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RESEARCH ARTICLE

Cluster Method: Effects on Performance in Handball

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Abstract
The aim of this study was to examine the effects of six week traditional and cluster training method applied in female handball players on speed, strength and throwing power. 32 handball players participated in this study. 16 athletes were assigned in the Cluster Training Group (CTG), 16 athletes in the Traditional Training Group (TTG). The training continued for six weeks, three days a week, during the preparation period of the annual training program. Both groups practiced leg extension/flexion, pulldown, butterfly, bench press, deep squat. The CTG performed 80% of repetition maximum (1RM), 4 repetitions with a 20-second rest, total of 12 repetitions and 2 sets. The TTG, on the other hand, performed 80% of 1RM, 12 repetitions, 2-3-minute rest between sets, and again 2 sets. At the beginning and end of the training, 10 and 20 m speed, hand grip strength, standing long jump, vertical jump, throwing speed, squat and bench press performance measurements were recorded. A statistically significant difference was found in the performance values within the group ($p<0.05$). A statistically significant difference was found between groups in the vertical jump and standing long jump ($p<0.05$). There was no statistically significant difference between groups in terms of the other performances ($p>0.05$). As a result, it was seen that the cluster method was effective on the development of the jump force. Considering the difference between cluster and traditional training methods, we can say that the cluster method provides more advantages than the traditional method in branches that require explosive strength.

Keywords
Cluster Training Method, Handball, Strength, Performance

INTRODUCTION

In handball, it is necessary to have a physical effort capacity that can resist violent contacts and short/high-intensity physical actions during trainings and games (**Bragazzi et. al., 2020**). In addition to technical and tactical skills, muscle strength and power (maximal isometric power) cannot be ignored in order to achieve success in both men's and women's handball (**Cherif et. al., 2016; Kohlmeier, 2015**).

Experiencing numerous high-intensity physical actions during the competition requires a high level of strength, which is to be maintained for a long time. Maximal strength, power, speed, endurance, and the Throwing speed are essential factors for success in elite handball (15). Throwing speed is very important in branches such as handball, baseball, throwing speed, and volleyball where overarm shots are dominant (**Andrade et. al., 2016**). The power produced during the shot will also affect the throwing speed. The ability of the player to dispose of the ball is directly related to the speed of the shot (**Debanne & Laffaye, 2013**). However, the strength in the arm should be evaluated not only with the upper extremity, but also with the throwing technique, the harmony of the body parts at this time, and the strength of the lower extremity.

The factors that determine performance in handball are explosive features such as strength, jump (vertical or horizontal), and speed (10 and 20 m sprint time). In handball, performance should be evaluated by measuring variables such as muscle

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strength, speed, and resistance (Marques et. al., 2011; Póvoas et. al., 2014).

The training methods to be applied in the training program play an important role. A plan prepared according to the purpose prevents over-training, provides adaptation, increases the motivation of the athlete, and increases the performance output. In the preparation of the training program, the intensity, frequency, scope, and type of the exercise vary depending on the feature and method to be developed. Newer methods lead to faster improvement in performance, but the more familiar an athlete is with the training, the slower the improvement in performance (Hodges et. al., 2005)

Traditional strength training can be characterized as exercises involving the general physiological adaptation of the body. This adaptation can be examined in two parts as neurological and morphological. Neurologically, it covers neurological factors such as muscle synchronization, motor unit activation, reflex tendons, and corpuscles. Morphologically, it includes changes in muscle size, muscle hypertrophy, muscle fibers, and muscle structure. In traditional strength training, the structure of a set requires performing it in a continuous fashion with no rest between each repetition of the set. In other words, it is the continuous application of repetitions by interrupting them with long rest intervals. In such a set structure, a 10-30 second repetition rest interval is used between each repetition performed (Haff et. al., 2003). As an example, in a set designed based on the classical method, 80% of 1RM training plan can be 6 repetitions, 3 sets, and a 1-2-minute rest between sets.

The variety in training is necessary for the athletes both to get used to their personal tasks more easily and to improve their performance quickly by keeping them away from overloads. Various parameters such as the number of repetitions, the number of sets, and the variety of movements can be used to make variety in training. Making changes in the structure of the set has recently been studied by sports experts. The newest approach to the structure of the set is the Cluster method (CM) method.

In CM, you have a pre-set training intensity and weight load. CM is a technique that emerged to slightly reduce the metabolic fatigue that occurs during traditional “no rest” sets. It is a method in which a set is divided into sets and a short rest interval is performed. In practice, the purpose of short rests (10-30 seconds) between repetitions is to provide efficient rests between repetitions and to ensure that the next repetition gives higher quality results. Due to the rests between repetitions and sets, more power output is achieved with the same load intensity compared to the traditional training method. During strength training, it causes less neuromuscular fatigue than the traditional set method, increases the nervous systems muscle contraction level, and prevents power losses. It has been observed that CM is more effective than RM and there is more strength development especially in vertical jump (McArdle et. al., 2010; Sancez-Moreno et. al., 2016).

Variable rest intervals can be used in the cluster method, or the resistance can be changed in each or several repetitions of the set depending on the purpose. In this method, unlike the traditional method (RM), the aim is to give short rest intervals between loads, to prevent injuries, and to replenish phosphocreatine stores (Cin et. al., 2021).

Creatine phosphate is the main high-energy, phosphate-storage molecule of muscle. In rested muscle, creatine phosphate is the predominant form; its maximal concentration is five times higher than that of ATP (Kohlmeier, 2015). For these reasons it is important to give short rest intervals between loads. When studies conducted so far are examined, effects of the cluster method on these performance parameters in handball has not been researched yet, to the best of our knowledge.

The aim of this study was to examine the effects of a six-week traditional and cluster training method administered in female handball players on speed, strength, and throwing power.

MATERIALS AND METHODS

Study participants

Thirty-two elite female handball players voluntarily participated in this study. Athletes were given detailed information about the study, an "informed consent form" was filled, and their consent was obtained. Research procedures were carried out in accordance with the human research ethical standards of the 2008 Principles of the Declaration of Helsinki. The demographic characteristics of the athletes are given in Table 1.

Table 1. Demographic characteristics of athletes

	CTG			TTG		
Variables	Range		Mean±Std.Dev.	Range		Mean±Std.Dev.
Height (cm)	164	184	173.35±5.66	1.69	1.85	1.74±0.03
Weight (kg)	52	78	64.71±6.54	58	80	67±6.23
Age (year)	20	30	24.21±2.87	18	38	26.20±6.16
Sport age (year)	10	20	13.85±2.74	8	31	15.73±6.76
NationalAthletes	3	75	34.64±20.89	2	150	34.8±41.95

Study organization

In order to minimize the fatigue factor in all the athletes in our study, physical exercise was discouraged for 24 hours before the measurements. A 15-minute general warm-up protocol was just before the study. Standard food and fluid intake was maintained throughout the training. Beverages containing caffeine were prohibited for 4 hours before measurements and no food was consumed 2 hours before. All athletes slept at least 7 hours per night during the training period and verbal encouragement was used for maximum effort throughout the training period. Sixteen athletes were randomly assigned to the CTG and 16 athletes to the TTG. The training continued for six weeks, three days a week, during the preparation period of the annual training program. Both groups practiced leg extension/flexion, pulldown, butterfly, bench press, and deep squat movements. The CTG performed 4 repetitions of 20 seconds rest in 80% of 1RM, totaling 12 repetitions and 2 sets (Table 2). On the other hand, the TTG applied 2 sets of 12 repetitions, resting 2-3 minutes between sets in 80% of 1RM. Data were collected just before and after the 6-week period (10 and 20 m sprint, hand grip strength, standing long jump, vertical jump and speed, squat and bench press).

Table 2. Cluster and traditional training

				Rest	
Group	Intensity	Number of repetitions	Set	Rest between repetitions	Rest between sets
CM	80% of 1 max rep	4x3 (12)	2	20 sec	5 min
TM	80% of 1 max rep	12	2	-	2-3 min

Data collection

The height of the athletes was measured bare feet with a Sega brand height measuring instrument with a sensitivity of 0.01 cm. A Baster brand scale with a precision of 0.1 kg was used for body weight measurement. The 10 m and 20 m speed measurements of the athletes were measured using the Microgate Witty photocell, with a precision of 0.01 second. The start and finish lines were clearly marked with cones. Each athlete completed two runs with a 3-minute rest period between sprints. Each athlete performed two rapid training tests with a rest period of 3 minutes in between. The best performance of the two repeated sprint tests was recorded.

For hand grip strength, right and left hand grip strength was measured using a digital hand dynamometer (CAMRY). The athletes grasped the measuring instrument for 2 seconds while standing, with their arms straight and without touching any part of their body to the dynamometer. Athletes practiced with each hand twice (alternately right and left) and rested for 1 minute between trials and their best values were recorded.

A tape measure was used for standing long jump measurement. The starting line was determined and a 3-m tape measure with 1-cm interval was fixed. The athlete stood without touching the starting line and jumped forward with both legs and the last point of contact with the body was measured from the front of the jump line. The athletes did not cut contact with the ground before jumping during the long jump. Each athlete repeated the jump twice and the best value was recorded. An Optojump Next® device was used for vertical jump measurement (Microgate, Bolzano, Italy). Device installation and data acquisition were carried out in accordance with the manufacturer's recommendations. The athletes were asked to kneel down at the highest possible speed and jump vertically, keeping their hands at the waist, their knees fully extended, and their body in an upright position. Each athlete repeated the movement twice and the best value was recorded.

Throwing speeds were measured with the Speed Sport Radar brand radar instrument. The ball throwing speeds of the handball players were measured by standing behind the 7m line with the dominant (D) arm. The handball players were asked to shoot at the highest speed they could apply, and the best value was recorded by having each athlete perform twice.

Statistical analysis

Regarding the normal distribution assumptions of the 1st and 2nd measurement of the variables, all variables were found to have a normal distribution (p value > α=0.05) and parametric tests were used in the analysis. Statistical properties of the variables, such as mean and standard deviation, according to groups and measurements are presented. Normality assumptions of the variables were examined with the Kolmogorov-Smirnov test. Parametric tests were used since the variables had a normal distribution (p value > α=0.05). The analyses between the 1st measurement and the 2nd measurement within groups were made with the Paired Sample t Test. The analyses of differences between the two measurements and between the groups were made with the Independent Sample t Test. The IBM-SPSS-21 program was used in the analysis of the data.

RESULTS

Table 3. Relationship between CTG and TTG performance values

Variables		CTG			TTG		
		Mean±Std.Dev.		Sig.	Mean±Std.Dev.		Sig.
Left hand grip strength (kg)	M 1	31.575	4.027	0.000*	31.774	3.669	0.000*
	M 2	35.213	3.152		33.956	3.634	
Right hand grip strength (kg)	M 1	34.742	3.986	0.000*	34.273	3.572	0.000*
	M2	39.113	4.341		37.175	3.491	
Vertical jump (cm)	M 1	31.919	4.009	0.000*	30.389	3.579	0.000*
	M 2	36.063	3.494		31.818	3.105	
10 m speed (sec)	M 1	1.933	0.102	0.000*	1.298	0.052	0.012*
	M2	1.859	0.106		1.931	0.055	
20 m speed (sec)	M 1	3.412	0.125	0.023*	3.481	0.1	0.010*
	M 2	3.348	0.159		3.437	0.091	
Standing long jump (m)	M 1	1.892	0.16	0.000*	1.898	0.165	0.546
	M2	2.011	0.106		1.914	0.161	
Throwing speed (km/h)	M 1	67.188	3.692	0.000*	65.625	3.649	0.000*
	M 2	71.375	3.052		67.938	3.821	
Squats (kg)	M 1	144.438	16.967	0.000*	111	17.662	0.000*
	M2	165.831	16.221		126.963	20.778	
Bench press (kg)	M 1	55.056	4.699	0.000*	46.388	5.808	0.000*
	M 2	71.094	7.303		59.056	6.066	

(p value> α=0.05)- M: Measurement

A statistically significant difference was found between M 1 and 2 in left-right hand grip strength, vertical jump, 10m-20m sprint, standing long jump, throwing speed, squat and bench measurement results in both groups (p=0.000 <α= 0.05) (Table 3).

Table 4. Performance values between groups

	Group	Mean±Std.Dev.	Sig.	Difference
Left hand grip strength	CTG	3.638±2.583	0.076	-
	TTG	2.183±1.823		
Right hand grip strength	CTG	4.375±2.253	0.068	-
	TTG	2.902±2.145		
Vertical jump	CTG	4.144±1.756	0.000*	1>2
	TTG	1.429±1.31		
10m speed	CTG	0.074±0.063	0.306	-
	TTG	0.049±0.069		
20m speed	CTG	0.064±0.101	0.514	-
	TTG	0.044±0.061		
Standing long jump	CTG	0.119±0.094	0.007*	1>2
	TTG	0.016±0.105		
Throwing speed	CTG	4.188±2.949	0.053	-
	TTG	2.313±2.272		
Squat	CTG	21.394±8.646	0.048	-
	TTG	15.963±6.03		
Bench press	CTG	16.038±5.336	0.068	-
	TTG	12.669±4.7		

(p value> α=0.05)

According to the differences of the variables between the 1st and 2nd measurements and the results of the independent samples t-test performed between the groups, a statistically significant difference was found between the groups regarding the vertical jump and the standing long jump (p=0.000 <α=0.05, p=0.007 <α=0.05). No statistically significant difference was found between the groups regarding the other performances (p=0.076> α=0.05, p=0.068 > α=0.05, p=0.402 > α=0.05, p=0.306 > α=0.05, p= 0.514 > α=0.05, p=0.053 > α=0.05, p=0.048 < α=0.05, p=0.068 > α=0.05). The differences found were due to the cluster group. The performance difference (vertical jump and standing long jump) between M 1 and 2 of the CTG was more (effective) than that in the TTG (Table 4).

DISCUSSION

In this study, it was determined that CM and RM strength training increased performance in both groups. When the performance differences between the groups were examined, CM was significantly more effective than RM in vertical jump and standing long jump.

Artacho et al. (2018) divided 19 athletes into two groups as CM group and RM group and applied the countermovement jump exercise for 3 weeks. The effects of CM on strength and velocity were examined. As a result of the study, while the CTG showed an increase in both speed and strength performance, there was no statistical difference in the TMG. Cin et al. (2021) conducted a study in elite volleyball players and stated that CMG showed higher significant gains in 1RM strength, sprint time, vertical jump, and agility compared to TMG. Zarezadeh Mehrizi et al. (2013) reported that CM applied in 22 male soccer players for 3 weeks showed higher strength improvements than TM, whereas higher gains were noted in the development of 90° knee flexion in RM. Moreno et al. (2014) emphasized that coaches had their athletes do 2-5 jumps with a 27-45 seconds rest and they argued that this will reduce fatigue and allow more eccentric sequential reloads. Haff et al. (2018) emphasized the importance of the number of sets and repetitions in training as well as rest intervals to achieve the highest efficiency in training, and argued that short rests between repetitions will have a positive effect on performance. In their study, the TMG applied 1 set of 5 repetitions with clean pull exercise and the CMG applied 5 sets of 1 repetition with 30 seconds of rest between sets, and they concluded that the average power outputs were much higher in the CMG. Asadi and Ramirez (Asadi Ramírez-Campillo) examined the effects of plyometric exercises applied 2 days a week for 6 weeks on standing long jump performance. In the study, the CMG applied 5 sets of 10 repetitions, with 30-second rests between repetitions and 90-second rests between sets, whereas the TMG applied 5 sets of 20 repetitions with 2-minute rests between repetitions.

In our study, there was an increase in performance in both training methods applied in bench press and squat exercises, but there was no difference in performance increase between the two methods. Lawton et al. (2006) performed the bench press exercise in their study with 12 basketball players and 14 football players and classified the athletes as TMG and 3 different CMG groups. In the TMG, there was a decrease in strength with each repetition, but there was no significant difference between CMGs. Again, Davies et. al. (2022) examined bench press performance in a study they conducted in 20 trained athletes for six weeks. The CMG performed 6 sets of five repetitions at 85% 1RM, with 30 seconds rest between repetitions, and a 3-minute rest between sets. The GMG performed three sets of five repetitions at 85% 1RM with a 5-minute rest between sets. They found that bench press exercise in CM did not have any muscle performance advantage over TM. Tufano et al. (2016) studied the squat exercise with 20 athletes performing strength training in their acute effect study. They divided the athletes into three groups as traditional, cluster 2, and cluster 4. The athletes applied the traditional method with 3 sets of 12 repetitions with a rest of 120 seconds between sets. Cluster 2 method was applied as 3 sets of 3 repetitions with a 120-second rest between sets. Cluster 4 method was applied with 3 sets of 6 units of 2 repetitions with a 120-second rest between sets and a 30-second rest between repetitions. As a result, cluster 4 performed in two repetitions yielded statistically better results compared TM results; it yielded statistically better results in some parameters compared to cluster 2 results, which was performed in four repetitions. It provided better results in terms of performance compared the rest of the groups.

Oliver et al. (2015) examined the squat exercise in two groups as TM and CM in the study they conducted with 24 students. Students performed TM with 4 sets of 10 repetitions with a rest of 120 seconds between sets. They applied CM with 4 sets of 2 units of 5 repetitions with a 90-second rest between sets and a 30-second rest between repetitions. They stated that CM produced more power than TM.

In another study, Haff et al. (2003) had 8 athletes and 5 weightlifters perform clean pulls. They were divided into three separate groups as traditional, cluster 1, and undulating cluster. The power output performance of the three groups was evaluated. While there was a decrease in power output (peak power) in the traditional setting, Cluster 1 maintained its peak power at each repetition. In the method where the intensity parameter between repetitions changed (Undulating Cluster), power output changed according to the intensity of repetition.

Hansen et al. (2011) applied the squat jump exercise in 20 rugby players. They divided the athletes into four groups as TM, CM 1, CM 2, and CM 3. As a result of the study, it was seen that CMs performed better than TM at the highest power and highest speed values, while CMs with less repetitions were more effective. Latella et al. (2019) stated that acute resistance exercises with CM maximize neuromuscular performance, especially reduce speed and power loss.

Sports scientists argues that changing the traditional set structure by dividing the number of sets more and shortening the rest time between sets will be more effective in the development of quick strength (Bompa, 2017; Haff et. al., 2008). As a result, in this study, it was seen that the Cluster method was effective on the development of jump force and explosive force. Considering the difference between cluster and traditional training methods, it can be concluded that CM provides more advantages than TM in branches that require explosive strength. In maximal strength training in handball, the cluster method has a positive effect on jumping force and explosive force performance and the applicability of this method in handball is supported. Nevertheless, although the benefits of the cluster method are strongly suggested in the literature, we can say that more comprehensive studies are needed by considering the differences in age, sports age, gender, number of groups, and exercises performed in sports branches.

Conflict of interest

The authors declare no conflicts of interest. No financial support has been received.

Ethics Committee

This study was approved by Zonguldak Bülent Ecevit University Non-Interventional Research Ethics Committee on 02.11.2022 with decision number 2022/19.

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Author Contributions

Study Design, SE, NE; Data Collection, SE; Statistical Analysis, NE; Data Interpretation, SE, NE; Manuscript Preparation, SE, NE; Literature Search, SE, NE. The published version of the manuscript has been read and approved by all authors.

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