RESEARCH ARTICLE

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An Investigation into the Optimal Number of Repetitions Needed to Maintain Power Output in the Flywheel Romanian Deadlift Exercise

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ABSTRACT

The aim of this study was to investigate the desired number of repetitions required to maintain a consistent maximum power output of concentric, eccentric, and eccentric overload in a flywheel Romanian deadlift (FW RDL). Fourteen male recreational athletes (27.9 ± 6.4 years old, 90 ± 10.7 kg, 180.7 ± 5.5 cm tall) participated in the study. They had a minimum of two years resistance training experience, but none of them had any experience in flywheel inertia training (FIT). The participants performed FW RDL on an FW device (kBox 3, Exxentric, ABTM, Bromma, Sweden). Each participant attended a single test session. The testing session consisted of four sets of 14 repetitions of the RDL. Both the first and second repetitions of each set were used to 'increase momentum' and were excluded from data analysis. Each set incorporated different inertial loads. The order of inertial load settings was randomised for each participant. A five-minute inter-set rest period was given to allow the cessation of any fatigue effects and to enable adequate recovery. During the repetition analysis, a ≥ 20% drop in value from the preceding repetition was used as a cut-off point and recorded. The optimal number of repetitions required to maintain peak concentric and eccentric power was between 10 and 11, whereas 6 to 8 repetitions is advised to maintain eccentric overload.

Keywords: Flywheel inertia training, inertial load, volume prescription.

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I. Introduction

Recently, flywheel inertia training (FIT) has gained prominence as a training method. FIT was first explored over 20 years ago as a gravity-independent training technique to offset the damaging effects of microgravity on skeletal muscles (Berg & Tesch, 1994). The flywheel is rotated by individuals during CON muscle actions; the energy expended is then recovered during the ECC phase of the exercise, requiring eccentric strength to halt the flywheel (Bollinger *et al.*, 2020). The flywheel principle is used by inertial devices to generate resistance throughout the entire range of motion (Maroto-Izquierdo *et al.*, 2017). The force used during the CON phase unwinds a string attached to the shaft of the FW, which then begins to rotate and stores energy. As the rotating speed increases, kinetic energy also increases (Onambélé *et al.*, 2008). The athlete must slow down by utilising an ECC muscle action to counteract the pull of the flywheel after the CON action is completed. ECC overload can be safely produced in force/power values by employing a suitable technique, such as gently resisting the inertial force during the first third of the ECC action and then exerting maximum effort to stop the movement at the conclusion of the range of motion (Tous-Fajardo *et al.*, 2006). ECC overload occurs when ECC force exceeds CON force during exercise (Tesch *et al.*, 2017).

Many studies have investigated the effectiveness of FIT in improving strength and power output, but there are very few practical guidelines regarding the number of repetitions advised to maximise warranted adaptations. A topical review by Tesch *et al.* (2017) summarised the findings of several FIT interventions and recommended four sets of seven repetitions as FIT guidelines. Many of the studies reviewed in this review used isolated single-joint movements or small-muscle group exercises. While this type of training may be advantageous for bodybuilding and rehabilitation settings, it is not commonly practiced with team sports athletes, where multi-joint, large muscle group exercises are favoured for strength and power development (Haff & Nimphius, 2012). Recent studies have used multi-joint, large muscle group exercises, such as bilateral squats (Nuñez Sanchez & Sáez de Villarreal, 2017; Sabido *et al.*, 2018), but the repetition range varied greatly between both studies (5–15 repetitions per set). Some studies have reported improvements in power output (counter-movement jump, squat jump, and running speed) using seven–eight repetitions (Naczk *et al.*, 2016), whereas other studies have reported similar improvements using 15–20 repetitions (Gual *et al.*, 2016). With the broad repetition ranges used in previous studies, further research is warranted to investigate the repetition range for both strength and power development in large muscle group exercises, such as RDL. The aim of this study is to determine the number of repetitions required to maintain both concentric and eccentric power outputs and an eccentric overload using an optimal inertial load. To the best of our knowledge, no previous study has investigated such effects in the FW RDL exercise.

II. Materials and Methods

A. Experimental Design

This study utilised a cross-sectional design to determine the optimal number of repetitions to maintain power output during bilateral FW hip extension on concentric and eccentric peak power and the eccentric: concentric peak power ratio.

B. Subjects

The study included 14 recreationally trained males (mean age: 27.9±6.4 years; mean weight: 90±10.7 kg; mean height: 180.7±5.5 cm). Although none of the participants had any prior FIT training, they all had at least two years of experience with resistance exercise. From 48 hours prior to testing, the subjects were asked not to engage in any severe activity. Participants underwent medical screening, and those with musculoskeletal injuries six months prior to the intervention were excluded. Before taking part, every subject provided written informed permission and was made aware of all the hazards associated with the investigation. This study was approved by the Ethics Committee of the South East Technological University.

C. Procedures

To stabilise FIT values, all participants received three familiarisation sessions (Sabido *et al.*, 2018). Each participant attended one test session. To avoid the negative effects of muscle fatigue and the delayed onset of muscle soreness, a five-day break was given between all familiarisation and test sessions. An active warm-up that lasted approximately 15 min preceded all sessions. Four sets of 14 repetitions of the Romanian Deadlift (RDL) on a flywheel machine (kBox 3, Exxentric, AB TM, Bromma, Sweden) was used in the testing session. The first and second iterations of each set were used to create momentum; and were excluded from the data analysis. The initial FIT repetitions, often known as “waste repetitions,” have been reported to be necessary in order to obtain the ideal FW velocity (Suchomel *et al.*, 2019b). Different inertial loads were applied to test each set. Each participant’s inertial load settings were arranged in random order. To allow for the cessation of any tiredness effects and guarantee appropriate recuperation, a five-minute pause was given between each set.

Participants were advised to stand precisely above the drive belt of the device to ensure uniform foot placement. A piece of tape was placed halfway between the most distal point of the tibial tuberosity and the most proximal point of the talus to standardise the range of motion of the subjects. The starting position for the exercise was complete flexion, or where the lowest range of motion was achieved. The handle began moving the FW when the RDL was in its concentric phase. The FW kept rotating while being slowed down by the eccentric muscle action during the eccentric phase of the RDL, producing a braking effect. For the subsequent repetitions, identical procedures were used. Participants were instructed not to elevate their shoulders while extending their hips fully, and ankle extension was not permitted. Participants were not permitted to stretch their ankles or shrug their shoulders during full hip extension. The concentric phase was completed by the participants as quickly as feasible. They were then advised to resist the inertial force during the first third of the eccentric action and use all their efforts to stop the motion at the end of the range of motion. Throughout the familiarisation and testing sessions, participants received verbal support.

A data reader and transmitter (Kmeter, Exxentric, AB TM, Bromma, Sweden) connected to the FW device was used to measure concentric and eccentric powers during each repetition. This device records FW rotational data based on angular displacement at a rate of one impulse for every 5.625° of FW rotation (O Brien *et al.*, 2022). After averaging the data across a 40 ms frame, Bluetooth-enabled to an iPad mini from Apple Inc. in Cupertino, California, USA. At high rotation speeds, this data collection method offers more thorough data sampling (Bollinger *et al.*, 2020). Peak eccentric and concentric power, as well as the ratio of the two, also known as the percent eccentric overload and calculated as [(eccentric peak power - concentric peak power)/concentric peak power] * 100, were the variables used for data analysis. Repetition maintenance was only examined for inertial loadings that were statistically significant ($p < 0.05$) and established in a prior study (O Brien *et al.*, 2022) as optimal for peak force output.

D. Statistical Analysis

Data are presented as the mean ± standard deviation (SD). During the repetition analysis, a ≥ 20% drop in the value from the preceding repetition was used as the cut-off point. A decrease of ≥ 20% in velocity/power has been reported as an indicator of neuromuscular fatigue during resistance training

(González-Badillo & Sánchez-Medina, 2010; Pareja-Blanco *et al.*, 2017; Sánchez-Medina & González-Badillo, 2011). All analyses were performed in Microsoft Excel.

III. Results

For concentric peak power at 0.025 kg·m², lower values were found after repetition 11 (Fig. 1). For eccentric peak power at 0.025 kg·m² & 0.05 kg·m² inertial load, lower values were found to commence after repetitions 10 and 11, respectively (Fig. 2). For eccentric overload at 0.05 kg·m², 0.075 kg·m² & 0.100 kg·m² inertial load, lower values were found to commence after repetitions 8, 6, and 7, respectively (Fig. 3).

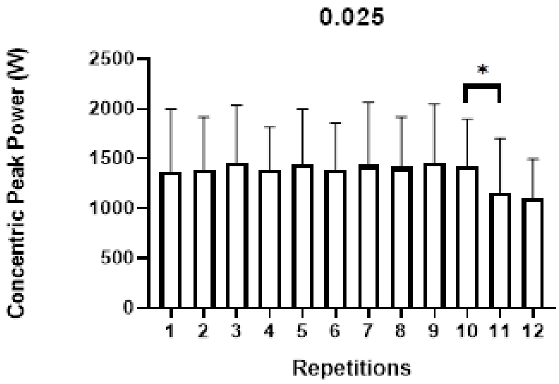

Fig. 1. Concentric peak power repetitions for 0.025 kg·m² inertial load.
The asterisk (*) denotes ≥ 20% decrease in performance.

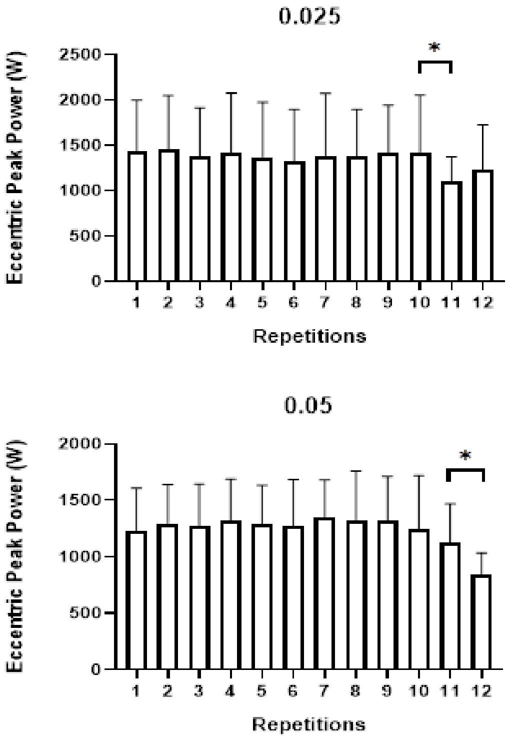

Fig. 2. Eccentric peak power repetitions for 0.025 & 0.05 kg·m² inertial load.
The asterisk (*) denotes a ≥ 20% decrease in performance.

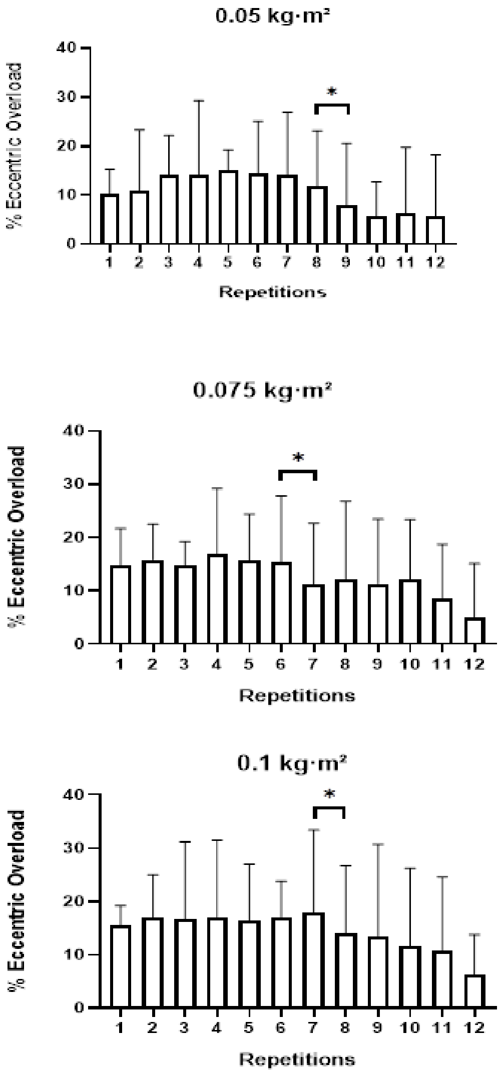

Fig. 3. Percentage of eccentric overload for varying inertial loads.
The asterisk (*) denotes a ≥ 20% decrease in performance.

IV. Discussion

This study aimed to establish the optimal number of repetitions required to maintain both concentric and eccentric power outputs and the percentage of eccentric overload during the RDL exercise. The data suggests that for the maintenance of concentric and eccentric peak power, repetitions of 10 and 11 are recommended; however, if eccentric overload is desired, then repetitions between 6 and 8 are recommended.

Volume prescription is a significant element in the design of training programs.The total number of repetitions made during a training session is typically used to estimate training volume. (Kraemer & Ratamess, 2004). The optimal volume in FIT is an important factor because an incorrect volume prescription will lead to training failure and poor training load management (Suchomel *et al.*, 2019a). Training to failure not only significantly reduces the force a muscle can generate, but also impairs the nervous system's capacity to voluntarily activate the muscles, leading to fatigue (Häkkinen, 1993), which could have antagonistic effects on rapid force production, movement velocity, and power production (Häkkinen & Kauhanen, 1989). There is a lack of research on optimal volume prescriptions for FIT. Many previous studies have used four sets of seven repetitions based on anecdotal evidence and without a clear principle for volume selection. It is generally accepted that different training volumes result in specific neuromuscular changes (Kraemer & Ratamess, 2004). Our study found that for concentric and eccentric peak powers, a range of 10–11 repetitions is recommended to maintain power values. Beyond this range, decreases were observed which are viewed as an indication of muscular fatigue. For eccentric overload, a lower range is suggested, with a range of 6-8 repetitions being adequate to maintain the power values. After this point, a significant drop-off occurred. Our findings are like those of Sabido *et al.* (2018), who reported that the total number of repetitions without significant decreases was similar between varying inertial loads in both concentric and eccentric peak powers, and eccentric overload. This data may be valuable for volume prescription to ensure that the specific adaptation required coincides with the specific repetitions needed to achieve the desired effect.

This research has practical implications for coaches, athletes, and fitness enthusiasts seeking to optimise FIT regimens. When the goal is to maintain concentric and eccentric peak powers, our results suggest that the appropriate volume of repetitions should be 10–11. This is beneficial for ensuring maximum power output during the training session without succumbing to muscular fatigue. For those who seek to maximise eccentric overload, often utilised to increase muscle hypertrophy, and improve eccentric strength (Suchomel *et al.*, 2019a), a lower volume range of 6-8 repetitions is recommended. Prescribing volumes beyond these ranges could potentially lead to decreased performance and an increased risk of injury due to fatigue. These findings offer a more nuanced approach to FIT, suggesting that one-size-fits-all repetition schemes may not always be effective. Tailoring volume prescriptions to specific goals may lead to more targeted neuromuscular adaptations, improving the efficiency and outcomes of FIT workouts.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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