ORIGINAL ARTICLE

Effects of triphasic training model combined with two different cluster sets on vertical jump and reactive strength index

Selman Kaya[1ABCD], Salih Pınar[2ABD]

[1] *Faculty of Sport Science, Yalova University, Yalova, Turkey*
[2] *Faculty of Sport Science, Fenerbahce University, Istanbul, Turkey*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim This study aims to examine the effects of the Triphasic Training Model (TTM) applied with different set designs (15-30 sec intra-set) on reactive strength index (RSI) and vertical jump values.

Material and Methods Sixteen male athletes over 18 with at least three years of strength training experience (2 days a week) actively engaged in sports participated in the study. The study group was divided into two groups by calculating the relative strengths. The 15-second cluster set (C15) group exercises were performed with 15 seconds of rest between repetitions, and the 30-second cluster-set (C30) group practiced the exercises with 30 seconds of rest between repetitions. The triphasic training model was applied to all study groups for six weeks. Countermovement jump (CMJ) and drop jump tests were performed on the athletes before and after the training. Optojump brand photocell system was used for CMJ and RSI tests. For the RSI test, the desk height was determined as 40cm. Kolmogorov-Smirnov values were examined to assess the homogeneity of the data. To compare the means between groups, ANOVA was used for Repeated Measures, and a t-test was used to compare the pretest-posttest mean of the groups. The statistical significance level was determined as $p<0.05$.

Results After triphasic training, CMJ and RSI values of both C15 and C30 groups increased ($p<0.05$). When the within-group pretest-posttest values were examined, it was seen that the C30 group showed more improvement than the C15 group.

Conclusions As a result, it was seen that the triphasic training model applied twice a week for six weeks improved the CMJ and RSI values of the athletes, and it was more effective to use C30 instead of C15 in the use of cluster sets.

Keywords: triphasic training, cluster set, reactive strength index, vertical jump, power

Introduction

Resistance training, also known as strength or weight training, has become one of the most popular forms of exercise to increase physical fitness for athletes and sedentary individuals [1]. Thus, strength and power parameters have become essential to improving athletic performance. Different training methods (for example, barbells with body weight, barbell, plyometric, eccentric, ballistic, and kettlebell training) can be applied to improve these parameters [2]. Most traditional training models focus on developing explosive strength by emphasizing the concentric phase of the movement. However, the key to improved strength generation and thus sports performance is not just in the concentric phase. Therefore, to develop explosive power, it is necessary to train the eccentric and isometric phases of dynamic movements at a level equal to that of the concentric phase [3].

Recently, two researchers [3] introduced a popular approach called the "triphasic training model" (TTM), which trains the eccentric, isometric, and concentric phases of the movement separately with the block training method. This training model aims to train each contraction phase separately and to increase the power output of the movement that ends in the concentric phase at the optimal level. Thus, it aims to increase the athlete's reactive strength and reveal more explosive strength [3].

Reactive strength is defined as the ability to complete the stretch-shortening cycle (SSC) as quickly as possible, that is, to quickly transition from the eccentric phase to the concentric phase [4]. The ability to improve SSC is typically calculated by the reactive strength index (RSI) [5]. RSI provides valuable information on neuromuscular and SSC function by measuring strength and the time taken to produce strength by dividing the jump height by the ground contact time during the drop jump (DJ) [6, 7, 8]. RSI is a reliable scientific measurement [6] and a practical way of evaluating the training dquality of athletes [9].

When designing a resistance training program, various factors such as exercise selection, training load, number of repetitions and sets, exercise order, frequency, and rest time should be considered to achieve optimum training results. However, one aspect of developing a resistance training

doi:10.15561/20755279.2022.0405

program that has been largely overlooked and underused is the ability to change the structure of sets [10] . Traditional set structures are performed continuously with no rest between reps, resulting in a decreased power output with each rep in the set [11]. Different set strategies such as cluster set (CS) can be utilized during exercise to maximize power outputs, primarily if a higher volume workout is targeted. CS is a set structure in which a short rest interval (15-45 seconds) is applied between repetitions to provide partial recovery and maximize movement speed and strength [10, 11, 12]. Recently, several studies have shown that instead of rest between sets, rest intervals between repetitions (cluster sets) result in lower speed and strength loss throughout the entire training session, improve mechanical performance [13], and allow larger training volume [11, 13, 14, 15] and can reduce accumulated fatigue seen during the traditional set while maximizing repetition performance [10, 11, 12, 16, 17].

A set structure designed with CS includes a short rest period between reps to partially or fully restore short-term energy systems. Today, CS is used for strength and power training that requires high intensity (>80% 1MR). TTM is a model that uses high intensity. Therefore, the benefits of using CS to TTM are a matter of curiosity. It is thought that using CS during training will allow the athletes to perform more repetitions than they can handle two or more times in a row without losing speed and strength production during intense loading stages over 80% of 1RM, such as TTM.

Purpose of the Study. To our knowledge, there is no study in the literature examining the structure of TTM and CS. Therefore, this study investigates the effects of TTM applied with different CS designs (15-30 seconds intra-set) on the reactive strength index and vertical jump values.

Materials and Methods

Participants

Sixteen male athletes over 18 with at least three years of strength training experience (2 days a week) actively engaged in sports participated in the study. The G Power [18] program was used to determine the sample group. In addition, before the study, the ability of all participants included in the study to perform back squat and deadlift exercises with an appropriate technique was evaluated by functional movement screen (FMS) [19]. Participants who met the prerequisite of getting 3 points from this test battery were included in the study. Athletes were asked not to participate in daily training programs 24 hours before the test. Tests were completed on two consecutive days in the same laboratory for all participants. The study group reported no chronic illness or a recent injury that could compromise testing procedures. All athletes were briefed on the testing procedures and signed a written informed consent form before starting the study. The study complied with the Declaration of Helsinki and was approved by the Marmara University Non-Interventional Clinical Research Ethics Committee (Protocol No: 09.2020.730). The demographic characteristics of the participants are given in Table 1.

Research Design

This study was evaluated as an intervention training and added to the participants' ongoing training program. Since the study group is selected from the same team, there is no difference between the training programs. At the beginning of the study, the back squat and deadlift one maximum repetitions (1RM) of each participant were taken. The study design is given in Figure 1. Then, the relative strengths of the participants for both strength tests were calculated separately. Next, both groups applied the triphasic training model with two different set-set models: The First Group (n=8) worked by resting for 15 seconds between repetitions (C15), and the Second Group (n=8) completed the training by using a 30-second cluster set (C30) between repetitions. To keep the training coverage equal between the groups, 4 minutes of rest were given in C15 and 3 minutes between sets in C30. The

Table 1. Demographic characteristics of the participants

Characteristics	$\overline{X}$	Sd	Min	Max	Median	Mod	Range
Age	20.93	5.54	18.00	40.00	19.00	18.00	22.00
Height (cm)	176.50	7.28	163.00	187.00	176.00	176.00	24.00
Body mass (kg)	87.24	18.66	60.00	120.00	83.50	76.00	60.00
BMI (kg/m2)	27.73	4.11	21.77	37.04	26.89	21.77	4.00
Training experience (years)	5.25	2.79	4.00	15.00	4.00	4.00	11.00

BMI=body mass index; Cm: centimetre; Kg: kilogram; Min: minimum; Max: maximum; Sd: standart deviation triphasic training model consists of 3 phases. Each of these phases was carried out in the following order according to the protocol determined by Dietz and Peterson [3]: Eccentric (6sec), Isometric (3sec), and Concentric (Explosive) sequences were applied for two weeks each. Eccentric and isometric phases were used two days a week (Monday-Friday), while the concentric phase was applied three days a week (Monday, Wednesday, and Friday). An assistant was kept with the athletes during the application for security purposes. The training program applied to the athletes is given in Figure 2.

Movement Tempo

Each of the four exercise-related numbers in the training program indicates how long, in seconds, the particular "phase" (eccentric, isometric, concentric, and rest time between reps) must be performed. For example, a back squat might be at the following tempo: 6:0:0:0. The first number (6) represents the duration of the eccentric phase of the movement. The second number (0) represents the isometric phase duration. The third number (0) represents the concentric phase time. Finally, the last number (0) describes how many reps to give a rest (cluster set) [3]. An intermittently beating metronome (Metronomo Batidas, Stonekick) was used to time each stage of the movement.

Measurements

One Maximum Repetitions (1RM) Back Squat-Deadlift Test

The maximum load of the Back squat and Deadlift exercise (1MR) was determined using the procedure outlined by Baechle and Earle [20]. As a warm-up for both exercises before 1MR measurement, athletes worked out with (a) 10 reps at 20 kg, (b) 5 repetitions with an estimated 50% 1MR, (c) 3 reps with an estimated 75% 1MR, (d) 1 rep at an estimated 90% 1MR to achieve maximum effort four sets of back

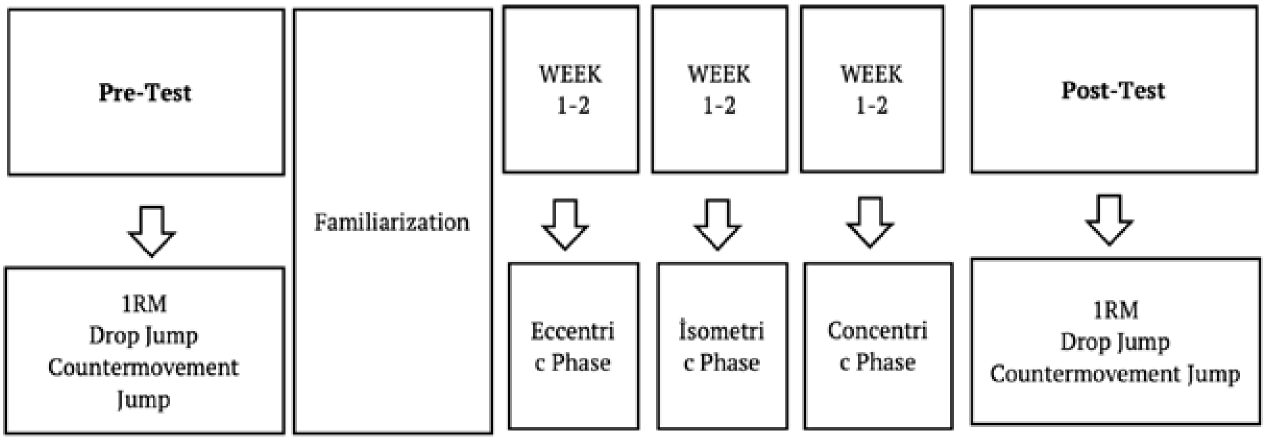

Figure 1. Study Design

EXCENTRIC PHASE (Week 1-2)					ISOMETRIC PHASE (WEEK 3-4)					CONCENTRIC PHASE (WEEK 5-6)				
DAY	LOAD	SEC	REPS	SET	DAY	LOAD	SEC	REPS	SET	DAY	LOAD	SEC	REPS	SET
MON	82-87%	5-6	1-3	3-4	MON	82-87%	2-3	1-3	4-5	MON	82-87%	Explosive	2-3	3-4
FRI	75-80%	6-7	2-4	3-4	FRI	75-80%	3-4	3-4	4-5	WED	90-97%	Explosive	1	1-4
										FRI	75-80%	Explosive	3-4	3-5
LOADING AND REST TIMES FOR THE ECCENTRIC PHASE					LOADING AND REST TIMES FOR THE ISOMETRIC PHASE					LOADING AND REST TIMES FOR THE CONCENTRIC PHASE				
C15			C30		C15			C30		C15			C30	
6.0.0.1			6.0.0.1		0.3.0.1			0.3.0.1		0.0.0.1			0.0.0.1	

Figure 2. 6-Week Triphasic Training Program [3]

squats and deadlift exercise. The estimated 1MR values of the athletes before participating in this study were used to determine the workload. The athletes then attempted an estimated 100% 1MR for both exercises, and the load was increased by 5-10 kg until unsuccessful. 1MR was determined with a maximum of 6 trials. A 5-minute rest was given between trials.

Drop Jump Test

Before starting the measurement, the test protocol was explained to the participants. A 10-minute warm-up program was applied before the measurement. Then, each participant performed three jumps from 40 cm high crates with hands on hips and elbows bent outward (Akimbo pose). A 30-second recovery was given between each trial [21]. Trials in which the technique deteriorated significantly were excluded and repeated. Contact time, air retention time, and jump height were recorded with the Optojump photocell system (Microgate, Bolzano, Italy). Participants were asked to fall with their right foot before the counter to prevent them from jumping off the platform with both feet. Athletes were instructed to "jump as high as possible by minimizing contact time (depreciation + take-off) after ground contact." RSI was calculated by dividing the jump height (mm) by the contact time (ms) [22].

Countermovement Jump

To familiarize the participants with the CMJ technique, they performed as many trials (ranging from 4 to 7) as necessary in the first test session. Participants stood still with their hands akimbo until the CMJ was given a verbal command. Participants were instructed to minimize the transition between descending and ascending stages and to jump as fast and high as possible. Participants were free to choose the depth of the movement. They were also instructed not to make any movements during the flight. All participants performed three trials. One minute was given between trials [23]. The jump heights of the participants were recorded with the Optojump photocell system (Microgate, Bolzano, Italy).

Statistical Analysis

The data set collected under the sub-problems of the research was recorded in the electronic environment. In the analysis part of the data obtained, Skewness and Kurtosis values and Kolmogorov-Smirnov values were examined to determine the homogeneity. To compare the means between groups, ANOVA was used for Repeated Measures, and a t-test was used to compare the pre test-post test mean of the groups. The statistical significance level was determined as $p<0.05$. In addition, ANOVA was used for Repeated Measurements to compare the pre-post test means between the groups, and the Sample t-test was used to compare the intra-group pre-post test means. Statistical analyses were performed using the SPSS 26.0 [24] package program. The effect size of the study was determined as 0.50, power of 0.80 and a margin of error of 0.05.

Results

When Table 2 is examined, it is seen that there is a significant difference between the CMJ ($P<0,05$) and RSI ($P<0,05$) pre- and post test values of the athletes participating in 2 different resting protocols. When Table 3 is examined, there is a statistically significant difference between the pre test-post test CMJ results of both groups ($p<0.05$). When the pre test-post test results of the groups are analyzed as percentage improvement, it is seen that the C30 group showed more improvement (11-8%) than the C15 group. When Table 4 is examined, there is a statistically significant difference between the pre test-post test RSI results of both groups ($p<0.05$). When the pre test-post test results of the groups were analyzed as percentage improvement, it was seen that the C30 group showed more improvement (11-8%) than the C15 group.

Table 2. ANOVA results for repeat measurements regarding the difference between intergroup CMJ and RSI pre-post test values

Measurement	Group	Pre-test (X̄ ± Ss)	Post-test (X̄ ± Ss)	F	p	η2
CMJ (cm)	C15	40.26 ± 9.76	43.98 ± 9.43	7.838	**.014***	0.35
	C30	39.75 ± 3.30	45.03 ± 2.44			
RSI	C15	1.20 ± .292	1.30 ± .227	5.832	**.030***	0.29
	C30	1.27± .227	1,44± .124			

C15: cluster 15sn. intra-set; C30: cluster 15sn. intra-set; CMJ: countermovement jump; RSI: reactive strength index; Cm: centimetre; *Statistically significant differences ($P< 0.05$).

Table 3. T-test results regarding the difference between within-group pre-post test CMJ values

Group	Measurement	X̄ ± Ss	t	Improvement %	p
C15	Pre-test	40.26 ± 9.76	-18.012	%8	**.000***
	Post-test	43.98 ± 9.43			
C30	Pre-test	39.75 ± 3.30	-10.200	%11	**.000***
	Post-test	45.03 ± 2.44			

C15: cluster 15sn. intra-set; C30: cluster 15sn. intra-set; *Statistically significant differences (P< 0.05).

Table 4. T-test results regarding the difference between within-group pre-post test RSI values

Group	Measurement	X̄ ± Ss	t	Improvement %	p
C15	Pre-test	1,20 ± .292	-3.666	%8	**.008***
	Post-test	1.30 ± .227			
C30	Pre-test	1.27 ± .144	15.506	%11	**.000***
	Post-test	1.44 ± .124			

C15: cluster 15sn. intra-set; C30: cluster 15sn. intra-set; *Statistically significant differences (P< 0.05).

Discussion

This study examines the effects of TTM applied with different CS designs on vertical jump and reactive strength index. In particular, it aims to compare the effects of different rest intervals between repetitions (15sec-30sec) on CMJ and RSI values using the triphasic training model. When the study findings were examined, it was observed that 6-week TTM applied with different rest periods improved both CMJ and RSI values of both groups.

The basis of this development is thought to be the nature of triphasic training, especially the training of the eccentric and isometric phases separately. Because in relation to the eccentric phase, SSC is responsible for the absorption of kinetic energy within the muscle and tendon. Elasticity means that a structure is able to resume its normal shape (length) after being distorted (lengthened). When a muscle and its attached tendon are stretched, elastic energy is stored within these two structures for later use in the concentric phase. An athlete needs a fast-growing, transitional, isometric contraction to maximize this energy transfer channel. Any delay between the eccentric and concentric phases will cause a loss of energy in the ESC as this energy store begins to dissipate as heat as soon as it is absorbed. For this reason, power and strength may increase by transitioning from the isometric phase to the concentric phase without any loss in the amount of energy stored during the eccentric contraction [3]. In one of the rare studies conducted with TTM, Russell and Brooks [25] studied the effects of TTM and plyometric training on CMJ and 1MR values in their study with seven basketball players. As a result of the study, they reported that six weeks of TTM and plyometric training did not increase the vertical jump values of the athletes. Previously, researchers have reported a reduction in concentric contraction times during strength exercises involving the ESC compared to concentric exercises alone [26, 27, 28]. However, some authors recently reported that additional eccentric training increased the RSI and CMJ values [26, 27]. These results are consistent with the results of our study.

When the within-group pretest-posttest CMJ values were examined, it was observed that the C30 (30sec rest between repetitions) group showed more improvement than the C15 (15sec rest between repetitions) group (11-8%). Similarly, TTM increased the RSI values of both groups. However, when the within-group RSI pretest-posttest values were examined, a higher increase was observed in the C30 group compared to the C15 group (11-8%). The reason why the C30 group increased more than the C15 group for both parameters is that the C30 group had a more extended rest period between repetitions compared to the C15 group.

A common strategy to control acutely developing fatigue is to provide the athlete with rest between repetitions [29]. It has been demonstrated in previous studies that the CS method is an effective method for providing speed and power adaptations against a specific load [14, 17, 30, 31, 32]. Acutely, such a method allows the athlete to have consistently higher power outputs while subjecting to less metabolic stress and fatigue [29, 33]. Our literature review did not find any studies examining the effect of TTM and intra-set rest intervals. However, the impact of intra-set rest intervals on performance has been investigated in different studies. Wetmore et al. [34] and Tufano et al. [35], in their study comparing TS and CS, reported that CS set structure will produce higher Peak Power, Average Power outputs, and movement speeds compared to TS. Because of its effect on power, CS can be said to be a valuable tool for increasing power, especially in the later stages of a sequential training plan that emphasizes power generation [36, 37]. Again, Hansen et al. [30] compared the effects of TS and three different CS structures on movement speed, strength, and power. As a result of the study, it has been reported that using CS instead of 6 repetitions of TS can reduce power and movement speed decreases throughout the set. In another study [38], the mechanical and metabolic responses between two different TS (TR1: 3x10 repetitions without rest, TR2: 5x6 repetitions without rest) and three different CS (CS5: 5sec between repetitions, CS10: 10sec between repetitions, CS15: 15sec rest between repetitions and 3x10 repetitions) designs in bench press exercise performed with 10MR load were compared. As a result of the study, TR1 and CS5 were reported as the two set designs with the highest speed loss. However, it was observed that there was no significant difference in speed loss in TR2, CS10, and CS15 set designs. When the speed loss between the three CS designs was examined, it was reported that a more significant speed loss occurred for the CS5 compared to the CS10 and CS15. Oliver et al. [39] compared the kinetic and kinematic (Strength, Speed, Power) structures of TS (4x10 reps; rest between sets 120sec) and CS (4 sets of 2x5 reps; 30sec rest between reps, 90sec rest between sets) during back squat exercise in men. The findings showed that using CS positively affected movement speed, power output, and overall volume.

Previous studies have shown that more frequent rest intervals during exercises that begin with eccentric muscle movements, use the lengthening-shortening cycle, and end with concentric muscle movements can preserve power output [11, 15, 39, 40, 41]. For example, Moreno et al. [40] examined the effects of 3 different cluster-set designs on power output during plyometric squats. Set designs were created as TS (2 sets of 10 reps; 90 seconds rest between sets), CS1 (4 sets of 5 reps; 30sec rest between sets), and CS2 (10 sets of 2 reps; 10sec rest between sets). The results showed that using a set helps maintain power output over a traditional set. Among the set designs, it has been reported that CS2 is the set structure that allows recovery the most. Hardee et al. [11] showed that Peak Power is better preserved when more extended rest periods are used in three different set designs (rest between repetitions: 0-20-40 sec) consisting of 3 sets of 6-rep power clean exercises performed with 80% of 1MR with a load. In this study, the triphasic training model, which considers the phases (eccentric, isometric, concentric) separately, and the cluster set and the traditional set were compared, and it was seen that it was consistent with the previous studies with traditional training models suggesting that using CS can increase power output.

Conclusions

As a result, the use of set sets with a predetermined number of repetitive intra-set rests (e.g., 30-45 s) may provide the most benefit during the strength or power phases of the training [33]. In addition, it can provide movement quality, which can be critical, especially in movements that require skill (for example, weightlifting) with less fatigue that occurs with the use of sets [11]. Thus, CS designs may be a practical resistance training approach that can be considered for use at various stages of periodic programs [33]. In this study, TTM combined with CS structure effectively increased CMJ and RSI values. In addition, it has been shown that applying the rest intervals between repetitions of 30 seconds instead of 15 seconds in the set used in the triphasic training model can provide a more significant stimulus for CMJ and RSI gains. Therefore, according to the outputs of this study, it is recommended that the trainers applying the triphasic training model should use cluster sets and a 30-second rest interval between repetitions in the cluster set. However, due to the insufficient number of studies on TTM, it is recommended to conduct more studies on this subject.

Conflict of interest

The authors declare no conflict of interest.

References

1. Fleck S, Kraemer WJ. *Designing Resistance Training Programs*. Fourth ed: Human Kinetics, United State.; 2014.
2. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The Importance of Muscular Strength: Training Considerations. *Sports Medicine*. 2018;48(4):765–85. https://doi.org/10.1007/s40279-018-0862-z
3. Dietz C, Peterson B. *Triphasic training: A systematic approach to elite speed and explosive strength performance.* Bye Dietz Sport Enterprise; 2012.
4. Suchomel TJ, Sole CJ, Stone MH. Comparison of Methods That Assess Lower-body Stretch-Shortening Cycle Utilization. *J Strength Cond Res*. 2016;30(2):547–54. https://doi.org/10.1519/jsc.0000000000001100
5. McMahon JJ, Suchomel TJ, Lake JP, Comfort P. Relationship Between Reactive Strength Index Variants in Rugby League Players. *J Strength Cond Res*. 2021;35(1):280–5. https://doi.org/10.1519/jsc.0000000000002462
6. Byrne PJ, Moody JA, Cooper SM, Kinsella S. Acute Effects of 'Composite' Training on Neuromuscular and Fast Stretch-Shortening Cycle Drop Jump Performance in Hurling Players. *Journal of Strength and Conditioning Research*. 2021;35(12): 3474–3481. https://doi.org/10.1519/JSC.0000000000003327
7. Wilson GJ, Wood GA, Elliott BC. Optimal stiffness of series elastic component in a stretch-shorten cycle activity. *J Appl Physiol*. 1991;70(2):825-33. https://doi.org/10.1152/jappl.1991.70.2.825
8. Lehnert M, Croix MDS, Xaverova Z, Botek M, Varekova R, Zaatar A, et al. Changes in Injury Risk Mechanisms After Soccer-Specific Fatigue in Male Youth Soccer Players. *Journal of Human Kinetics*. 2018;62(1): 33–42. https://doi.org/10.1515/hukin-2017-0157
9. McClymont D, Hore A, editors. Use of the reactive strength index (RSI) as an indicator of plyometric training conditions. *Science and Football V: The proceedings of the fifth World Congress on Sports Science and Football*. Lisbon: Portugal; 2003.
10. Haff GG, Hobbs RT, Haff EE, Sands WA, Pierce KC, Stone MH. Cluster Training: A Novel Method for Introducing Training Program Variation. *Strength & Conditioning Journal*. 2008;30(1): 67–76. https://doi.org/10.1519/SSC.0b013e31816383e1
11. Hardee JP, Triplett NT, Utter AC, Zwetsloot KA, McBride JM. Effect of interrepetition rest on power output in the power clean. *J Strength Cond Res*. 2012;26(4):883–9. https://doi.org/10.1519/JSC.0b013e3182474370
12. Haff GG, Burgess S, Stone MH. Cluster training: theoretical and practical applications for the strength and conditioning professional. *Prof Strength Cond*. 2008;12:12–7.
13. Denton J, Cronin JB. Kinematic, Kinetic, and Blood Lactate Profiles of Continuous and Intraset Rest Loading Schemes. *The Journal of Strength and Conditioning Research*. 2006;20(3): 528. https://doi.org/10.1519/18135.1
14. Davies TB, Tran DL, Hogan CM, Haff GG, Latella C. Chronic Effects of Altering Resistance Training Set Configurations Using Cluster Sets: A Systematic Review and Meta-Analysis. *Sports Medicine*. 2021;51(4): 707–736. https://doi.org/10.1007/s40279-020-01408-3
15. Tufano JJ, Halaj M, Kampmiller T, Novosad A, Buzgo G. Cluster sets vs. traditional sets: Levelling out the playing field using a power-based threshold. *Plos One*. 2018;13(11): e0208035. https://doi.org/10.1371/journal.pone.0208035
16. Girman JC, Jones MT, Matthews TD, Wood RJ. Acute effects of a cluster-set protocol on hormonal, metabolic and performance measures in resistance-trained males. *Eur J Sport Sci*. 2014;14(2):151–9. https://doi.org/10.1080/17461391.2013.775351
17. Jukic I, Tufano JJ. Shorter but More Frequent Rest Periods: No Effect on Velocity and Power Compared to Traditional Sets not Performed to Failure. *Journal of Human Kinetics*. 2019;66(1): 257–268. https://doi.org/10.2478/hukin-2018-0070
18. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*. 2009;41(4):1149–60. https://doi.org/10.3758/BRM.41.4.1149
19. Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement screening: the use of fundamental movements as an assessment of function-part 1. *International Journal of Sports Physical Therapy*. 2014;9(3):396.
20. Baechle TR, Earle RW. *Essentials of strength training and conditioning*: Human kinetics; 2008.
21. Bobbert MF, Huijing PA, van Ingen Schenau GJ. Drop jumping. I. The influence of jumping technique on the biomechanics of jumping. *Med Sci Sports Exerc*. 1987;19(4):332–8. https://doi.org/10.1249/00005768-198708000-00003
22. Young W. Laboratory strength assessment of athletes. *New Studies in Athletics*. 1995;10:89–95.
23. Souza AA, Bottaro M, Rocha VA, Lage V, Tufano JJ, Vieira A. Reliability and Test-Retest Agreement of Mechanical Variables Obtained During Countermovement Jump. *Int J Exerc Sci*. 2020;13(4):6–17.
24. IBM Corp. *Released 2019. IBM SPSS Statistics for Windows, Version 26.0.* Armonk, NY: IBM Corp. NY; 2019.
25. Russell JL, Brooks KA, editors. Effects of a Triphasic Block Method on Power in Collegiate Basketball Players. *International Journal of Exercise Science: Conference Proceedings*, 2013;2(5): 74.
26. Cronin J, McNair PJ, Marshall RN. Developing explosive power: a comparison of technique and training. *J Sci Med Sport*. 2001;4(1):59–70. https://doi.org/10.1016/s1440-2440(01)80008-6
27. Jimenez-Reyes P, Sarnozino P, Garcia-Ramos A, Cuadrado-Penafiel V, Brughelli M, Morin JB. Relationship between vertical and horizontal force-velocity-power profiles in various sports and levels of practice. *Peerj*. 2018;6: e5937. https://doi.org/10.7717/peerj.5937

28. Newton RU, Murphy AJ, Humphries BJ, Wilson GJ, Kraemer WJ, Häkkinen K. Influence of load and stretch shortening cycle on the kinematics, kinetics and muscle activation that occurs during explosive upper-body movements. *Eur J Appl Physiol Occup Physiol*. 1997;75(4):333–42. https://doi.org/10.1007/s004210050169
29. González-Hernández JM, García-Ramos A, Castaño-Zambudio A, Capelo-Ramírez F, Marquez G, Boullosa D, et al. Mechanical, Metabolic, and Perceptual Acute Responses to Different Set Configurations in Full Squat. *J Strength Cond Res*. 2020;34(6):1581–90. https://doi.org/10.1519/jsc.0000000000002117
30. Hansen KT, Cronin JB, Pickering SL, Newton MJ. Does cluster loading enhance lower body power development in preseason preparation of elite rugby union players? *J Strength Cond Res*. 2011;25(8):2118-26. https://doi.org/10.1519/JSC.0b013e318220b6a3
31. Latella C, Peddle-McIntyre C, Marcotte L, Steele J, Kendall K, Fairman CM. Strengthening the Case for Cluster Set Resistance Training in Aged and Clinical Settings: Emerging Evidence, Proposed Benefits and Suggestions. *Sports Medicine*. 2021;51(7):1335–1351. https://doi.org/10.1007/s40279-021-01455-4
32. Tufano JJ, Conlon JA, Nimphius S, Brown LE, Seitz LB, Williamson BD, et al. Maintenance of Velocity and Power With Cluster Sets During High-Volume Back Squats. *Int J Sports Physiol Perform*. 2016;11(7):885–92. https://doi.org/10.1123/ijspp.2015-0602
33. Asadi A, Ramírez-Campillo R. Effects of cluster vs. traditional plyometric training sets on maximal-intensity exercise performance. *Medicina (Kaunas)*. 2016;52(1):41–5. https://doi.org/10.1016/j.medici.2016.01.001
34. Wetmore AB, Wagle JP, Sams ML, Taber CB, DeWeese BH, Sato K, et al. Cluster Set Loading in the Back Squat: Kinetic and Kinematic Implications. *J Strength Cond Res*. 2019;33 Suppl 1:S19–s25. https://doi.org/10.1519/jsc.0000000000002972
35. Tufano JJ, Conlon JA, Nimphius S, Brown LE, Banyard HG, Williamson BD, et al. Cluster Sets: Permitting Greater Mechanical Stress Without Decreasing Relative Velocity. *Int J Sports Physiol Perform*. 2017;12(4):463–9. https://doi.org/10.1123/ijspp.2015-0738
36. DeWeese BH, Hornsby G, Stone M, Stone MH. The training process: Planning for strength–power training in track and field. Part 2: Practical and applied aspects. *Journal of Sport and Health Science*. 2015;4(4):318–24. https://doi.org/https://doi.org/10.1016/j.jshs.2015.07.002
37. Stone MH, Stone M, Sands WA. *Principles and practice of resistance training*: Human Kinetics; 2007. https://doi.org/10.5040/9781492596875
38. García-Ramos A, González-Hernández JM, Baños-Pelegrín E, Castaño-Zambudio A, Capelo-Ramírez F, Boullosa D, et al. Mechanical and Metabolic Responses to Traditional and Cluster Set Configurations in the Bench Press Exercise. *J Strength Cond Res*. 2020;34(3):663–70. https://doi.org/10.1519/jsc.0000000000002301
39. Banyard HG, Nosaka K, Vernon AD, Haff GG. The Reliability of Individualized Load-Velocity Profiles. *International Journal of Sports Physiology and Performance*. 2018;13(6): 763–769. https://doi.org/10.1123/ijspp.2017-0610
40. Moreno SD, Brown LE, Coburn JW, Judelson DA. Effect of cluster sets on plyometric jump power. *J Strength Cond Res*. 2014;28(9):2424–8. https://doi.org/10.1519/jsc.0000000000000585
41. Aminaei M, Yazdani S, Amirseyfaddini M. Effects of plyometric and cluster resistance training on explosive power and maximum strength in karate players. *International Journal of Applied Exercise Physiology*. 2017;6(2):34–44. https://doi.org/https://doi.org/10.22631/ijaep.v6i2.142

Information about the authors:

Selman Kaya; (Corresponding Author); https://orcid.org/0000-0002-2185-6436; selman.kaya@yalova.edu.tr; Faculty of Sport Science, Yalova University; Yalova, Turkey.

Salih Pınar; https://orcid.org/0000-0001-8399-7835; salih.pinar@fbu.edu.tr; Faculty of Sport Science, Fenerbahce University; Istanbul, Turkey.

Cite this article as:
Kaya S, Pınar S. Effects of triphasic training model combined with two different cluster sets on vertical jump and reactive strength index. *Physical Education of Students,* 2022;26(4):199–206.
https://doi.org/10.15561/20755279.2022.0405

Received: 17.07.2022

Accepted: 19.08.2022; **Published**: 30.08.2022