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The Acute Effects of Cluster Set during Complex Training on Countermovement Jump

Asmadi Ishak, Ali Md Nadzalan, Thariq Khan Azizuddin Khan, Zulezwan Ab Malik, Yusri Yakub , Hishamuddin Ahmad, Hairul Anuar Hashim

Abstract*: This study aims to determine the acute effects of complex training with a cluster set configuration on countermovement jump. A crossover counterbalance design was used in this study. Fourteen recreational male underwent three sessions of trainings, with a minimum of 72 hours between each session. In the complex training (CT) protocol, squats with 65% 1RM were used for resistance training while jump squats with 80% of maximum effort for plyometric. Subjects performed the resistance and plyometric training alternately, using either traditional (TRA) or cluster with two sets (CS2). In TRA, no rest was given between the repetitions until they completed the entire set. For CS2, the pairs of CT 30s rest were inserted between the repetitions. The results of the study showed no significant interaction between TRA and CS2 across the all parameters: CMJ height (p> 0.05), power (p>0.050, and velocity (p>0.05) respectively. This study shows that both TRA and CS2 provide better CMJ height, power and velocity during CT. In conclusion, both TRA and CS2 can be adopted in training to enhance power.

Index Terms*: Recovery, Cluster set, Inter-repetitions rest, Velocity, Countermovement jump

I. INTRODUCTION

Power has been considered to be an important factor in contributing to the successful performance of sport-specific movements [1]. Power can be developed through the use of many training modalities such as resistance training using a heavier load or plyometric training incorporating either acceleration and deceleration of body weight or a combination of both [2, 3, 4]. Complex training (CT) has been referred as an alternating specific resistance followed by a biomechanically similar plyometric exercise [5].

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***** Correspondence Author

Asmadi Ishak*, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Malaysia.

Ali Md Nadzalan, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Malaysia.

Thariq Khan Azizuddin Khan, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Malaysia.

Zulezwan Ab Malik, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Malaysia..

Yusri Yakub, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Malaysia.

Hishamuddin Ahmad, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, Malaysia.

Hairul Anuar Hashim, School of Health Sciences, Universiti Sains Malaysia, Malaysia.

Theoretically, complex training (combining resistance and plyometric training in the same session) can improve power [6, 7]. This improvement may be attributed to CT mechanisms that stimulate motor unit excitability and increase phosphorylation of myosin light chain thus allowing the myofilaments to become more sensitive to calcium and also decrease presynaptic inhibition [8]. Resistance training which includes high force and low movement velocity can create conditions appropriate for post activation potential (PAP) leading to maximal strength. Conversely, low force and high movement velocity in plyometric training is appropriate for PAP in the build-up for explosive power [9, 10, 11]. However, previous studies have concluded that a heavy load exercise does not only produce PAP but also induces muscular fatigue [12]. This has been suggested a factor which interferes with the development of muscular power [13]. Moreover, balance between PAP and fatigue during complex training is very crucial to ensure the attainment of optimal explosive power performance. Therefore, the insertion of short inter-repetition rest periods of between 15-45 s [14] during exercise may be one of the best strategies to maintain or enhance power in complex training [15]. The use of a cluster set as a method to manage fatigue during individual resistance training and plyometric workout has been proposed to facilitate the partial restoration of the metabolic and excitatory cellular environment [16, 17]. Furthermore, [18] suggested that cluster set is important to avoid fatigue when attempting to maximize power with an appropriate rest interval.

To date, only one study has used a cluster set protocol in complex training. In consideration that the acute effect of cluster set during complex training on countermovement jump has not been elucidated, this study therefore aims to determine the acute effect of using a cluster set configuration during complex training on countermovement jump height.

II. METHODOLOGY

A. Subjects

Fourteen male recreational athletes [age (mean ± SD) 22.0 ± 0.2 years, height 169.7± 5.1 cm, body mass 63.1± 5.0 kg, BMI 21.9 ± 1.7 kgm^2, 1RM-Squat 116.6 ± 5.0 kg]volunteered to participate in this counterbalanced design study. The subjects had at least two years of resistance training experience. Subjects trained three to four times per week and participated in at least two competitions per year. They were also able to squat one half times their body weight and perform five repetitions of the back squat with 60% of their body weight within five seconds or less [19].

All the subjects had no history of musculoskeletal injuries and none of them were taking any dietary supplements or any pharmaceutical drugs that may affect their performance during the study. Prior to this study, a written informed consent was obtained from all subjects.

B. Procedures

Subjects underwent three separate sessions with a minimum of 72 hours separated between each experimental sessions. Testing for each subject was conducted on similar days (8:00-11:00 am), ambient conditions (25.3±0.2ºC) and relative humidity (67.4%±1.6%). Before testing, subjects were asked to avoid any strenuous activity for 24 hours and on the day of the experimental sessions.

One week before the experimental sessions, subjects completed a familiarization session using the testing protocol and measurement procedures. Before the testing sessions, all subjects were required to perform a standardized dynamic warm-up protocol adapted from [20]. Subjects were instructed to perform a series of dynamic exercises consisting of two sets of bodyweight squats and two repetitions of lunge walk over 10 m with two minutes of recovery. Subjects then performed two sets of three CMJ at an intensity of 60% of maximum effort, separated by a two minute rest.

A 3-RM squat test was used to determine their strength using the guidelines from the National Strength and Conditioning Association (NSCA) [19]. Subjects were instructed to attempt three repetitions (with each repetition to 90º of knee flexion) of the chosen set load. If the weight was successfully lifted, the weight was then increased (14-18 kg) until the weight could no longer be lifted through the full range of motion. A five minute recovery was given between all attempts [12]. From the 3-RM squat, an estimation of 1-RM was then determined using the table from [21].

The countermovement jump (CMJ) was performed on a force platform (Quattro jump: Kistler, Winterthur, Switzerland) and recorded with a sampling rate of 500Hz. To perform the CMJ, subjects were instructed to execute it with correct technique. This technique requires the subjects, to keep their hands on their hips throughout the jump to minimize lateral and horizontal displacement and prevent any influence arm movements on jump performance [22]

In the traditional set (TRA), subjects perform the exercises without rest in between the repetitions. In this regard, squats were immediately followed by jump squats. Subjects completed eight repetitions per set without the inter-repetition rest (IRR). In total, each subject performed 24 repetitions for the entire three sets of complex training. Three minutes were given for rest between each set [23].

In the configuration cluster of two sets (CS2), subjects performed similar exercise and repetitions as in the TRA set. However, each subject executed the two different exercises with a rest period of 30s in between the exercise. They then continued with the exercises until all eight repetitions per set were completed. For the CS2 complex training, subjects completed three sets of the said exercises with 24 repetitions in total. Inter-set rest of 30s and three minutes of intra-set rest were prescribed for this training.

Complex training involves alternating between traditional resistance training (heavy loads) and plyometric exercises (lighter loads) within a single session [4, 5, 15]. For the complex training protocol, the exercise used for resistance training is the squat with an intensity of 65% 1RM. For the plyometric exercise, the jump squat with 80% of maximum effort was used [15]. Subjects performed resistance training and plyometric exercise alternately using the cluster set configuration (CS2). In the TRA set, no rest was given in between repetitions until subjects completed the entire set. Subjects were allowed to three minutes inter-set rest. Subjects completed their sessions with 24 repetitions with equal distribution between resistance and plyometric exercise.

C. Statistical Analysis

All data were analysed by using of the Statistical Package for Social Sciences (SPSS) for all parameters. A repeated measure analysis of variance (ANOVA) was used to analyse differences between conditions and all primary variables. The alpha level of significance was set at $p>0.05$.

III. RESULTS

Descriptive statistics of the primary variables are presented in Table 1.

Table 1. Mean ± SD Values for primary variables

Variables	Baseline	CS2	TRA	P Value
CMJ- cm	44.8±6.0	46.9±6.0	46.2±6.0	0.33
PowerW. kg^{-1}	50.7±4.6	52.6±5.1	51.1±4.8	0.07
Velocity $m.s^{-1}$	2.73±0.2	2.67±0.1	2.64±0.2	0.10

CS2 = cluster set of 2, TRA = Traditional set, CMJ = Countermovement jump.

The results of repeated measure one-way ANOVA showed no significant differences between TRA and CS2 on the primary variables of CMJ height jump, power and velocity. However, the mean between baseline and after using cluster set and traditional set showed slight increase in jump height (4.71% and 3.08%) respectively. Meanwhile, the mean for power also showed slightly higher in CS2 and TRA sets compared to baseline (3.59% and 0.63%), respectively. Mean for velocity were found to slightly decrease after using CS2and TRA sets (2.2% and 3.3%) compared to the baseline.

IV. DISCUSSIONS

The present study aimed to determine the acute effects of cluster set configuration during complex training on countermovement jump.

The main findings of this study showed that performing either traditional or cluster set configuration did not affect the main parameters of the countermovement jump. Many research studies been conducted the effect of cluster set during resistance training or plyometric training on athlete performance [14, 20, 24, 25, 26, 27]. However, the literature on the effect of cluster set on the complex training is scant and does not provide clear conclusion in regards to the acute effect of cluster set on power performance [15, 28]. Theoretically, the addition short rest periods between repetitions in the cluster might offer greater benefits in reducing accumulating fatigue for enhanced performances [16]. Numerous studies have shown showed positive results in response to increase movement velocity and power output after implied cluster set [29, 30].

A study by [30] found that peak power output, peak velocity and peak force can be maintained through cluster set compared to decrease in the same parameters in the traditional set. Furthermore, [31] supported the contention that cluster set structure can maintain the results of velocity and power compared to traditional set structure. Indeed, [31] CS2 demonstrated peak velocity, mean velocity, peak power and mean power which is greater than a cluster set of 4 ($p<.02$) and showed decrement in all parameters in traditional set.

In our study, mean jump height and power performance showed slight increase after the completion of three sets when using the cluster set (4.71%) and (3.59%) respectively, and 3.08% and 0.63% respectively for traditional set when compared to baseline data. Meanwhile the mean for velocity were found to be slightly decrease after using the cluster and traditional sets (2.2% and 3.3%) respectively when compared to the baseline. However, these results were not statistically significant. CS2, with the insertion time of 30s for recovery did not differ significantly in the height of a jump, power and velocity compared to the traditional set. Although, both protocols used 65% of the subject's squat exercises and 80% of maximum effort in jump squat and three minutes of rest to execute the three set of eight repetitions, it seems that the traditional set in this study was likely not as fatiguing as the traditional set protocols of other studies [27]. It is possible that the structure of the traditional set by performing added repetitions through multiple sets in to ensure greater stimulus can generate more fatigue. Despite the sequence of exercise during complex training are alternating between resistance and plyometric exercises are likely difficult to performed in traditional structures.

In contrast, a study by [15] revealed that CMJs improved after 10 sets of complex training by using the training load of 65% or 87% of 1RM Back Squat for elite volleyball players. The results of our study are not in line with that by [15] because of the difference in the initial strength of subjects. Our study used recreational athletes compared to the elite athletes used in that study. Another study by [28] found that CMJ paired with back squats allowed an increased in jump height of 2.0 cm during complex training. It could be speculated that the speed of resistance exercise preceding the execution of the subsequent set of plyometric exercises may have impacted the magnitude of power production [28]. The main findings of this study showed that both TRA and CS2 provide better results for power parameters in CMJ performance during complex training protocols.

V. CONCLUSIONS

Based on the findings of this study, it is important for any coaches and athletes to consider using either the cluster set or traditional set when embarking on a program of complex training. However, the cluster set is likely the best option when the aim of training is maximize acute velocity and power output. In line with this suggestion, a future study is needed to elucidate the different configurations of cluster sets in optimizing power performance in complex training.

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