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Original Article

Acute effects of different intra-repetition rest configurations on barbell peak velocity during the jump-shrug exercise

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Abstract
Problem Statement: Resistance training with intra-repetition rest (IRR) may lead to the maintenance of peak velocity (PV), reduce fatigue, induce lower blood-lactate concentration, and enhance the technical performance of exercises compared to continuous repetitions. Several studies have investigated the effect of various IRR on various resistance exercises, but the acute effects of IRR on jump-shrug exercise PV remain unexplored. ***Purpose:*** This study examined whether different IRR configurations may contribute to maintaining velocity using fast velocity loads in the jump-shrug exercise. ***Methods:*** The study involved 12 resistance-training participants (age: 23.4±3.7 years, body mass: 70.3±12.7 kg, body height: 1.70±0.08 m) with 4.3±2.1 years of experience in resistance training. Participants performed the jump-shrug exercise on three different days using three different fast velocity loads of 15, 20, and 25% calculated from the maximum isometric mid-thigh pull dynamometer (IMTPd) test with a randomized order. For each training load, three sets were performed with three different IRR intervals of 2 (IRR2), 6 (IRR6), and 12 (IRR12) seconds with 10 minutes of rest between sets. Measurements included anthropometric characteristics, the maximum IMTPd score, and the PV evaluation across 12 repetitions during the three different load conditions. ***Results:*** Significant differences were found for 15, 20, and 25% load conditions for PV between IRR2 and IRR12 configurations ($p<0.05$). In addition, significant differences were found for the 20% load condition between IRR2 and IRR6 configurations ($p<0.05$). The percentage of PV loss was significantly lower for the IRR12 configuration than IRR2 across all training loads ($p<0.05$), while the percentage of PV loss was significantly lower for IRR6 compared to IRR2 for only the 20% load condition. ***Conclusions:*** These results suggest that an IRR configuration equal to or greater than 6 seconds during jump-shrugs may contribute to maintaining PV and the percentage of PV loss. Consequently, when fast velocity loads are used for jump-shrugs during power training, IRR equal to or greater than 6 seconds (ideally 12 seconds) should be applied to better maintain PV during repetitions.
Keywords: ballistic training, velocity loss, rest intervals, isometric mid-thigh pull.

Introduction

The jump-shrug exercise is considered a ballistic multi-joint movement that activates both the upper and the lower body's muscle groups (Suchomel et al., 2014). The jump-shrug exercise is a weightlifting derivative that eliminates the catch phase of the Olympic movements (snatch and clean), while it has previously effectively been used during power training of weightlifters (Suchomel et al., 2015), track and field throwers (Zaras et al., 2014) and soccer players (Panteli et al., 2023). Although, the jump-shrug exercise has lower technical demands compared to other weightlifting derivatives (i.e., power clean, hang-power snatch, etc.), the activation of several muscle groups, the high velocity of the movement required, and the easy-to-teach nature of the exercise make it a vital tool for neuromuscular power enhancement training and a useful power exercise during all training periods for almost all athletes (Suchomel et al., 2017; Suchomel et al., 2015). A recent study showed that the ground reaction forces of barbell-lifter system velocity and power outputs were higher for the jump-shrug exercise compared with the hang power clean, especially during the final 10% of the movement leading to the conclusion that this exercise might lead to greater enhancement in movement velocity and muscle power production (Kipp et al., 2021). Furthermore, previous studies that used the jump-shrug exercise utilized training loads that were calculated either from the one repetition maximum (1-RM) of the hang power clean (Kipp et al., 2021; Suchomel et al., 2013; Suchomel et al., 2016), or the percentage of body mass (Rysgaard et al., 2018). Thus, training loads of 30-45% of 1-RM hang power clean or 15-45% of body mass are effective training loads and could be used during training. However, the isometric mid-thigh pull (IMTP) is a performance test that correlates with weightlifting performance (Haff et al., 2005; Beckham et al., 2013), while it is biomechanically similar to the jump-shrug exercise since it involves the activation of both upper and lower musculature system. Nevertheless, no study has investigated so far, the calculation of training loads in the jump-shrug exercise from IMTP in order to design power training.

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The maintenance of high velocity of movement execution throughout a training set is crucial for athletic performance. However, the accumulation of fatigue results in significant velocity and muscular power particularly loss, when fast velocity contractions are required (Garcia Ramos et al., 2015). Therefore, utilizing intra-repetition rest (IRR) configurations in training, which includes a small rest interval between single repetitions (ranging from 10-40 seconds, depending on the training goal), may maintain peak velocity (PV) and muscle power throughout a training session (Haff et al., 2008). In contrast to a continuous set of repetitions, adding a small rest period between repetitions may result in lower depletion of intramuscular phosphocreatine (PCr), lower blood lactate concentration, and potentially enhance the technical execution of the exercise (Nicholson et al., 2016; Mora - Custodio et al., 2018; Rial-Vázquez et al., 2020), leading to a higher quality of repetitions during training. Recently, two training studies showed that strength training with IRR in leg press and bench press may induce greater percentage increases in lower and upper rate of force development compared to continuous repetitions, without limiting muscle hypertrophy (Zaras et al., 2021; Zaras et al., 2022). In addition, a training set with IRR configuration may lead to a greater training load performed to a higher percentage of maximum strength compared to a continued set of repetitions (Haff et al., 2008; Nicholson et al., 2016). Results from a study in 10 weightlifters showed that introducing IRR periods of 20 and 40 seconds intervals between repetitions during power cleans at 80% of 1-RM resulted in the maintenance of peak power output, muscular force, and PV compared to continuous repetitions (Hardee et al., 2012). Moreover, IRR has been proposed as a beneficial strategy to attenuate velocity loss and maintain peak muscular force, muscle power and neuromuscular performance during strenuous resistance training (Latella et al., 2019). Consequently, IRR configurations during resistance training may be beneficial for athletes in an attempt to maintain training velocity and muscle power production. However, it remains uncertain whether IRR configuration may have a positive effect on PV during multiple sets of different loads of jump-shrugs.

Accumulated fatigue during resistance training results in a significant decrease in muscular PV reducing athletic performance (Sanchez-Medina & González-Badillo, 2011). Consequently, when the primary focus of training is to maximize the velocity of muscular movement, the progression of fatigue development during resistance training should be monitored. Using linear encoders (Fritschi et al., 2021) and IRR configurations during resistance training may be a feasible approach to solve this particular training problem as it provides the ideal conditions to monitor the movement velocity and maximize athletic performance. Thus, coaches and strength and conditioning professionals may have the training tools not only to monitor modifications in neuromuscular movement velocity during resistance training but also to adjust the specific training programs for enhancing PV and muscle power production during training. In line with this, previous studies have shown that introducing IRR configurations in the bench press and squat exercises may result in lower percentage velocity loss and maintenance of PV compared to traditional continuous repetitions (Mora Custodio et al., 2016; Garcia Ramos et al., 2015). According to the authors' knowledge, data are scarce regarding the effects of IRR configurations on PV and velocity loss during the jump-shrug exercise. The results of the current study may assist coaches and strength and conditioning professionals to design more effective training programs aiming to enhance PV of movement and as a consequence athletic performance.

Therefore, the purpose of the current study was to examine whether different IRR configurations may maintain PV during jump-shrugs and to what extent different resistance training loads and IRR may induce dissimilar velocity losses during training. The hypothesis of the study was that lower resistance training loads performed with higher velocity may induce lower velocity loss while a longer IRR configuration will maintain PV during jump-shrugs.

Materials and Methods

Participants

Twelve resistance-training participants, (8 males: age: 24.7 ± 3.8 years, body mass: 76.5 ± 10.4 kg, height: 174.3 ± 0.5 cm, BMI: 25.25 ± 3.93; and 4 females: age: 20.75 ± 1.25 years, body mass: 57.75 ± 4.4 kg, height: 161.2 ± 0.2 cm, BMI: 22.25 ± 2.24), with 4.3 ± 2.1 years of training experience in resistance training, voluntarily participated in the study. Participants were informed about the experimental procedures and signed an informed consent form. The inclusion criteria were a) age range between 18 to 25 years b) more than 2 years of training experience in resistance training c) absence of any neurological disease and orthopedic issues d) absence of drug abuse and medications that affect the neuromuscular system and e) absence from their systematic training during the experimental procedures. All procedures were under the 1975 Declaration of Helsinki as revised in 2013 and were approved by the National Bioethics Committee (project number ΕΕΒΚ/ΕΠ/2022/44).

Experimental Design

Experimental procedures were performed at the university strength and conditioning training center. All participants completed three different training sessions during a 10-day period. Before the initiation of the training, participants were informed about the purpose of the study and signed the informed consent form. Then, participants initially visited the laboratory for the evaluation of the anthropometric characteristics, maximum IMTP, and for the familiarization training sessions of jump-shrugs consisting of 4 sets of 8 repetitions at 15% of their IMTP. Following the laboratory measurements, participants performed three different training sessions, with a counterbalance design both for IRR and load conditions. During training, three different IRR conditions were applied: continuous (2 seconds, IRR2), 6 seconds rest (IRR6), and 12 seconds rest (IRR12) (Garcıá-Ramos et al., 2015). Results from our pilot study showed that the minimum time duration for continued repetitions was approximately 2sec (continuous repetitions) including landing the barbell at the training boxes, regaining position, and jumping again. Training loads were calculated from the IMTP dynamometer test (IMTPd) at 15%, 20%, and 25% of maximum IMTPd. Although previous studies have used similar or higher training intensities for jump-shrug exercise, these were calculated either from the 1-RM of power clean (Suchomel et al., 2013; Suchomel et al., 2016) or from the percentage of body mass (Rysgaard et al., 2018). In the current study, the IMTPd was chosen to determine the training loads because of the biomechanical similarity with the jump-shrug exercise.

Anthropometric Characteristics and Isometric Mid-Thigh Pull Force Measurements

During the first day of the experimental procedure, participants visited the laboratory for the evaluation of the anthropometric characteristics and IMTPd. Body mass and body height were measured on a portable scale and stadiometer to the nearest 0.1kg and 0.1cm, respectively. Following the anthropometric characteristics evaluation, participants performed a warm-up session including a 10-minute aerobic exercise on a stationary ergometer bike at 70 rpm followed by a full body dynamic stretching. Then, the IMTPd evaluation was performed. The IMTPd was chosen because is an easy-to-use laboratory tool and relative accessible for the majority of coaches and strength and conditioning practitioners especially when access to force platforms is not possible. Participants stepped on the dynamometer (Takei 5002 Analogue Dynamometer, UK) and held the barbell with both hands using lifting straps to ensure a safe grip. The knee angle was set at 131.6 ± 2.6 degrees (Haff et al., 2005; Hornsby et al., 2017). This position refers to the barbell's beginning position during the initiation of jump-shrug exercise as well as during the beginning of the second pull for clean and snatch. Participants were instructed to keep straight hands while holding the barbell, hinge and flex forward at the hip while properly keeping a neutral spine, isometrically contract the spinal erectors to stabilize the trunk, retain retracted and depressed shoulders while maintaining a "big chest" and head in a neutral position relative to the spine. Participants also were instructed to apply their muscular force as hard as possible for achieving the highest peak force. For each participant 2 submaximal attempts for warm-up purposes were given followed by 3 maximal attempts with 3 minutes of rest between attempts. The best attempt was used for the statistical analysis. The intra-class correlation coefficient (ICC) for IMTPd was: 0.998 (95% confident intervals (CI): Lower = 0.998, Upper = 0.999).

Training

Participants visited 3 times the university training center during the training phase of the study with 72 hours of rest between each visit (approximately 10 days training duration). Both IRR conditions and training loads were assigned in a randomized order. All participants followed the same protocol designed by the researchers during all three training sessions. All training sessions began with a short 10-minute warm-up on a stationary bike at 70 rpm followed by whole-body dynamic stretching exercises and 2-3 unloaded jump-shrug sets (with the 20kg barbell). Then, 3 sets of 12 repetitions with the same load (either 15, 20, or 25% of IMTPd, randomly assigned), but with 3 different IRR (2, 6, and 12 seconds, randomly assigned), were performed. Rest between sets was 10 minutes to ensure that participants were fully recovered from the previous training set and resistance load (Garcıá-Ramos et al., 2015). During training, the barbell was placed on two training boxes which were adjusted to each participant's individual kneecap height, close to their thighs similar to the initial position of IMTPd test. Participants' feet were shoulder-width apart, their toes were slightly turned outwards and their hands were placed a slightly wider than shoulder width (clean grip). In addition, a lifting belt as well as lifting straps was used during all training sessions so that the grip would not be a limiting factor during jump-shrugs. Participants were instructed to engage both lower and upper body muscles and to jump as high as possible during the concentric phase of the movement. Moreover, during the descending phase of the repetition, participants lowered the barbell onto the boxes and regained their starting position for the next repetition according to the predetermined IRR period. A linear encoder was perpendicularly attached to the barbell and collected PV data from all repetitions during all training sessions (Vitruve encoder, Vitruve fit, Madrid, Spain). Peak velocity was defined as the maximum instantaneous velocity recorded during the ascending phase of the barbell. The IRR periods and rest between sets were monitored with a stopwatch that started as soon as the barbell was lowered on the boxes.

Statistical Analysis

All variables are presented as Mean ± SD. All data were normally distributed according to the Kolmogorov-Smirnov test. A repeated measures analysis of variance with Bonferroni post hoc correction and η^2 effect size were used to examine differences in PV values between IRR for each load and absolute values PV losses for each training load. The average PV value of the 3 set configurations obtained from the first repetition for each load and rest configuration was set as the criterion to compare PV losses between different rest configurations (Garcıá-Ramos et al., 2015). This was performed since the majority of participants achieved their maximum PV during the first repetition. Reliability for all measurements was performed using a two-way random effect intra class correlation coefficient (ICC) with 95% confident intervals (CI). All data were analyzed using SPSS 21, whilst $p \leq 0.05$ was used as a 2-tailed level of significance.

Results

All participants completed the laboratory measurements and the three training sessions without injuries. Table 1 presents the training loads used in each condition, the absolute PV values collected from the mean of the first repetitions of each load as well as the average PV for each load. Absolute PV at 25% of IMTPd was significantly lower compared to 15% and 20% load conditions (p=0.001). Similarly, the average PV was significantly lower for 25% load conditions compared to 15% and 20% load conditions (p=0.001).

Table 1. Training loads, peak velocities achieved during the first repetition for all training loads, and average peak velocities for all training loads.

	15% Load	**20% Load**	**25% Load**	**p**
Mean Training Load (kg)	24.4±7.2	32.5±9.5	40.6±11.9*	0.001
PV For 2sec IRR ($m\cdot sec^{-1}$)	2.19±0.18	2.10±0.13	1.88±0.21*#	0.001
PV For 6sec IRR ($m\cdot sec^{-1}$)	2.21±0.21	2.12±0.16	1.90±0.21*#	0.001
PV For 12sec IRR ($m\cdot sec^{-1}$)	2.22±0.19‡	2.13±0.17	1.91±0.20*#	0.001
Average PV ($m\cdot sec^{-1}$)	2.21±0.20	2.11±0.15	1.89±0.20*#	0.001

*p = Significant difference between 25% load and 15% load, #p = Significant difference between 25% load and 20% load, PV = peak velocity.

Figure 1 presents the PV loss in absolute values for the 15% of IMTPd condition. No significant differences were found for the 2nd (p=0.284, η^2=0.223) and 3rd (p=0.313, η^2=0.207) repetitions between conditions. However, significant differences were found at the 4th repetition (p=0.020, η^2=0.544), between the IRR2 configuration with the IRR6 (p=0.034) and IRR12 (p=0.014) configurations. In addition from 5th to 12th repetition significant differences were found between the IRR2 and IRR12 configuration ($p<0.05$, η^2 ranged from 0.507 to 0.791). For the 11th repetition, significant difference was found (p=0.001, η^2=0.729), between IRR2 with IRR6 (p=0.017), IRR2 with IRR12 (p=0.001) and IRR6 with IRR12 (p=0.033). No other differences were found between IRR6 and IRR12 for the15% IMTPd condition. The percentage PV loss was significantly lower for the IRR12 configuration compared to IRR2 (IRR2: -8.9±1.1% vs. IRR12: -2.8±1.1%, p=0.001). Furthermore, the percentage PV loss for the IRR6 configuration (-5.3±1.1%), was not significantly different from the IRR2 and IRR12 configurations (p>0.05).

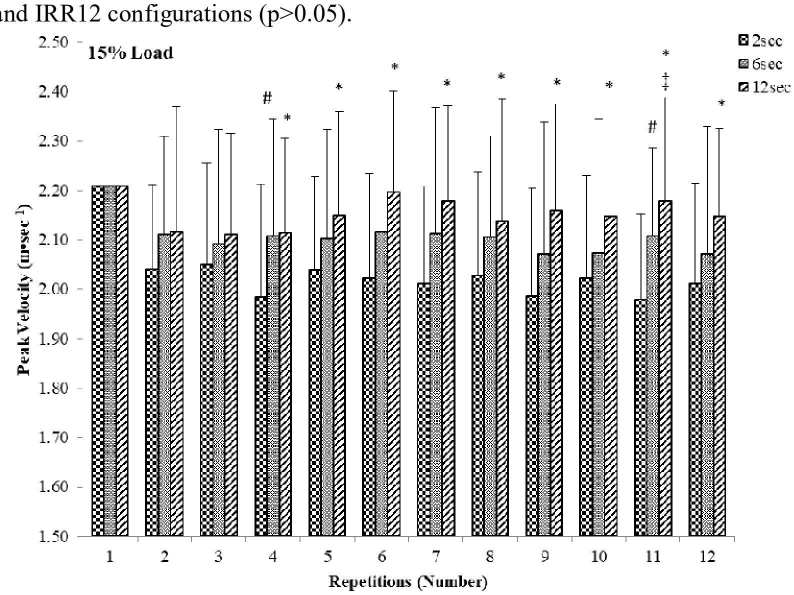

Figure 1. Differences in absolute peak velocity values for the 15% of IMTPd condition. *Significant difference between IRR12 and IRR2, #Significant difference between IRR6 and IRR2, ‡Significant difference between IRR12 and IRR6.

Figure 2 presents the PV loss in absolute values for the 20% of IMTPd condition. Significant differences were found between the IRR2 and the IRR12 configuration from the 2nd until the 12th repetition ($p<0.05$, η^2 ranged from 0.555 to 0.820). Additionally, significant differences were found between IRR2 and IRR6 configuration for the 2nd and from the 4th to 12th repetition ($p<0.05$, η2 ranged from 0.555 to 0.820). Moreover, significant differences were found between IRR6 and IRR12 at 7th (p=0.028, η^2=0.658), 8th (p=0.042, η^2=0.702) and 12th repetition (p=0.036, η^2=0.818). Similar to the 15% load condition, in the 20% load condition the percentage PV loss was significantly lower for IRR12 compared to IRR2 (IRR2: -9.3±1.1%, vs. IRR12: -1.1±0.1%, p=0.001). Moreover, significant difference was also found between the percentage PV loss between the IRR6 and IRR2 configurations (IRR2: -9.3±1.1%, vs. IRR6: -4.0±0.4%, p=0.04). No significant difference was found between the percentage PV losses between IRR12 and IRR6 configurations (p>0.05).

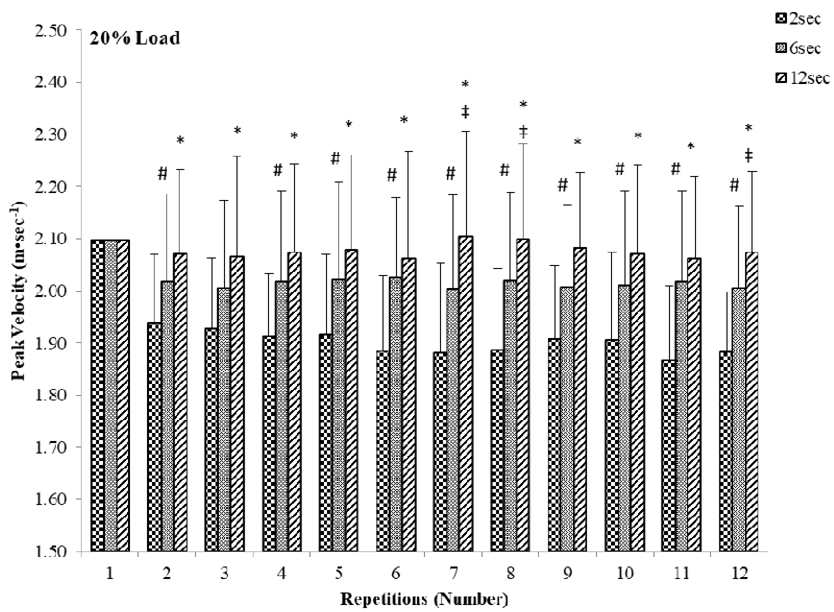

Figure 2. Differences in absolute peak velocity values for the 20% of IMTPd condition. *Significant difference between IRR12 and IRR2, #Significant difference between IRR6 and IRR2, ‡Significant difference between IRR12 and IRR6.

Figure 3 presents the PV loss in absolute values for the 25% of IMTPd condition. Significant differences were found between the IRR2 and the IRR12 configuration during all 12 repetitions ($p<0.05$, η^2 ranged from 0.466 to 0.580). Also, significant differences were found between IRR2 and IRR6 only for the 7th repetition ($p=0.031$, $\eta^2=0.527$). During the 3rd repetition IRR12 was significantly higher compared to IRR6 ($p=0.038$, $\eta^2=0.506$). The percentage PV loss was significantly lower for IRR12 compared to IRR2 (IRR2: -9.2±1.2%, vs. IRR12: -3.4±0.4%, $p=0.001$). The percentage PV loss for the IRR6 (-5.3±1.2%), was not significantly different from the IRR2 and IRR12 configurations ($p>0.05$).

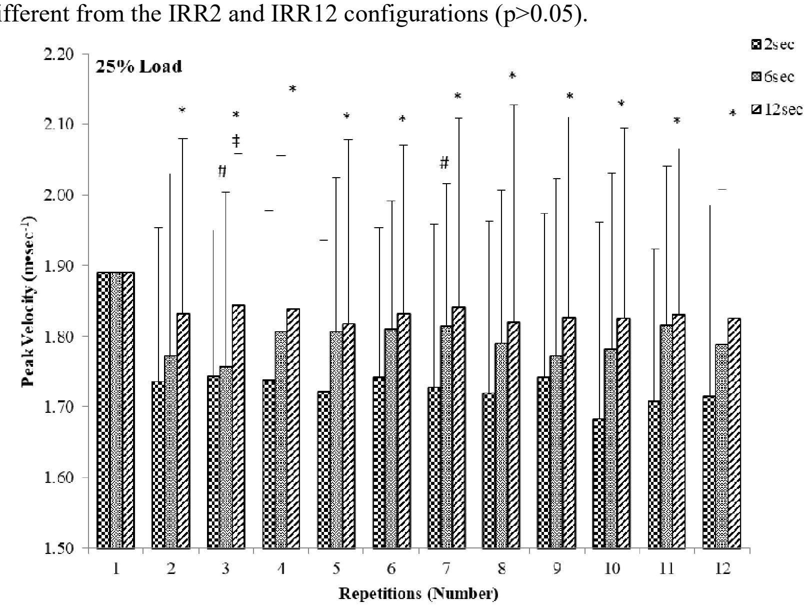

Figure 3. Differences in absolute peak velocity values for the 25% of IMTPd condition. *Significant difference between IRR12 and IRR2, #Significant difference between IRR6 and IRR2, ‡Significant difference between IRR12 and IRR6.

Discussion

The purpose of the study was to investigate whether different IRR configurations may maintain PV during jump-shrug exercise and to what extent the different resistance training loads may induce different velocity losses. The main finding of the study was that IRR12 configurations maintain PV in absolute values compared to the IRR2 configuration. These differences were apparent almost for all repetitions and during all training load conditions. However, the differences between IRR6 and IRR12 configurations were not consistent during conditions and configurations leading to the conclusion that even 6 seconds of rest between repetitions may maintain PV. In addition, the percentage of PV loss was lower for the IRR12 configuration compared to IRR2 during all training load conditions. Although, there were significant differences between IRR2 and IRR6 configurations these were more pronounced only for the 20% load condition. These results suggest that 6 seconds IRR interval may maintain the PV loss in absolute and percentage values in the jump-shrug exercise leading to a higher movement velocity during training. Consequently, coaches may use IRR greater than 6 seconds (ideally 12 seconds) to enhance the velocity of movement when jump-shrug exercise is used in training.

The jump-shrug exercise is a more complex and technical movement compared to other resistance exercises like the bench press and the squat since it involves and activates several muscle groups (Suchomel et al., 2014). In addition, the jump-shrug exercise demands fast velocity movements including a maximum vertical jump at the end of the movement which enhances the total velocity of the exercise (Kipp et al., 2021). Several studies have used training loads of 30-45% of the 1-RM power clean (Kipp et al., 2021; Suchomel et al., 2013; Suchomel et al., 2016), or the 15-45% of the percentage of body mass (Rysgaard et al., 2018). An originality of the present study was the application of loads calculated from the IMTPd test (15-20-25% of IMTPd), which is a laboratory test that has previously shown a strong correlation with weightlifting performance (Haff et al., 2005; Beckham et al., 2013). Furthermore, the jump-shrug exercise in the current study started from the top of the kneecap close to the thighs, a position biomechanically similar to the IMTPd. Therefore, coaches and strength and conditioning professionals may effectively use the IMTPd for calculating the training loads of their athletes during the jump-shrug exercise for PV enhancement, especially during power-oriented training phases.

During the past decades, the application of IRR set (involving single repetitions) and cluster set (involving groups of repetitions) configurations have shown significant increases in power and PV during resistance training (Torrejón et al., 2019). These positive outcomes on power and PV are driven by the advantages of a rest period between repetitions (Haff et al., 2008). More specifically, the introduction of a small rest period between repetitions results in acute metabolic responses such as faster resynthesis of adenosine triphosphate (ATP) and lower blood lactate concentration as well as in acute training adaptations including increases in the repetition PV and significant increase in training load compared to traditional sets (Nickolson et al., 2016; Mora-Custodio et al., 2018; Rial-Vázquez et al., 2020). Additionally, long-term training studies have shown that IRR periods may induce similar increases in muscle mass, muscle strength, and rate of force development compared to traditional resistance training mainly due to the higher velocity execution of each repetition (Zaras et al., 2021; Zaras et al., 2022). Although a large part of the research has focused on the effects of IRR configurations on structural exercises, such as the bench press (Garcia-Ramos et al. 2015), the squat (Boulosa et al., 2013), the leg press (Zaras et al., 2021) as well as on power exercises such as the power clean (Hardee et al., 2012), scarce data exist regarding the effects of IRR configuration on a fast velocity movement like the jump-shrug exercise. The results from our study demonstrate that longer IRR periods (approximately 6 seconds) may result in significant maintenance of PV compared to lower rest periods or even following continuous repetitions equal or lower to 2 seconds, as performed in the current study. A study that performed ballistic bench press throws found that the reduction in PV during the IRR12 configuration was significantly lower compared to continuous repetitions (Garcia - Ramos et al 2015). Similarly, results from a study that used the power clean exercise, which is a power exercise frequently used in weightlifting, showed that longer IRR configurations (> 20 seconds) resulted in higher maintenance of movement velocity, neuromuscular power, and force production compared to a continuous repetition configuration (Hardee et al., 2012). Moreover, studies that performed back squats showed that IRR configurations maintain repetition velocity higher than continuous repetitions or continuous sets of repetitions (Mora - Custodio et al 2018; Gonzalez-Hernandez et al., 2020). Consequently, longer IRR intervals may lead to higher maintenance of velocity in jump-shrug exercise, as previously shown in the bench press, and power clean. The outcome of the current study suggests that coaches and strength and conditioning professionals may use greater IRR intervals (equal or longer than 6 seconds), when training programs are focusing on increasing PV with jump-shrug exercise.

A significant finding of the present study was that IRR12 configuration led to a lower velocity loss between repetitions and during all load conditions compared to continuous repetitions (IRR2). More specifically, the IRR12 configuration showed significantly lower velocity loss compared to IRR2 during all load conditions. Velocity loss is considered a critical variable for neuromuscular fatigue during resistance training and may determine the optimum thresholds of velocity loss for greater benefits in hypertrophy and maximum strength (Pareja-Blanco et al., 2020). In the current study, velocity loss was lower for the IRR12 configuration compared to IRR2, but not for IRR6 configuration. These results may suggest that when the jump-shrug exercise is applied to increase PV, then equal or longer than 6 seconds IRR configurations may be used. Similarly, a study in bench press showed that the reduction in PV was significantly lower in IRR12 compared to continuous repetitions and partially with IRR6 configuration (Garcia-Ramos et al., 2015). According to the authors' knowledge, this is the first study which investigated the effect of velocity loss during jump-shrug exercise following different load conditions. Longer IRR configurations may lead to lower velocity loss and as a consequence to greater athletic performance. However, more research is required to reach certain conclusions.

The current study has some limitations. First, the small number of participants, their training level and training experience may limit the generalization of the results to elite athletic population. Although, participants were regularly trained with resistance programs and followed familiarization training before the three training sessions, the jump-shrug exercise is a multi-joint movement involving several muscle groups and demands high neuromuscular coordination which makes it a challenging exercise. Finally, the loads used in the study were calculated from the IMTPd test, thus more studies are needed to justify whether the calculation of loads through IMTPd or through force platforms is an effective method to calculate the training loads and enhance PV during jump-shrug exercise. Future studies may focus on different ranges of loads calculated from either IMTP or power clean.

Conclusions

The current study suggests that the introduction of IRR intervals equal or greater than 6 seconds may contribute in maintaining PV when the jump-shrug exercise is used in power training. The jump-shrug exercise is a fast velocity exercise frequently used in velocity-based training programs aiming to develop muscle power and PV in many athletes. Training loads from 15 to 25% of IMTPd may effectively be used as reference points in order to design effective power training programs and enhance PV during the jump-shrug exercise. Moreover, the IMTPd is an easy-to-use and low cost laboratory instrument to calculate training loads especially when access in force platforms is limited. Consequently, coaches and strength and conditioning professionals aiming to maximize PV and minimize velocity loss during a training session, may utilize low-loads but with high velocity repetitions using IRR intervals equal or greater than 6 seconds (ideally 12 seconds). These results may be applied to individual and team sport athletes, especially during the competition phase to potentially minimize fatigue and maintain PV during resistance-power training.

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