

Using cluster set configurations within a resistance training programme

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ABSTRACT

Altering the configuration of a training set can add a unique training variation to a resistance training programme. Cluster sets can be used by strength and conditioning (S&C) professionals to modify the internal and external training loads that impact the training adaptations that result from resistance training. The purpose of this review is to provide the theoretical foundation for the use of cluster sets within resistance training programmes and to offer practical examples of how to implement cluster sets as part of a periodised training plan.

responses across a series of sets.^{34,35,61,91} To effectively design resistance training programmes using a cluster set configuration, S&C professionals need to understand how to modify training factors to maximise the potential benefit of the cluster set and how to align the cluster set with the overall goal(s) of the phase of training.

As such, the aim of this brief review is to provide the theoretical foundation for the use of cluster set configurations within resistance training programmes. We will first define key terminologies typically used within the scientific literature examining cluster set configurations. We will then present information regarding how to programme cluster sets. In addition, practical examples of how to implement cluster sets into a periodised training plan will also be presented.

Introduction

Resistance training is a well-established method for enhancing muscular strength,⁹⁵ a key physical quality that underpins several athletic performance tasks such as sprinting,^{13,55} jumping,⁹⁵ and change of direction.^{41,51,63} Resistance training can develop muscle, tendon, bone and cartilage, making an athlete less vulnerable to injury, and enhance quality of life.⁵⁴ Historically, performing repetitions until muscular failure was considered to be a requirement for maximising muscle hypertrophy and enhancing maximal strength.⁸¹ However, based upon recent research, resistance training protocols that are not performed to repetition failure have been reported to result in greater maximal strength gains,^{37,45} muscle hypertrophy,⁶ and improvements in performance tasks,^{7,45} with less exercise-induced fatigue.^{17,19,59,70} when compared

with resistance training performed to failure. Based upon these studies, therefore, resistance training that requires repetition failure may be unnecessary, with alternative strategies considered when constructing resistance training programmes.

Modulating training factors such as intensity, volume, duration of the inter-set rest interval (ie, rest between sets), type of exercise, and the exercise order can allow for the training stimulus to be individualised and provide the athlete with an appropriately varied training stimulus that targets specific training outcomes.^{53,73} One of the training variations that has recently gained in popularity is the modification of the set configuration.⁴⁹ Several authors have reported that cluster sets can be used as an alternative way to construct a set configuration and to alter the acute performance and physiological

Traditional sets

Traditionally, during a set of resistance exercise, repetitions are performed in a continuous manner (ie, no inter-repetition or intra-set rest) with a predetermined rest interval between sets (see Figure 1A).^{49,89} This set configuration is repeated until the number of prescribed sets for the given exercise have been completed.⁸⁹ When repetitions are performed using a traditional set configuration, muscular fatigue occurs and can be represented

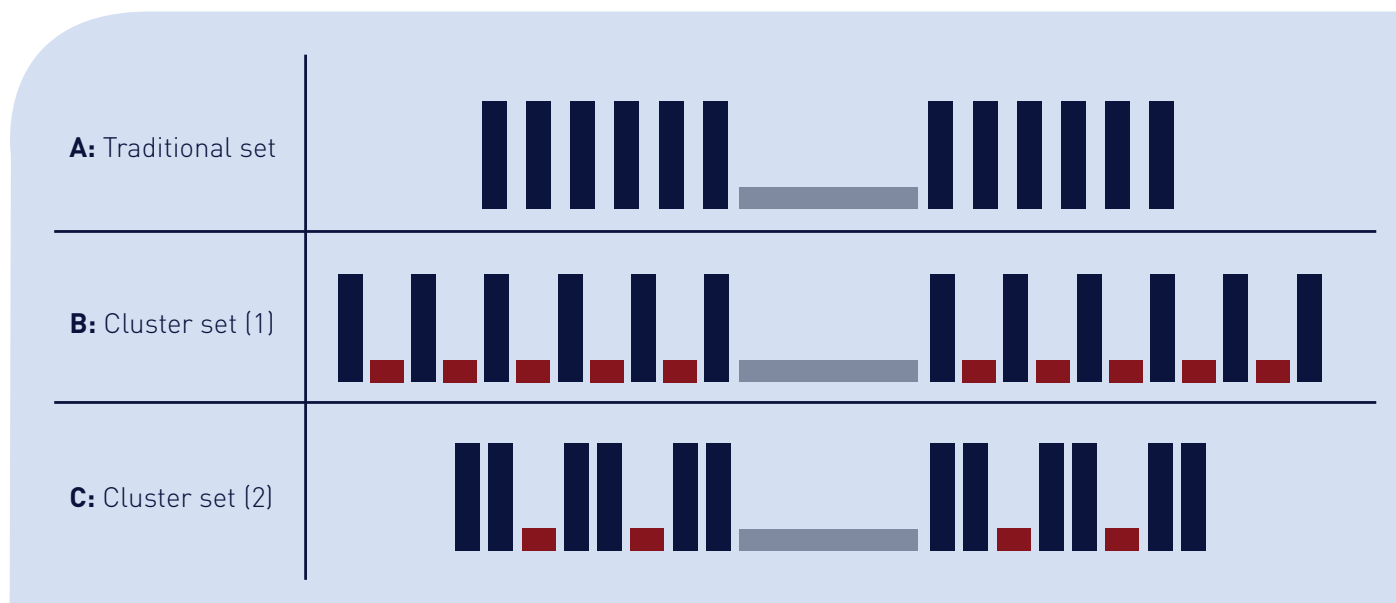


Figure 1. (top) Two sets of six repetitions with three different set configurations.

Figure 2. (bottom) Fundamental differences between several set configurations.

Note: Dark blue bars indicate repetitions performed in a set, red quadrilateral shapes indicate inter-repetition or intra-set rest intervals, and light blue quadrilateral shapes indicate inter-set rest intervals

Type of set	Graphic description	Inter-set rest (s)	Inter repetition rest (s)	Total rest (s)	Loading pattern
Traditional set		180	0	180	Constant
Standard cluster set		180	0	420	Constant
Undulating cluster set		180	30	420	Change
Ascending cluster set		180	30	420	Change
Rest redistribution (1)		100	10	180	Constant
Rest redistribution (2)		20	0	180	Constant

as a reduction in movement velocity or power output across the set.^{31,35,67,91} For example, Gorostiaga and colleagues²¹⁻²³ have reported that when performing the leg press with three sets of 10 repetition maximum (RM) there were reductions in power output during each set (ie, 35-45%). In these studies, the reduction in power output likely resulted from a decline in movement velocity, as force production would not have changed during exercise due to the use of consistent loads throughout each set.⁹¹ Gorostiaga and colleagues have also reported that the reductions in movement velocity during a series of leg press sets were accompanied by decreased ATP and PCr availability. Greater lactate accumulation and decreased pH was also noted when

performing sets to volitional failure, both of which may be related to the noted reductions in movement velocity.^{12,76} Therefore, when performing repetitions in a continuous fashion, muscular fatigue can manifest as a reduction in movement velocity that occurs toward the end of the set because of changes in several bio-chemical substances and processes within the activated muscles.

It is well documented that resistance training using traditional sets with high volumes results in reductions in movement velocity and significant metabolic disruptions, when performed with repetition maximum loads.^{21-23,67} Traditional sets may be a useful part of an athlete's training programme, especially when targeting the

maximisation of muscle hypertrophy and/or strength gains. Based upon previously published studies, resistance training with traditional sets increases blood lactate and serum growth hormone concentrations,^{14,66} as well as muscle activation, as indicated by an increase in electromyography (EMG) activity toward the end of each set.^{48,58,68} Historically, these metabolic and hormonal responses have been considered to be important factors that underpin muscle hypertrophy,⁷⁷⁻⁷⁹ and increased muscle activation has been considered to be essential for maximal strength development.⁵² However, although it seems that resistance training using traditional sets is an effective programming strategy when targeting muscle hypertrophy and the

development of maximal strength, not all researchers agree with this argument.^{61,65,74,96}

Although traditional sets are well-suited for stimulating muscle hypertrophy and developing maximal strength,^{27,29} they may not be the best set configuration when attempting to maximise rapid force-generating capacities. From a biomechanical standpoint, the magnitude of force applied to a constant mass with respect to time, which is termed impulse, dictates the change in velocity of the object to which the force is applied.^{20,94} With this in mind, large impulses can be achieved by applying either low forces for long periods or high forces for brief periods.²⁰ When performing resistance exercises that require large impulses to be produced for brief periods (eg, second pull during weightlifting movements and their derivatives), a high rate of force application is required to maximise the velocity of the object (barbell) within the required time epoch. This emphasises the importance of movement velocity during resistance exercise, as maintaining movement velocity across a set of resistance exercise theoretically would be indicative of a maintenance of rapid force applications. Therefore, an alternative set configuration may need to be considered to allow for the maintenance of movement velocity during every repetition contained within the set of resistance exercise, especially when implementing weightlifting movements or their derivatives that require a high rate of force application as part of an athlete's resistance training programme.

Defining key terminologies

INTER-REPETITION REST

An inter-repetition rest interval can be defined as the rest interval placed between individual repetitions within the cluster set.⁸⁹ For example, when two sets of six repetitions are performed in a cluster set format using the inter-repetition rest, the six repetitions in each set are performed with rest intervals between each individual repetition (Figure 1B).

INTER-SET REST AND INTRA-SET REST

An inter-set rest interval and an intra-set rest interval are occasionally used incorrectly in the scientific literature.⁴⁴

It is therefore important to appropriately define these terminologies. Tufano and colleagues⁸⁹ defined an inter-set rest interval as the rest interval between sets, while an intra-set rest interval was defined as the rest interval between groups of repetitions within the cluster set. For example, when two sets of six repetitions are performed in a cluster set format, six repetitions in each set can be broken into three clusters of two repetitions with intra-set rest intervals between each pair of repetitions (Figure 1C).

STANDARD CLUSTER SETS

To the best of the authors' knowledge, the first documented proposal of an alternative set configuration is an article by Peary Rader, published in *Iron Man* magazine in 1952.⁷¹ The author reported that using the rest-pause method, in which repetitions are performed with 8-10 second rest intervals placed between each individual repetition or group of repetitions, allowed for higher training loads to be used without accumulating excessive fatigue during a set of resistance exercise.⁷¹ Although this set structure was not named a standard cluster set, the concept of the rest-pause method is similar to what is now commonly referred to as a standard cluster set. Specifically, Verkhoshansky and Siff⁹³ have defined the standard cluster set as an extended set configuration in which one or more repetitions are performed with short rest intervals (ie, 10-20 seconds) between each individual repetition or group of repetitions within the set (Figure 2).

UNDULATING CLUSTER SETS

Unlike the standard cluster set, where the load remains constant during all repetitions performed in the set, the undulating cluster set entails modulating the training load within the set.^{27,29} When an undulating cluster set is constructed, the load ascends and peaks in the middle of the set and then is reduced across the remaining repetitions (Figure 2).³¹ For example, in an undulating cluster set of five repetitions that is performed with an average load of 80% of 1RM, the load ascends from the first to the third repetition (eg, 75%, 80%, 90% 1RM) and then is decreased for the fourth and fifth repetition (eg, 80%, 75% 1RM). In contrast to the standard cluster set, the undulating cluster set has not

been extensively examined within the scientific literature.^{11,31}

Haff et al²⁹ stated that, theoretically, barbell velocities achieved during the descending part of the undulating cluster set should be increased as a result of a post activation performance enhancement (PAPE) effect. To examine this phenomenon, Dudley et al¹¹ investigated the effect of undulating cluster sets on kinetic and kinematic variables during three sets of five repetitions performed with the hang snatch. However, the authors did not compare peak velocities achieved at the first repetition to those achieved at the fifth repetition during the undulating cluster sets, thereby making it difficult to substantiate if a PAPE effect occurred during the undulating cluster set. Due to a paucity of contemporary scientific literature examining the effects of undulating cluster sets, it is difficult to postulate whether the chronic use of undulating cluster sets results in greater performance gains when compared with standard cluster sets. When deciding whether or not to use undulating clusters, it may be important to consider the athlete's strength level, as stronger individuals generally display greater PAPE responses compared to weaker athletes.⁸⁰ In addition, given that the undulating cluster set is an advanced set manipulation strategy, this method may be more beneficial for highly trained, stronger athletes, as greater training variation is required to improve physical capacities that underpin athletic performance compared to novice or intermediate athletes.⁷³

ASCENDING CLUSTER SETS

Whereas the undulating cluster set uses a fluctuating loading pattern, an ascending cluster set uses a progressive load that increases across the set (Figure 2).^{27,29} For example, in the ascending cluster set of five repetitions with the average load corresponding to 80% of 1RM, five repetitions are performed in a cluster format in which the load is progressively increased (eg, 70, 75, 80, 85, 90% 1RM). Theoretically, ascending cluster sets, as with undulating cluster sets, may induce a PAPE effect during subsequent sets. For example, the first ascending cluster set may act as a conditioning activity that stimulates a PAPE effect during the early portion of the subsequent set(s) when the load

progression is repeated. However, in contrast to standard cluster and undulating cluster sets, to the best of the authors' knowledge, there are no known research studies that have directly examined the acute effects of ascending cluster sets. It may be important, as with undulating cluster sets, to consider an athlete's strength level and their training experience when using ascending cluster sets, as the concept of this set structure is like undulating cluster sets. To substantiate this assumption, further research is warranted outlining the mechanical and physiological responses to ascending cluster sets to understand how this set configuration can be applied to resistance training programmes.

REST-REDISTRIBUTION

Although standard cluster sets are an effective method for maintaining velocity across a series of sets, an often noted downside of this strategy is that it inevitably extends total training session time as additional rest intervals are placed within each set.⁹¹ As strength training sessions in real-world settings are often administered under time constraints, this may not be an ideal scenario for S&C professionals.⁹¹ To account for the limited time normally available within applied environments, several authors have recommended what is referred to as a rest-redistribution set.^{16,50,67} This training method can be applied by: 1) redistributing the inter-set rest interval to include the inter-repetition or intra-set rest interval and/or 2) decreasing the total number of repetitions performed per set and increasing the total number of sets while the overall rest is unchanged (Figure 2).⁸⁹ Several authors have suggested that the rest-redistribution set is a more effective set configuration for maintaining mechanical performance,^{32,64,67} lessening metabolic stress,^{16,66,72} and decreasing perceptual exertion,^{5,39,50} than traditional sets, while avoiding extending the training session time. Although standard cluster sets and rest-redistribution sets have often been referred to interchangeably within the coaching and scientific literature,^{2,4,16,32,33,48,64-67,92,97} this has caused some confusion as these set strategies are likely different constructs. Based upon their meta-analytic study, Jukic et al⁴⁹ recently reported that standard cluster sets and rest-redistribution sets are different constructs as rest-

redistribution sets are less effective for maintaining mechanical performance, mitigating metabolic stress and perceptual exertion when compared to standard cluster sets. This is likely a result of rest-redistribution sets having less amount of total rest time than standard cluster sets.⁴⁹ Jukic et al suggest that S&C professionals use and classify standard cluster and rest-redistribution sets independently, due to the fundamental differences in the total amount of rest accumulated and the set structure specific impact on performance.

Programming cluster sets

Programming is a term that describes the micro-management of various training factors that are strategically aligned based upon a periodised training plan.⁹ Some factors of programming include structuring training intensity, training volume, duration of the inter-set rest interval, intra-set and inter-repetition rest interval, exercise selection, exercise order, sets and repetitions.⁹ These training factors should be considered and appropriately modified when using cluster sets for programming. In the following section, specific focus has been placed on programming variables that are associated with cluster sets, specifically exercise selection, training intensity, and duration of the intra-set and inter-repetition rest interval.

EXERCISE SELECTION

When using cluster sets as part of a training programme, the coach should consider which exercises are best suited for cluster sets. Although most exercises contained in a training session can be performed using cluster sets, this is not recommended, as this practice excessively extends a training time that is often limited in applied settings. It is generally recommended that cluster sets should be used for one or two of the most technically challenging and fatiguing exercise(s).⁶⁰

Weightlifting movements (eg, clean and snatch) and their derivatives (eg, pulls, power clean and snatch) are often used as part of a training programme as they provide a greater training stimulus when compared with other types of training, including jumping,⁸⁸ kettlebell,⁶⁹ and powerlifting-based training methods.⁴⁰ Several authors recommend that cluster

sets are best suited for weightlifting movements and their derivatives.^{27,29,60} To support this recommendation, Haff et al³¹ reported greater barbell peak velocity in a cluster set with one set of five repetitions of clean pulls, when compared with a traditional set, when both sets were performed with 90% and 120% of the power clean 1RM (ie, 90%: effect size [ES] = 2.10, 120%: ES = 1.94). In addition, Tan et al⁸⁷ reported that using cluster sets with a 30-second inter-repetition rest interval maintained peak ankle, knee and hip joints velocities during the transition and second pull phase of snatch. Furthermore, Hardee et al³⁴ investigated how cluster sets with 20-second inter-repetition rest intervals impacted the biomechanical characteristics of power cleans performed with three sets of six repetitions at a load of 80% of 1RM. The authors reported that the subjects maintained barbell trajectories across each set.³⁴ Conversely, when using traditional sets, they tended to display a greater forward movement of the barbell during the first pull and a greater forward movement of the barbell during the second pull when the sixth repetition was compared with the first repetition.³⁴ When taken collectively, cluster sets are likely best suited for weightlifting movements and their derivatives as they maintain performance, especially when multiple repetitions and sets are performed.

The deadlift is a key exercise within many resistance training programmes that targets the development of lower-body strength,⁶² and is one of the competition lifts in the sport of powerlifting.³⁸ Although positive performance effects on movement velocity are associated with the use of cluster sets,^{31,91} one study reported that cluster sets might potentially have a detrimental effect on movement velocity during a set of deadlifts at 90% of 1RM.⁵⁶ In this study, a single set of four repetitions performed with 90% of 1RM was broken into two clusters of two repetitions with a 30-second intra-set rest interval.⁵⁶ This set configuration was reported to stimulate a greater level of fatigue when compared with traditional sets performed with the same load.⁵⁶ The authors of this study also reported that the inclusion of 30-second inter-repetition rest intervals resulted in a progressive decrease in power output, which was not observed

Table 1: Loading classification

INTENSITY	RELATIVE INTENSITY (%)	% INITIAL 1RM (KG) (BACK SQUAT 1RM: 100KG)	% ESTIMATED 5RM (KG)	% ESTIMATED 10RM (KG)
Max	100	100	87	75
Very heavy	95-100	95-100	83-87	71-75
Heavy	90-95	90-95	78-83	68-71
Moderately heavy	85-90	85-90	74-78	64-68
Moderate	80-85	80-85	70-74	60-64
Moderately light	75-80	75-80	65-70	56-60
Light	70-75	70-75	61-65	53-56
Very light	65-70	65-70	57-61	49-53

Note: Back squat 1RM is 100kg. All the estimations are based off back squat 1RM. Modified from Haff and Haff²⁸

Table 2: Loading cluster sets

Intensity	Relative Intensity (%)	Max Repetitions												
		1	2	3	4	5	6	7	8	9	10	12	15	
Max	100	100	95	93	90	87	85	83	80	77	75	67	65	
Very heavy	100	100	95	93	90	87	85	83	80	77	75	67	65	
	95	95	90	88	86	83	81	79	76	73	71	64	62	
Heavy	95	95	90	88	86	83	81	79	76	73	71	64	62	
	90	90	86	84	81	78	77	75	72	69	68	60	59	
Moderately heavy	90	90	86	84	81	78	77	75	72	69	68	60	59	
	85	85	81	79	77	74	72	71	68	65	64	57	55	
Moderate	85	85	81	79	77	74	72	71	68	65	64	57	55	
	80	80	76	74	72	70	68	66	64	62	60	54	52	
Moderately light	80	80	76	74	72	70	68	66	64	62	60	54	52	
	75	75	71	70	68	65	64	62	60	58	56	50	49	
Light	75	75	71	70	68	65	64	62	60	58	56	50	49	
	70	70	67	65	63	61	58	58	56	54	53	47	46	
Very light	70	70	67	65	63	61	58	58	56	54	53	47	46	
	65	65	62	60	59	57	54	54	52	50	49	44	42	

Modified from Haff and Haff²⁸

for traditional sets.⁵⁶ Given that force did not change during all training protocols, the decrease in power output observed in response to the cluster set was most likely caused by decreases in movement velocity.⁵⁶ This result might have occurred because the deadlift movement only involves a concentric muscle action and lacks a stretch-shortening cycle. However, this

unfavourable result might not occur if multiple sets of deadlifts are performed, as greater reductions in the rate of ATP resynthesis within the activated muscles would be expected when multiple sets are performed.^{21,23} In this scenario, the cluster set may be used to attenuate these biochemical changes within the activated muscles, which in turn might result in the maintenance of

mechanical deadlift performance.

Other exercises that have previously been investigated and presented in the contemporary body of scientific literature on cluster sets include: back squat,^{18,57,91} bench press,^{8,14} bench press throw¹⁵ and loaded squat jump.⁴² A limitation of using cluster sets with these exercises is that the barbell must

be placed into a rack before every intra-set and inter-repetition rest interval and removed from the rack after the rest interval. This practice often requires a considerable effort for the athlete to get in the right starting position prior to performing the movement.¹⁰ Therefore, cluster sets may have less practicality with exercises that require un-racking and re-racking the barbell for each group of repetitions. If, however, the coach decides to implement these exercises, we suggest either using traditional sets or lengthening the inter-repetition or intra-set rest intervals employed with cluster sets to account for the additional effort required to un-racking and re-racking the barbell.

TRAINING INTENSITY

The most common method of monitoring and adjusting the prescription of training intensity within resistance training programs is to determine training intensity as a percentage of an athlete's 1RM.⁸⁶ A 1RM is typically determined as the heaviest weight that can be lifted for one repetition and used to estimate other RMs (xRM), such as the 5RM or 10RM. The xRM is then used to estimate other RM values and to estimate percentage training zones (Table 1).²⁸ This loading classification is an excellent method to create within-week variation that has been demonstrated to elicit greater training adaptations (eg, vertical jump performance, rate of force development, maximal strength and muscle hypertrophy) when compared with the RM zone training that necessitates a constant maximum effort.^{6,7} When using cluster sets, we recommend two methods to determine training intensity using the loading classification. One method is that training intensity is simply based on the total number of repetitions contained in the set. For example, if the athlete is scheduled to perform a set that contains a total of four repetitions (two clusters of two repetitions) using a moderately heavy load, the training intensity would be defined as 85-90% of 4RM, or ~77-81% of 1RM (Table 2). The other method of programming training intensity is to base it on the repetitions contained in each cluster, as additional rest allotted between individual repetitions or clusters of repetitions can allow for the use of greater training intensities.^{43,90} With this programming method, the training intensity would be defined as 85-

Table 3: Duration of the intra-set and inter-repetition rest interval in cluster sets

NUMBER OF REPETITIONS WITHIN EACH CLUSTER	DURATION OF THE INTRA-SET AND INTER REPETITION REST INTERVAL IN CLUSTER SETS (S)
1	15-25
2	20-30
3	25-35
4	30-40
5	30-40
6	30-40

90% of 2RM, or 81-86% of 1RM (Table 2). The latter method may be preferred for highly trained athletes, as weaker individuals may not have the capacity to handle higher intensity in the cluster training.

DURATION OF THE INTRA-SET AND INTER-REPETITION REST INTERVAL

When determining the duration of intra-set and inter-repetition rest intervals in cluster sets, the coach should consider the time-course of ATP resynthesis and the number of repetitions contained within each cluster. When longer duration rest intervals in cluster sets are provided, there is probably a more complete resynthesis of ATP and PCr, which allows for more rapid muscular contractions.²¹ Conversely, if the rest interval is shortened, incomplete resynthesis of ATP and PCr would occur and result in greater levels of muscular fatigue.^{27,29,85} In addition, when a higher number of repetitions within each cluster is used, longer intra-set rest intervals should be provided to ensure that greater recovery is provided to complete the cluster set. Conversely, if a lower number of repetitions within each cluster is chosen, a shorter rest interval can be implemented with cluster sets to facilitate the maintenance of performance and still allow for higher training loads than what can be used in traditional sets. A detailed proposal of intra-set and inter-repetition rest interval duration when programming cluster sets is presented in Table 3.

Implementing clusters sets into a periodised training plan: practical examples

Cluster sets have a variety of potential applications that can allow for the set

configuration to be aligned with the overall goal(s) of the phase of training.²⁹ In the following section, several examples of implementing cluster sets in the context of three different training phases – specifically, the hypertrophy-strength endurance, basic strength, and strength-power phases – will be presented. For more detail on practical applications of cluster sets within a resistance training programme, we direct the reader to the review by Nagatani et al.⁶⁰

HYPERTROPHY-STRENGTH ENDURANCE PHASE

During the hypertrophy-strength endurance phase of a periodised training programme, the primary goals for training are to increase muscle size and work capacity.^{26,82,83} To achieve these goals, it has been suggested that traditional sets be prioritised, especially for less technically challenging exercises, such as squats and weightlifting pulling derivatives.^{24,27} However, cluster sets can be incorporated into resistance training programmes to increase the time under tension and mechanical strain if the athlete is able to perform the set with greater training loads and volumes.^{31,43,90} An example of a training programme contained in the hypertrophy-strength endurance phase is presented in Table 4. In this example, cluster sets are used for a combination of power clean and front squat. This cluster set includes a total of three clusters with each cluster consisting of three repetitions of power clean, followed by three repetitions of front squats. Training intensity can be based on either the total number of repetitions of power clean contained in the set (ie, nine repetitions) or the number of repetitions of power clean contained in each cluster (ie,

Table 4: An example of cluster set implementation during a hypertrophy-strength endurance phase of a periodised training plan

DAY	EXERCISE	SET TYPE	SETS × REPS	INTRA-SET REST INTERVAL (S)	INTER-SET REST (S)	TRAINING INTENSITY			
						WK 1	WK 2	WK 3	WK 4
1	Power clean + front squat @	CLU	3 × 9/3 *	25-35	120	ML	M	L	M
	Back squat	TRAD	3 × 10	0	120	ML	M	L	MH
	Clean grip pull from floor	TRAD	3 × 10	0	120	ML	M	L	MH
	Standing behind neck press	TRAD	3 × 10	0	90	ML	M	L	M
	Prone row	TRAD	3 × 10	0	120	ML	M	L	MH
2	Deadlift	TRAD	3 × 10	0	120	ML	M	ML	MH
	Bench press	TRAD	3 × 10	0	120	ML	M	ML	MH
	Pull up	TRAD	3 × 10	0	120	ML	M	ML	MH
	Triceps extension	TRAD	3 × 10	0	90	ML	M	ML	MH
	Biceps curl	TRAD	3 × 10	0	90	ML	M	ML	MH
3	Power clean + front squat @	CLU	3 × 9/3 *	25-35	120	ML	M	ML	MH
	Back squat	TRAD	3 × 10	0	120	ML	M	ML	MH
	Clean grip pull from floor	TRAD	3 × 10	0	120	ML	M	ML	MH
	Romanian deadlift	TRAD	3 × 10	0	120	ML	M	ML	MH
	Prone row	TRAD	3 × 10	0	120	ML	M	ML	MH

Note: TRAD = traditional sets; CLU = cluster sets; MH = moderately heavy; M = moderate; ML = moderately light; L = light. @ each cluster consists of three repetitions of power cleans followed by three repetitions of front squats * 9/3 = cluster sets with an intra-set rest interval between each three repetitions

Table 5: An example of cluster set implementation during a basic strength phase of a periodised training plan

DAY	EXERCISE	SET TYPE	SETS × REPS	INTRA-SET REST INTERVAL (S)	INTER-SET REST (S)	TRAINING INTENSITY			
						WK 1	WK 2	WK 3	WK 4
1	Power clean	CLU	3 × 5/1 *	15-25	150	ML	M	L	MH
	Back squat	TRAD	4 × 5	0	150	M	MH	H	TEST #
	Romanian deadlift	TRAD	4 × 5	0	150	ML	M	L	MH
	Bench press	TRAD	4 × 5	0	120	ML	M	L	M
	Prone row	TRAD	4 × 5	0	120	M	MH	H	TEST #
2	Deadlift	TRAD	4 × 5	0	150	M	MH	ML	MH
	Pull up	TRAD	4 × 5	0	120	M	MH	ML	MH
	Military press	TRAD	4 × 5	0	120	M	MH	H	TEST #
	Biceps curl	TRAD	3 × 10	0	90	ML	M	L	MH
	Triceps extension	TRAD	3 × 10	0	90	ML	M	L	MH
3	Power clean	CLU	3 × 5/1 *	15-25	150	ML	M	L	MH
	Back squat	TRAD	4 × 5	0	150	ML	M	L	M
	Push press	TRAD	4 × 5	0	120	M	MH	ML	MH
	Prone row	TRAD	4 × 5	0	120	ML	M	L	M
	Bench press	TRAD	4 × 5	0	120	M	MH	H	TEST #

Note: TRAD = traditional sets; CLU = cluster sets; H = heavy; MH = moderately heavy; M = moderate; ML = moderately light; L = light. * 5/1 = cluster sets with inter-repetition rest intervals. # repetition maximum test

three repetitions). This form of set configuration allows for greater training loads and volumes to be used while avoiding repetition failure that can occur when using higher training loads with a traditional set of resistance exercise.⁹⁰

BASIC STRENGTH PHASE

During the basic strength phase, the primary focus of training is on the development of maximal strength.²⁵ Several authors have suggested that performing resistance training with traditional sets probably results

in larger maximal strength gains when compared to using traditional sets alone,^{3,24,75} and thus it may be recommended to use traditional sets for most non-ballistic resistance exercises, such as squats, bench press and deadlift.³ We present an example

Table 6: An example of cluster set implementation during a strength-power phase of a periodised training plan

DAY	EXERCISE	SET TYPE	SETS × REPS	INTRA-SET REST INTERVAL (S)	INTER-SET REST (S)	TRAINING INTENSITY			
						WK 1	WK 2	WK 3	WK 4
1	Power clean	CLU	3 × 3/1 *	15-25	180	M	MH	H	TEST #
	A: Back squat @	TRAD	3 × 3	0	180	ML	M	L	MH
	B: Box jump @	TRAD	3 × 5	0	---	---	---	---	---
	Romanian deadlift	TRAD	3 × 3	0	120	ML	M	L	MH
	Prone row	TRAD	3 × 3	0	120	M	MH	ML	H
2	Push jerk	TRAD	3 × 3	0	150	M	MH	ML	H
	Clean grip pull from floor	TRAD	3 × 3	0	150	ML	M	L	MH
	Bench press	TRAD	3 × 3	0	120	M	MH	ML	H
	Pull-up	TRAD	3 × 3	0	120	M	MH	ML	H
	Reverse flyes	TRAD	3 × 10	0	90	ML	M	L	MH
3	Clean grip shrug from thigh	TRAD	3 × 3	0	120	M	MH	ML	H
	Power clean	A-CLU	3 × 3/1 **	30-40	180	M	MH	ML	H
	A: Back squat @	TRAD	3 × 3	0	180	M	MH	ML	H
	B: Box jump @	TRAD	3 × 5	0	---	---	---	---	---
	Push press	TRAD	3 × 3	0	120	ML	M	L	MH

Note: TRAD = traditional sets; CLU = cluster sets; A-CLU = ascending cluster sets; H = heavy; MH = moderately heavy; M = moderate; ML = moderately light; L = light. @ the superset of back squat and box jump * 3/1 = cluster sets with inter-repetition rest intervals. ** 3/1 = ascending cluster sets with a progressively increased load across the sets. # 1RM testing

of a training programme that aligns with the goals of a basic strength phase in Table 5. In this training programme, the first exercise completed on Monday and Friday is the power clean, which is performed using a cluster set programming strategy. Training intensity can be based on either the total number of repetitions contained in the set (ie, five repetitions) or the number of repetitions contained in each cluster (ie, one repetition). This type of set configuration has been demonstrated to maintain lifting technique and lower-body joints velocities by lessening muscular fatigue that occurs across sets.^{34,87} In addition, the cluster set allows the strength and conditioning professionals an opportunity to provide the athlete with immediate feedback during the rest intervals between individual repetitions.⁶⁰

STRENGTH-POWER PHASE

During the strength-power phase, the focus of training centres on the continued development of maximal strength and its translation into the development of rapid force-generating capacity.^{26,82,83} Several authors have suggested that resistance training programmes during this phase of training should focus on various aspects of the force-velocity curve to better optimise the athlete's

performance.^{1,36,46,47} This form of training is known as a mixed method approach, which involves a wide range of training loads and exercises.³⁰ An example of a training programme with cluster sets that is structured to target the goals of a strength-power phase is presented in Table 6. In this training programme, the first exercise completed on Monday is the power clean, which is performed using a cluster set programming strategy. Training intensity can be based on either the total number of repetitions contained in the set (ie, three repetitions) or the number of repetitions contained in each cluster (ie, one repetition). The use of cluster sets can maintain high force production and high velocity across a series of sets,³⁴ which potentially develops the high-force and high-velocity portion of the force-velocity curve.³⁰ Some of the other exercises in this training programme are performed using traditional sets, with an emphasis on either the high force end of the force-velocity curve or the high velocity end of the force-velocity curve.³⁰ This mixed method approach using cluster sets may allow for force-generating capacity to be developed across the entire force-velocity curve.³⁰

Another way of integrating cluster sets into the strength-power phase is

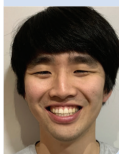
to use ascending cluster sets. In the training programme in Table 6, two advanced programming strategies are used in Friday's training session to induce a PAPE effect. The first strategy involves the clean grip shrug from the thigh to induce a PAPE effect for a subsequent exercise.⁸⁴ The second strategy involves performing the power clean with ascending cluster sets. A total of three repetitions are performed in a cluster format, in which the training load is increased with each repetition performed in the set. When choosing the training intensity for ascending cluster sets, it is recommended that the targeted intensity should be the average intensity across the ascending cluster set.²⁷ In this example, the targeted training intensity at the first week for ascending cluster sets is within a moderate intensity zone. In this case, the training intensity at the first repetition can be determined within the moderately light intensity zone, while the training intensity at the third repetition can be chosen within the moderately heavy intensity zone. The first ascending cluster set may act as a conditioning activity that induces a PAPE effect during the first and/or second repetition of the subsequent set(s) when the load progression is repeated.²⁷ When using ascending

cluster sets, the S&C professionals should consider extending the intra-set or inter-repetition rest interval (ie, + 10-15 seconds) to account for additional time required for the lifter to manually increase the load in the ascending cluster set.

Conclusion

Cluster sets can be used by S&C professionals as an additional programming strategy for modifying the external and internal training loads that result from resistance training. When using cluster sets, several programming variables should be carefully selected or altered to maximise the potential benefit of the cluster set: specifically exercise selection, training intensity, and duration of the intra-set and inter-repetition rest interval. In addition, for S&C professionals to appropriately integrate cluster sets into resistance training programmes, it is important to contextualise and establish the training goal of the athlete based upon a periodised training plan and then align the set configuration with these goals.

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