International Journal of Sports Physiology and Performance, 2021, 16, 243-249
https://doi.org/10.1123/ijspp.2019-1005

Human Kinetics
ORIGINAL INVESTIGATION

Effect of Resistance-Training Programs Differing in Set Configuration on Maximal Strength and Explosive-Action Performance

Jesualdo Cuevas-Aburto, Ivan Jukic, Jorge Miguel González-Hernández, Danica Janicijevic, Paola Barboza-González, Luis Javier Chirosa-Ríos, and Amador García-Ramos

Purpose: To compare the effects of 2 upper-body strength-training programs differing in set configuration on bench press 1-repetition maximum (BP1RM), bench press throw peak velocity against 30 kg (BPT30), and handball throwing velocity. ***Methods:*** Thirty-five men were randomly assigned to a traditional group (TRG; n = 12), rest redistribution group (RRG; n = 13), or control group (n = 10). The training program was conducted with the bench press exercise and lasted 6 weeks (2 sessions per week): TRG—6 sets × 5 repetitions with 3 minutes of interset rest; RRG—1 set × 30 repetitions with 31 seconds of interrepetition rest. The total rest period (15 min) and load intensity (75% 1RM) were the same for both experimental groups. Subjects performed all repetitions at maximal intended velocity, and the load was adjusted on a daily basis from velocity recordings. ***Results:*** A significant time × group interaction was observed for both BP1RM and BPT30 ($P < .01$) due to the higher values observed at posttest compared with pretest for TRG (effect size [ES] = 0.77) and RRG (ES = 0.56–0.59) but not for the control group (ES ≤ 0.08). The changes in BP1RM and BPT30 did not differ between TRG and RRG (ES = 0.04 and 0.05, respectively). No significant differences in handball throwing velocity were observed between the pretest and posttest (ES = 0.16, 0.22, and 0.02 for TRG, RRG, and control group, respectively). ***Conclusions:*** Resistance-training programs based on not-to-failure traditional and rest redistribution set configurations induce similar changes in BP1RM, BPT30, and handball throwing velocity.

Keywords: bench press, cluster training, 1-repetition maximum, rest redistribution, throwing velocity

Muscular power has been related to a number of athletic performance tasks, such as sprinting, jumping, and throwing velocity.[1,2] In addition, the capacity to generate muscular power could differentiate between performance levels of athletes and between starters and nonstarters.[1,3] It is also important to note that muscular strength contributes significantly to the production of muscle power.[2] Consequently, sport professionals are constantly seeking ways to optimize training interventions to improve maximal strength and power generating capacities. Both muscular strength and power can be developed through resistance training while manipulating a wide range of variables such as exercise type and order, number of sets and repetitions, loading magnitude, rest between sets and movement velocity.[4,5] Therefore, it is important to understand the effects of different resistance training protocols on muscular strength and power adaptations.

Regardless of how a resistance training protocol is designed, maximizing movement velocity seems to be a key factor when the aim is to develop muscular strength and power.[6] For instance, Pareja-Blanco et al[7] found that a lower magnitude of velocity loss within each set (20%) was associated with similar squat maximal strength gains but greater enhancements in vertical jump height than training with a higher velocity loss (40%), despite the fact that the latter group performed 40% more repetitions during an 8-week training intervention. These results suggest that once a moderate velocity loss is achieved, performing more repetitions will not elicit further strength gains and could be detrimental for improving explosive strength. Without decreasing training loads or volume, likely the simplest and most effective way to mitigate acute fatigue and maintain high-movement velocities is to add intraset rest.[8] Although the addition of intraset rest is effective, these so-called “cluster sets” might not always be feasible from a practical perspective since they can extend total training time.[8]

One alternative to cluster set structures is to redistribute the total rest time of traditional (TR) set structures to include shorter and more frequent rest intervals.[9] This strategy, known as rest redistribution (RR), can maintain velocity and power output within individual sets compared with TR sets.[10–12] Furthermore, a recent study investigated the possibility of RR serving as a free ad hoc equivalent to commonly used velocity loss thresholds during clean pulls at multiple loads.[13] Interestingly, when rest periods of TR sets were redistributed to create short but more frequent rest periods, the number of repetitions performed within 10% and 20% velocity loss thresholds was greater ($g = 0.66–0.69$) than during TR sets. This suggests that sport professionals who are financially constrained to implement velocity loss thresholds during training could likely induce similar training stimuli by redistributing long interset rest periods and performing less repetitions during each set.

Numerous studies have showed beneficial effects of RR technique on acute performance maintenance during resistance training.[10–12] However, a few recent studies suggested that RR may

Cuevas-Aburto and García-Ramos are with the Dept of Sports Sciences and Physical Conditioning, Faculty of Education, Universidad Católica de la Santísima Concepción, Concepción, Chile. Jukic is with the Sport Performance Research Inst New Zealand (SPRINZ), Auckland University of Technology, Auckland, New Zealand. González-Hernández is with the Faculty of Health Science, Universidad Europea de Canarias, Tenerife, Spain. Janicijevic is with the Research Center, Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia. Barboza-González is with the Faculty of Education, Universidad Andres Bello, Concepción, Chile. Chirosa-Ríos and García-Ramos are with the Dept of Physical Education and Sport, Faculty of Sport Sciences, University of Granada, Granada, Spain. Janicijevic (danica.janicijevic@fsfv.bg.ac.rs) is corresponding author.

only be effective if TR sets are performed to failure.[9,14,15] Although the body of evidence regarding the acute responses of RR technique is continually growing, fewer studies have investigated muscular strength and power adaptations after utilizing RR in a training environment.[16–23] For instance, Lawton et al[19] did not find superior strength and power training adaptations using the RR technique after 6 weeks of bench press (BP) training. Similarly, Morales-Artacho et al[21] reported similar increments in maximal force and power capacities for TR and RR set configurations after 3 weeks of jump squat training. However, Hansen et al[18] reported greater peak power outputs during the squat jump exercise after 8 weeks of training, and Oliver et al[20] found RR to be more effective than TR sets in provoking both strength and power adaptations after 12 weeks of training. Collectively, the effects of RR on maximal strength and power training adaptations are unclear, and further research is evidently needed.

Therefore, we designed a longitudinal study to elucidate whether the gains in maximal strength and explosive actions performance induced by resistance training programs conducted with the BP exercise could be influenced by the set configuration. Specifically, the main aim of the present study was to compare the effects of 2 upper-body strength training programs differing only in the set configuration (TR and RR) on the BP 1-repetition maximum (BP1RM), BP throw peak velocity against 30 kg (BPT30), and handball throwing velocity (HTV). As a secondary aim, we explored the association of (1) HTV with BP1RM and BPT30 before and after training and (2) the percentage change in HTV with the percentage change in BP1RM and BPT30. Given that previous acute studies conducted with the BP exercise have revealed small differences in mechanical variables between RR and not-to-failure TR set configurations,[14,15] we hypothesized that the gains in BP1RM, BPT30, and HTV would be comparable for both experimental groups (traditional group [TRG] and rest redistribution group [RRG]) in comparison with a control group (CG). A positive association was expected between the BP1RM and BPT30 with HTV before and after training,[1,24] although the lack of similar studies did not allow us to hypothesize whether the percentage change in BP1RM and BPT30 would be significantly correlated with the percentage change in HTV.

Methods

Subjects

A total of 39 recreationally resistance trained men volunteered to participate in this study. Subjects were randomly assigned to a TRG (n = 13), RRG (n = 13), and CG (n = 13). However, 4 subjects (1 from TRG and 3 from CG) were not considered for statistical analyses because they failed to complete the whole experiment protocol. The general characteristics of the subjects used for statistical analyses, who completed the study protocol without missing any sessions, were the following: TRG—n = 12, age = 21.0 (2.5) years, body mass = 73.4 (9.2) kg, height = 1.75 (0.05) m; RRG—n = 13, age = 20.3 (3.1) years, body mass = 75.0 (10.6) kg, height = 1.72 (0.05) m; and CG—n = 10, age = 22.2 (2.1) years, body mass = 73.8 (14.3) kg, height = 1.70 (0.05) m.

All subjects reported they were healthy, physically active, and had experience with BP training, but none of them were professional athletes. Subjects were instructed not to perform additional upper-body strength training over the course of the study. All subjects were informed about the study procedures and signed a written informed consent form before the commencement of the study. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the institutional review board of the University of Granada (935/CEIH/2019).

Study Design

The present study used a controlled longitudinal pre–post design with random assignment of the subjects to 3 parallel groups (2 experimental [TRG and RRG] and 1 control [CG]). The study protocol consisted of 15 sessions that were performed during an 8-week period: 2 pretests (week 1), 12 training sessions (weeks 2–7; only for TRG and RRG), and 1 posttest (week 8). All sessions were separated by at least 48 hours of rest and were performed at a consistent time of the day for individual subjects (± 1 h).

Testing Procedures

Subjects reported to the laboratory after refraining from strenuous exercise for a minimum of 48 hours. Their body mass (Tanita BC 418 segmental; Tanita Corp, Tokyo, Japan) and height (Seca 202; Seca Ltd, Hamburg, Germany) were assessed in the first testing session. The warm-up consisted of 5 minutes of jogging, dynamic stretching exercises, 10 push-ups, and 5 repetitions of the BP throw (BPT) exercise performed in a Smith machine against 20 kg. After warming up, subjects rested for 3 minutes, and then they performed these tests in the following order.

Handball Throwing Velocity. Explosive strength production was evaluated on an indoor court using a 7-m standing handball throw. A Stalker Acceleration Testing System II radar device (model: Stalker ATS II; Applied Concepts, Dallas, TX) was used to determine HTV. Subjects were instructed to throw a standard handball size III ball (mass = 480 g; circumference = 58 cm) toward the radar device at the maximal possible velocity. The radar device was positioned 2 m behind the net that stopped the ball at a height of 1 m above the ground. Subjects were positioned at a distance of 5 m from the radar device. At least 3 submaximal throws were performed as a part of the specific warm-up until subjects felt prepared for the maximal HTV assessment. Subsequently, they performed 4 maximal throws with the dominant arm separated by 30 seconds. The average value of the 3 best trials was used for statistical analyses. A researcher provided HTV feedback immediately after each trial and ensured that all throws were performed using a standard 7-m standing handball throw technique (front foot remained in contact with the ground). The throw was repeated if it was not executed with an appropriate technique.

BP Throw Peak Velocity Against 30 kg . Subjects performed 3 trials of the BPT exercise separated by 15 seconds against an external load of 30 kg. Subjects were instructed to throw the barbell as high as possible, and 2 spotters were responsible for catching the barbell during its downward movement. Barbell velocity was recorded by a linear velocity transducer (T-Force System; Ergotech, Murcia, Spain) at a frequency of 1000 Hz. The highest peak concentric velocity of the 3 trials was used for statistical analyses. The BPT and BP exercises were always performed in a Smith machine (FFittech, Taipei, Taiwan) using the touch-and-go and 5-point body contact position technique (head, upper back, and buttocks firmly on the bench with both feet flat on the floor). Subjects were allowed to self-select the grip width. The position of the bench was adjusted so that the vertical projection of the bar corresponded to each subject's intermammary line.

BP 1-Repetition Maximum. The BP1RM was determined through an incremental loading test. The initial load was 30 kg