum (CSG) and fatigue (TSG) measurements. The percentage changes between the groups were as follows: Minimum Watt: TSG increased by 18.49% and CSG by 18.47%. Maximum Watt: TSG increased by 35.89% and CSG by 70.46%. Average Watt: TSG increased by 24.51% and CSG by 44.35%. Fatigue Watt: TSG showed an increase of 44.83%, and CSG showed an increase of 80%. The results indicate a more significant change in maximum, average, and fatigue watts in the CSG group compared to the TSG group. This finding aligns with literature suggesting that regular sports participation before adolescence contributes to higher anaerobic capacity and power values.

When we look at the studies in the literature examining the relationship between plyometric training and LS;

In the study by Ateş and Ateşoğlu (2), 24 football players aged 16-18 were divided into two groups: the control group (KG) and the plyometric group (WG). The KG continued their regular football training, while the WG received additional plyometric training twice a week for 10 weeks. The results indicated that bench press strength improved by 5.74 kg in the KG and 22.16 kg in the WG. When comparing the groups, the plyometric training was found to improve bench press strength more than the regular training alone.

In the study by Yarayan (38), a total of 40 male football players aged 13-14 were divided into two groups: the control group (CG) and the plyometric training group (WG). Over eight weeks, the effects of plyometric training on parameters such as vertical jump height, speed, strength, and agility were examined. The results showed a statistically significant improvement in bench press strength in the WG compared to the CG, indicating that plyometric training had a more pronounced effect on strength development. Similarly, Güzel (15) conducted a study with 50 female volleyball players, divided into the control group (CG) and the plyometric training group (WG). Plyometric training was applied to the WG for eight weeks. The study found that the WG exhibited significant improvements in strength, with pre-test and post-test mean values for strength increasing from 45.58±14.49 to 53.20±13.59. Additionally, plyometric training was found to impact strength and increase BMI positively.

In the study by Erzeybek et al. (13), male basketball athletes aged 19-24 were divided into three groups, each consisting of 10 participants: a basketball group, a korfball group, and a control group (CG). The CG continued their everyday activities, while the basketball and korfball groups underwent plyometric training for eight weeks, three days a week. The findings revealed that the basketball group experienced a significant improvement in bench press strength, with a final result of 29.34 kg. In comparison, the korfball group showed a result of 11.14 kg, and the control group demonstrated a result of 5.6 kg. The plyometric training applied to the basketball players led to better strength development than the training provided to the korfball and control groups.

The results obtained from the study investigating the effects of plyometric exercises applied with the Cluster Set Method (CSY) on various physical and physiological parameters in female handball players are summarized below. When examining the pre-test and post-test results for the CSG group:

Although the statistical changes in the vertical jump (VJ) results were significantly different within the groups, no significant difference was found between the groups. The change percentage (PC) distribution between the groups showed an increase of 1.01% for TSG and 5.15% for CSG. This indicates that the effect of plyometric training with the Cluster Set Method (CSG) is greater than the traditional set method (TSG) in improving vertical jump performance.

Although there was a statistically significant difference in reactive agility test (RCT) results within each group, no significant difference was observed. The percentage increase (PC) between groups was 14.22% for TSG and 23.88% for CSG. The study found that the development level in the Cluster Set Method (CSG) was higher than the traditional set method (TSG) in terms of improvement in reactive agility.

Although there was a statistically significant difference in the 10 m sprint test (ST 10 m) results within each group, no significant difference was found between the groups. The percentage increase (PC) between groups was 18.64% for TSG and 23.25% for CSG, with a higher increase in CSG. Similarly, for the 30 m sprint test (ST 30 m), although there was a statistically significant difference within each group, no significant difference was found between the groups. The percentage increase (PC) between groups was 1.92% for TSG and 2.93% for CSG, with CSG showing a greater increase than TSG.

When examining the changes in the Peak Running Anaerobic Sprint Test (PRAST) results, statistically significant differences were found for PRAST maximum, average, and fatigue values within each group. Significant differences were noted between the groups for PRAST fatigue (post-test) values.

Percentage changes in leg strength parameters revealed some notable differences between groups. While minimum power output showed similar increases (18.49% for TSG and 18.47% for CSG), the CSG demonstrated significantly greater improvements in maximum (70.46% vs. 35.89% for TSG), average (44% vs. 24.51% for TSG), and fatigue index (80% vs. 44.83% for TSG) power outputs. These findings indicate that the cluster set training method (CSG) significantly enhanced peak power, sustained power, and resistance to fatigue compared to the traditional set training method (TSG).

Statistically significant differences were observed in the bench press (LS) results between the pre-test values within and between the groups. The percentage changes (PC) between groups were as follows: **TSG**: 7% increase, **CSG**: 20% increase. The study concluded that CSG exhibited a greater improvement in bench press strength compared to TSG.

The study concluded that the Cluster Set (CSY) method demonstrated statistically superior improvements in Leg strength (LS) and fatigue in the Performance of Repeated Anaerobic Sprint Test (PRAST-Fatigue) parameters compared to the Traditional Set (TSG) method. The literature review revealed a lack of sufficient research on the effects of CSY in plyometric training, specifically for female handball players aged 12-15.

This study is believed to serve as a guide for training practitioners. Additionally, the following recommendations are suggested for those interested in incorporating Cluster Set (CSY) methods into plyometric training:

The findings demonstrate that the cluster set (CS) method elicited superior improvements compared to the traditional set (TS) method, particularly in leg strength and the fatigue index of the repeated anaerobic sprint test (PRAST). While the CS group also exhibited greater improvements in vertical jump, reactive agility, and 10m-30m speed tests, these differences did not reach statistical significance. Nevertheless, this study provides evidence supporting the efficacy of the cluster set method as a performance-enhancing training approach for young female handball players.

The findings of this study suggest several avenues for future research. First, replicating this study with younger age groups, elite athletes, and male participants would increase the generalizability of the findings across populations. Second, extending the intervention period beyond the six weeks used in this study could allow for a more comprehensive evaluation of long-term training adaptations. Third, a comparative analysis across different sport disciplines would determine the transferability and effectiveness of these training methodologies across athletic contexts. Finally, a larger sample size is recommended in future studies to increase statistical power and confidence in generalizing the results.

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