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Effects of Different Inertial Load Settings on Power Output Using a Flywheel Leg Curl Exercise and its Inter-Session Reliability

by
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This study aimed to analyze the influence of the inertial load on both concentric and eccentric power output production during the flywheel leg curl exercise, and to assess the reliability of power output variables. Sixteen participants (8 males, 8 females) attended 4 testing sessions. During testing, participants performed one set of eight repetitions using a specific inertial load (0.083, 0.132, 0.182, 0.266 and 0.350 kg·m²) with a flywheel leg curl exercise. Concentric (CON) power, eccentric (ECC) power and the ECC/CON ratio were analyzed. The reliability analysis between sessions was performed. A significant interaction of inertia load x gender was found in CON power ($p < 0.001$) and in ECC power ($p = 0.004$), but not in the ECC/CON ratio ($p = 0.731$). A significant with-in (inertia loads) effect was found in CON power ($p < 0.001$) and in ECC power ($p < 0.001$), but not in the ECC/CON ratio ($p = 0.096$). CON power showed very high reliability scores, ECC power showed high to very high reliability scores, while the ECC/CON ratio ranged from poor to moderate. A significant between gender effect was found in CON power ($p < 0.001$) and in ECC power ($p < 0.001$), but not in the ECC/CON ratio ($p = 0.752$). This study is the first to report that power output in the flywheel leg curl exercise is altered by the inertia load used, as well as power output is different according to gender. CON and ECC power output presents high to very high reliability scores, and the ECC/CON ratio should not be used instead. These results can have important practical implications for testing and training prescription in sports.

Key words: *eccentric overload, iso-inertial, resistance training, hamstring muscles.*

Introduction

Flywheel (FW) training has emerged as an alternative to traditional resistance training (Beato et al., 2019; Tous-Fajardo et al., 2016). FW devices allow for greater force and power during the eccentric phase of the movement than using isotonic exercises, which is the main advantage offered by this technology (Berg and Tesch, 1994). FW training allows for a near maximal muscle activation in the concentric (CON) phase and also for an increased load production in the eccentric (ECC) phase compared to the CON phase of the movement (de Hoyo et al., 2014; Norrbrand et al., 2008, 2010). In detail, during the concentric phase, the athlete rotationally accelerates the flywheel,

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and this rotation results in a flywheel inertial torque that imparts high vertical resistance during the eccentric phase (Beato et al., 2019; Coratella et al., 2015; Petré et al., 2018; Staniszewski et al., 2020). When using FW devices, subjects are generally instructed to perform the CON phase of the movement as fast as possible, and to delay the braking action until the last part of the ECC phase (Beato et al., 2019). Using such an exercise approach, an eccentric overload is generated (Petré et al., 2018). For such a motivation, some different training systems have been designed, based on the FW paradigm, to enhance lower limb performance (Berg and Tesch, 1994; Tesch et al., 2017).

The effects of resistance training using FW devices have been extensively investigated over the past 20 years. Thus, several studies have confirmed the efficacy of FW resistance training for eliciting muscle hypertrophy and force production (Berg and Tesch, 1994). In addition, FW devices have been used as an aid in the treatment and prevention of tendon and muscle injuries (Tesch et al., 2017). Improvements in athletic performance and decreases in injury prevalence have usually been found when training with FW devices, in spite of the wide variety of training loads used in the different studies (Illera-Domínguez et al., 2018; Petré et al., 2018; Tesch et al., 2017; Tous-Fajardo et al., 2016). The management of exercise variables is essential to achieve a specific muscle response (*e.g.*, power increase) and to optimize performance enhancement (*e.g.*, sport specific tasks) (Beato et al., 2018; Folland and Williams, 2007; Norrbrand et al., 2010), as well as to obtain acute muscle variations (Piqueras-Sanchiz et al., 2019). The most typical prescriptions to achieve these goals have reported the utilization of 4 sets of 7 all-out repetitions during 5–15 weeks (Naczk et al., 2016; Sabido et al., 2018; Tous-Fajardo et al., 2006, 2016). However, some different mechanical responses during training using FW devices have been observed depending on the inertia used, which seems to be a critical component for training optimization (Sabido et al., 2018). Previous research reported that the training load could be analyzed using the mean and peak power output during ECC and CON phases of FW exercises (Piqueras-Sanchiz et al., 2019). Recently, power production has been analyzed during FW resistance exercise with different inertial settings for men and women in a knee extension device (Martínez-Aranda and Fernández-Gonzalo, 2017). Power decreased at higher inertia, with male participants showing greater decrements than females (-36 vs. -29%), and males reported higher power values than females. Additionally, Sabido et al. (2018) analyzed the effects of different inertial loads on power production during the FW quarter-squat, showing that greater ECC and CON peak power was elicited with the lightest inertial load used in the study (0.025 kg·m²), and conversely, this load elicited the lowest ECC/CON ratio. However, this previous evidence is related to exercises involving knee extensor muscles, but no background is currently available on knee flexion exercises (*e.g.*, leg curl).

Compared with other hamstring exercises (e.g., Romanian deadlift, “good morning” and glute ham-rise), the prone leg curl exercise performed on a weight-stack machine, resulted in a lower CON, and especially ECC muscle activation (McAllister et al., 2014). However, Tous-Fajardo et al. (2006) showed that both biceps femoris and semitendinosus muscles were almost maximally activated during the flywheel leg curl exercise. Consequently, the flywheel leg curl exercise has been commonly used to produce eccentric overload (Norrbrand et al., 2010; Tous-Fajardo et al., 2006). Despite the widespread use of this device in strength and conditioning, the reliability of power output over time and the influence of different inertial loads on both ECC and CON power output, as well as the ECC/CON ratio have not been studied before. Therefore, further research is needed to clarify the impact of different inertial loads on power output using FW hamstring exercises. This could be particularly important for practitioners, since this device has been increasingly implemented in exercise programs designed to prevent hamstring injuries (Hagglund et al., 2013; Vicens-Bordas et al., 2017, 2018). To the authors' knowledge, there is no solid evidence indicating the number of sessions required to determine reliable values when employing this exercise, even if previous studies reported the necessity of familiarization (Sabido et al., 2018; Tous-Fajardo et al., 2006). Moreover, there is no research that has analyzed the reliability and the possible differences between inertia and sexes, in terms of power output, during a FW hamstring (knee dominant) exercise.

Therefore, the first aim of this study was to analyze power output (*i.e.,* ECC and CON peak power and ECC/CON ratio) obtained in the FW leg curl exercise using different loads (0.083, 0.132, 0.182, 0.266, and 0.350 kg·m^2) involving male and female participants. The second aim was to analyze the reliability over time in these power variables while applying five different inertial loads. Authors hypothesized that, firstly, greater power values could be obtained with a light inertial load compared to heavier loads, secondly, male participants could produce higher CON and ECC power output compared to female participants, lastly, a higher value of reliability would be reached in the ECC and CON peak power compared to the ECC/CON ratio.

Methods

Participants

Sixteen amateur university sports athletes (8 males, age = 24.2 ± 2.4 years, body height = 1.79 ± 0.05 m, body mass = 75.7 ± 6.0 kg; and 8 females, age = 20.3 ± 1.9 years, body height = 1.65 ± 0.03 m, body mass = 60.1 ± 3.4 kg) voluntarily participated in the study. All participants were trained and were regularly competing in their respective sports (soccer [n = 5], tennis [n = 4], volleyball [n = 4], handball [n = 2], and taekwondo [n = 2]). For inclusion in the study, participants were required to be outside regular competition and to have reduced training schedules for at least one full week prior to testing, and throughout the study, to avoid the effects of accumulated fatigue on results. All participants were carefully informed about the potential risks of the testing sessions and signed written informed consent approved by the Research Ethics Committee of the University Isabel I (code: PI-008) in accordance with the Declaration of Helsinki before participation.

Design and Procedures

The study used a parallel group design to evaluate the influence of different inertial loads on concentric power, eccentric power and its ratio in the FW leg curl exercise. In addition, the inter-day reliability of the outcome measures was evaluated using a cross-over protocol. To this end, each participant attended four testing sessions in a 4-week period in randomized order to avoid a potential learning effect (Sabido et al., 2018). During all testing sessions, each participant performed 5 sets of 8 repetitions (one repetition was necessary to activate the inertia) of the FW leg curl exercise. Each of these 5 sets differed in the inertial load used (0.083, 0.132, 0.182, 0.266, and 0.332 kg·m^2). To avoid experimental variability, the same researcher conducted all testing sessions, and participants were scheduled each week on the same day and at the same time for each session. Each participant was asked to refrain from heavy exercise for the 48 hours preceding testing and were encouraged to maintain their normal diet and fluid intake for the duration of the study. In addition, participants were requested not to take any nutritional supplements or anti-inflammatory medications, and to refrain from caffeine intake in the 3 hours before each testing session.

Measures

After a standardized warm-up consisting of 5 minutes of jogging (including upper and lower-body joint mobility without static stretching), and a submaximal set of 10 repetitions in the FW leg curl exercise with an inertial load of 0.132 kg·m^2, each participant performed 5 sets of 8 all-out repetitions using the mentioned FW device. To avoid accumulated fatigue effects derived from the performance of multiple sets, participants were randomly divided into ascending order (starting with the lighter inertial load of 0.083 kg·m^2) and descending order (starting with the higher inertial load of 0.350 kg·m^2) (Sabido et al., 2018). In addition, the rest interval between sets was set at 5 min, ensuring participants' complete recovery. The range of motion was limited by the FW device "Eccophysic" (Byomedic System SCP, Barcelona, Spain), allowing a movement from the full extension of the knee (180º), up to 80º of the knee joint angle at the end of the movement. Participants were instructed and fully encouraged to perform the CON phase of the movement as fast as possible, and to delay the braking action until the last part of the ECC phase. During all repetitions, kinetic and kinematic data were recorded by means of a rotational encoder coupled to the FW device and analyzed by software (Chronopic, ChronoJump, Boscosystem®, Spain). The variables used for analysis were peak ECC power, peak CON power, and its ratio (*i.e.,* ECC/CON). The data analysis was performed using the mean of the 8 repetitions for each set.

Statistical analysis

Data are presented as mean ± standard deviation (SD). Analysis of variance (ANOVA) was employed to detect possible with-in (inertial loads) and between-group differences (gender). Sphericity assumption check was performed by the Mauchly's test, and if a violation was found, correction by Greenhouse-Geisser was applied. When significant F-values were found, post hoc analysis was performed (with Bonferroni corrections applied to the alpha value). Statistical significance was set at $p < 0.05$. Robust estimates of 95% Confidence limits (CL) and heteroscedasticity were calculated using bootstrapping technique (1000 randomly bootstrapped samples). Effect size (ES) based on the Cohen d principle were reported with 95% CL and interpreted as: *trivial* < 0.2; 0.2 ≤ *small* < 0.6; 0.6 ≤ *moderate* < 1.2; 1.2 ≤ *large* < 2.0; *very large* > 2.0. The reliability of the measures was assessed through Cronbach-α and reported with 95% CL. Cronbach-α values were interpreted as: *poor* (0-0.49), *moderate* (0.5–0.69), *high* (0.7–0.89), and *very high* (≥0.9). Statistical analyses were performed by JASP software version 0.9.1 (Amsterdam, Netherlands) for Mac.

Results

A significant interaction inertia (loads x gender) was found in CON power (F = 17.25, p < 0.001) and in ECC power (F = 7.61, p = 0.004), but not in the ECC/CON ratio (F = 0.31, p = 0.731). A significant with-in (inertia loads) effect was found in CON power (F = 115.68, p < 0.001) and in ECC power (F = 57.38, p < 0.001), but not in the ECC/CON ratio (F = 2.58, p = 0.096). The graphical representation of the effect of the different inertial loads and gender on CON power, ECC power, and the ECC/CON ratio is reported in Figures 1 to 3.

With-in (inertia loads) post-hoc analysis was performed for CON power and ECC power, but not for the ECC/CON ratio (as no with-in effect was found). Post-hoc analysis is reported in Tables 1 and 2.

A significant between (gender) effect was found in CON power (F = 36.87, p < 0.001) and in ECC power (F = 31.16, p < 0.001), but not in the ECC/CON ratio (F = 0.10, p = 0.752). Post-hoc analysis was performed for CON power and ECC power, but not for the ECC/CON ratio (because no between effect was found).

A statistical difference was found between genders in CON power using 0.083 kg·m^2 (p < 0.001, ES = 3.1), 0.132 kg·m^2 (p < 0.001, ES = 3.1), 0.182 kg·m^2 (p < 0.001, ES = 3.0), 0.266 kg·m^2 (p < 0.001, ES = 3.0, and 0.332 kg·m^2 (p < 0.001, ES = 2.1). A significant difference was found between genders in ECC power using 0.083 kg·m^2 (p < 0.001, ES = 2.4), 0.132 kg·m^2 (p < 0.001, ES = 2.8), 0.182 kg·m^2 (p < 0.001, ES = 2.7), 0.266 kg·m^2 (p < 0.001, ES = 3.0), and 0.332 kg·m^2 (p < 0.001, ES = 1.9).

The inter-day reliability of the outcomes measured between sessions 1-2, 2-3, 3-4 is reported in Table 1. CON power showed *very high* α scores, ECC power showed *high* to *very high* α scores, while the α values for the ECC/CON ratio ranged from *poor* to *moderate*. Only participants that performed all four sessions were involved in the reliability analysis (n = 10).

Discussion

The aims of this study were to show the differences in power variables (CON and ECC peak power and ECC/CON ratio) in response to five different inertial loads (0.083, 0.132, 0.182, 0.266 and 0.350 kg·m^2) in both genders, and to analyze the reliability over time of these power variables obtained in the FW leg curl exercise. In agreement with the hypothesis, greater power values were obtained with a light inertia compared to heavier loads, in addition, males generated greater power output than female participants using any inertia. Moreover, *high* to *very high* reliability scores were obtained when evaluating the CON and ECC peak power in most inertial loads, while ECC/CON ratios showed *poor* to *moderate* reliability scores.

Sport-specific actions such as jumps, sprints or changes of direction play a critical role in sports and have a high relationship with muscle power (Coratella et al., 2018; Haugen et al., 2014). In this sense, literature has shown that to optimize athletic actions and achieve sporting success, high muscular power is required (Cormie et al., 2011).

Table 1

Post-hoc analysis of CON power for the following inertial loads: 0.083, 0.132, 0.266, and 0.350 kg·m² (n = 16).

Inertial load (kg·m²)	P_{conc} (W)	Standardized difference (95%CL)	Qualitative assessment	p-level
MALES				
0.083 vs. 0.132	247 ± 54 vs. 245 ± 61	0.03 (-0.18, 0.24)	*trivial*	$p > 0.05$
0.083 vs. 0.182	247 ± 54 vs. 212 ± 58	0.58 (0.35, 0.80)	*small*	$p < 0.05$
0.083 vs. 0.266	247 ± 54 vs. 158 ± 42	1.46 (1.19, 1.74)	*large*	$p < 0.01$
0.083 vs. 0.350	247 ± 54 vs. 91 ± 32	2.58 (2.08, 3.08)	*very large*	$p < 0.01$
0.132 vs. 0.182	245 ± 61 vs. 212 ± 58	0.55 (0.40, 0.69)	*small*	$p < 0.01$
0.132 vs. 0.266	245 ± 61 vs. 158 ± 42	1.44 (1.15, 1.72)	*large*	$p < 0.01$
0.132 vs. 0.350	245 ± 61 vs. 91 ± 32	2.55 (1.99, 3.12)	*very large*	$p < 0.01$
0.182 vs. 0.266	212 ± 58 vs. 158 ± 42	0.89 (0.66, 1.12)	*moderate*	$p < 0.01$
0.182 vs. 0.350	212 ± 58 vs. 91 ± 32	2.01 (1.51, 2.51)	*very large*	$p < 0.01$
0.266 vs. 0.350	158 ± 42 vs. 91 ± 32	1.12 (0.80, 1.44)	*moderate*	$p < 0.01$
FEMALES				
0.083 vs. 0.132	111 ± 31 vs. 98 ± 30	0.37 (0.11, 0.63)	*small*	$p < 0.05$
0.083 vs. 0.182	111 ± 31 vs. 84 ± 21	0.79 (0.46, 1.11)	*moderate*	$p < 0.05$
0.083 vs. 0.266	111 ± 31 vs. 61 ± 19	1.44 (1.08, 1.81)	*large*	$p < 0.01$
0.083 vs. 0.350	111 ± 31 vs. 41 ± 11	2.11 (1.64, 2.58)	*very large*	$p < 0.01$
0.132 vs. 0.182	98 ± 30 vs. 84 ± 21	0.42 (0.18, 0.67)	*small*	$p < 0.05$
0.132 vs. 0.266	98 ± 30 vs. 61 ± 19	1.08 (0.82, 1.33)	*moderate*	$p < 0.01$
0.132 vs. 0.350	98 ± 30 vs. 41 ± 11	1.83 (1.51, 2.16)	*large*	$p < 0.01$
0.182 vs. 0.266	84 ± 21 vs. 61 ± 19	0.66 (0.49, 0.82)	*moderate*	$p < 0.01$
0.182 vs. 0.350	84 ± 21 vs. 41 ± 11	1.35 (1.08, 1.61)	*large*	$p < 0.01$
0.266 vs. 0.350	61 ± 19 vs. 41 ± 11	0.68 (0.50, 0.85)	*moderate*	$p < 0.01$

CON = concentric contraction; W = Watt; CL = Confidence limits.

Table 2

Post-hoc analysis of ECC power for the following inertial loads: 0.083, 0.132, 0.266, and 0.350 kg·m² (n = 16).

Inertial load (kg·m²)	P_{ecc} (W)	Standardized difference (95%CL)	Qualitative assessment	*p*-level
MALES				
0.083 vs. 0.132	338 ± 96 vs. 344 ± 91	-0.05 (-0.25, 0.14)	*trivial*	$p > 0.05$
0.083 vs. 0.182	338 ± 96 vs. 287 ± 85	0.47 (0.23, 0.71)	*moderate*	$p < 0.05$
0.083 vs. 0.266	338 ± 96 vs. 230 ± 58	1.00 (0.59, 1.42)	*moderate*	$p < 0.01$
0.083 vs. 0.350	338 ± 96 vs. 135 ± 47	1.89 (1.32, 2.46)	*large*	$p < 0.01$
0.132 vs. 0.182	344 ± 91 vs. 287 ± 85	0.53 (0.36, 0.69)	*small*	$p < 0.01$
0.132 vs. 0.266	344 ± 91 vs. 230 ± 58	1.06 (0.71, 1.40)	*moderate*	$p < 0.01$
0.132 vs. 0.350	344 ± 91 vs. 135 ± 47	1.94 (1.39, 2.50)	*large*	$p < 0.01$
0.182 vs. 0.266	287 ± 85 vs. 230 ± 58	0.53 (0.27, 0.80)	*small*	$p < 0.01$
0.182 vs. 0.350	287 ± 85 vs. 135 ± 47	1.42 (0.95, 1.88)	*large*	$p < 0.01$
0.266 vs. 0.350	230 ± 58 vs. 135 ± 47	0.89 (0.59, 1.18)	*moderate*	$p < 0.01$
FEMALES				
0.083 vs. 0.132	158 ± 54 vs. 152 ± 39	0.18 (-0.16, 0.52)	*trivial*	$p > 0.05$
0.083 vs. 0.182	158 ± 54 vs. 115 ± 36	0.72 (0.31, 1.13)	*moderate*	$p < 0.01$
0.083 vs. 0.266	158 ± 54 vs. 90 ± 34	1.14 (0.69, 1.59)	*large*	$p < 0.01$
0.083 vs. 0.350	158 ± 54 vs. 62 ± 22	1.69 (1.21, 2.17)	*large*	$p < 0.01$
0.132 vs. 0.182	152 ± 39 vs. 115 ± 36	0.48 (0.27, 0.69)	*small*	$p < 0.01$
0.132 vs. 0.266	152 ± 39 vs. 90 ± 34	0.94 (0.68, 1.20)	*moderate*	$p < 0.01$
0.132 vs. 0.350	152 ± 39 vs. 62 ± 22	1.51 (1.27, 1.75)	*large*	$p < 0.01$
0.182 vs. 0.266	115 ± 36 vs. 90 ± 34	0.42 (0.21, 0.63)	*small*	$p < 0.01$
0.182 vs. 0.350	115 ± 36 vs. 62 ± 22	1.03 (0.79, 1.27)	*moderate*	$p < 0.01$
0.266 vs. 0.350	90 ± 34 vs. 62 ± 22	0.57 (0.39, 0.75)	*small*	$p < 0.01$

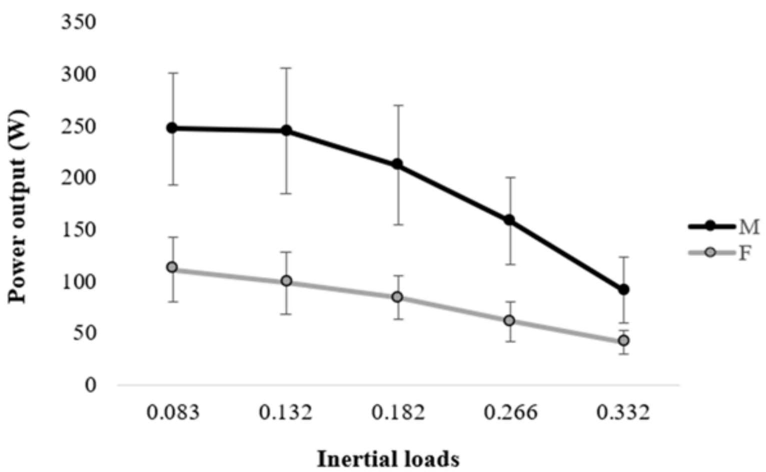
ECC = Eccentric contraction; W = Watt; CL = Confidence limits.

Table 3

Reliability of the variables considered in the study between sessions 1-2, 2-3, 3-4 (n = 10).

Variable	α 1-2 (95% CL)	α 2-3 (95% CL)	α 3-4 (95% CL)
P_{conc} 0.083 kg·m²	0.96 (0.89, 0.99)	0.94 (0.81,0.98)	0.97 (0.90, 0.99)
P_{ecc} 0.083 kg·m²	0.92 (0.75, 0.97)	0.85 (0.51, 0.95)	0.95 (0.82, 0.98)
Ratio 0.083 kg·m²	0.70 (0.04, 0.91)	0.43 (-0.85, 0.82)	0.37 (-0.55, 0.80)
P_{conc} 0.132 kg·m²	0.91(0.72, 0.97)	0.92 (0.75, 0.97)	0.96 (0.88, 0.99)
P_{ecc} 0.132 kg·m²	0.90(0.68, 0.97)	0.89 (0.65, 0.97)	0.94 (0.80, 0.98)
Ratio 0.132 kg·m²	0.49(-0.65, 0.84)	0.74(0.15, 0.92)	0.30 (-0.70, 0.79)
P_{conc} 0.182 kg·m²	0.94 (0.80, 0.98)	0.93 (0.76, 0.97)	0.96 (0.88, 0.99)
P_{ecc} 0.182 kg·m²	0.92 (0.75, 0.98)	0.90 (0.69, 0.97)	0.96 (0.87, 0.98)
Ratio 0.182 kg·m²	0.69 (0.01, 0.91)	0.24 (-0.70, 0.83)	0.45 (-0.80, 0.83)
P_{conc} 0.266 kg·m²	0.97 (0.92, 0.99)	0.95 (0.83, 0.98)	0.93 (0.80, 0.98)
P_{ecc} 0.266 kg·m²	0.91 (0.70, 0.97)	0.89 (0.65, 0.97)	0.92 (0.73, 0.97)
Ratio 0.266 kg·m²	0.30 (-0.40, 0.78)	0.61 (-0.24, 0.88)	0.45 (-0.40, 0.87)
P_{conc} 0.350 kg·m²	0.97 (0.92, 0.99)	0.92 (0.77, 0.98)	0.96 (0.88, 0.99)
P_{ecc} 0.350 kg·m²	0.94 (0.82, 0.98)	0.85 (0.45, 0.95)	0.91 (0.72, 0.97)
Ratio 0.350 kg·m²	0.67 (-0.07, 0.90)	0.60 (0.30, 0.89)	0.58 (0.35, 0.87)

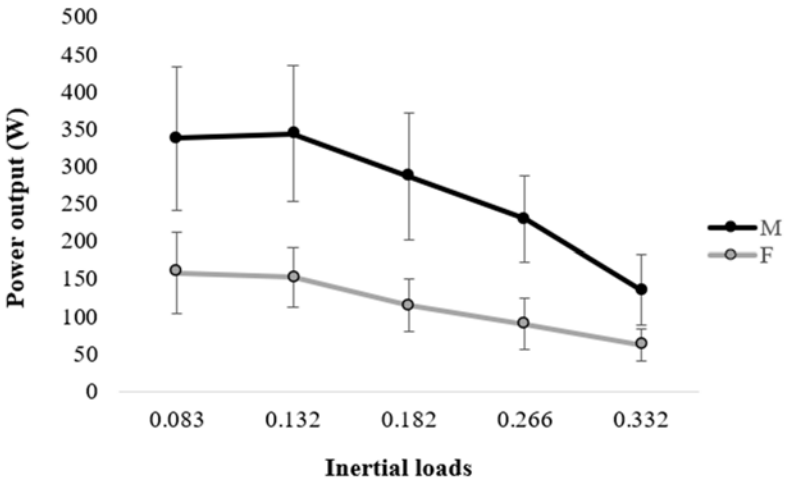
Pconc = Peak concentric power output; Pecc = Peak eccentric power output; W = Watt; Cronbach-α = Reliability; CL = Confidence limits.



F = Females; M = Males

Figure 1

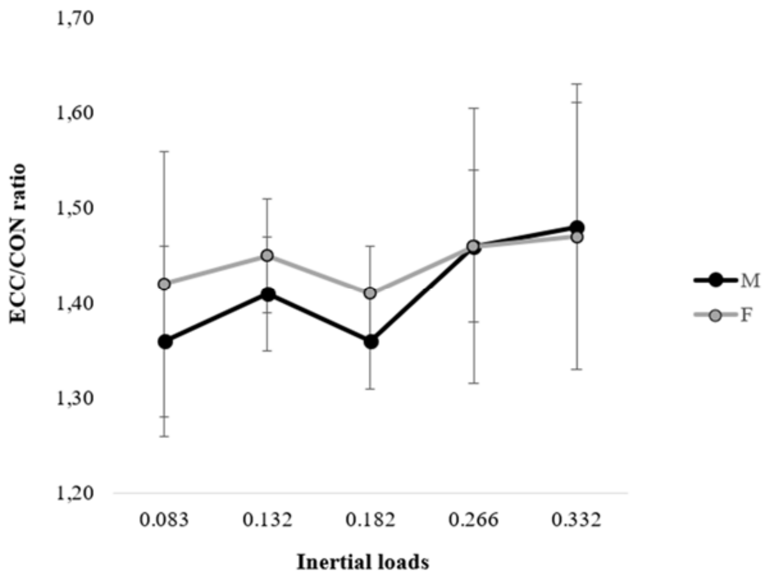
CON power for the chosen inertial loads: 0.083, 0.132, 0.266, and 0.350 kg·m² in both males and females.



F = Females; M = Males

Figure 2

ECC power for the chosen inertial loads: 0.083, 0.132, 0.266, and 0.350 kg·m² in both males and females.



F = Females; M = Males

Figure 3

ECC/CON ratio for the chosen inertial loads used such as 0.083, 0.132, 0.266, and 0.350 kg·m² in both males and females.

Although previous research has focused on determining the influence of different inertial loads on CON and ECC power production during knee extension exercise (Martinez-Aranda et al., 2017; Sabido et al., 2018), no previous studies have investigated differences in the power outcome using different inertial loads in a FW leg curl exercise involving both male and female participants. In the present study, independently of the inertial load used, males showed significantly higher CON and ECC power output than females, which may be explained by several underlying mechanisms including higher muscle mass and a greater percentage of type II muscle fibers (Staron et al., 2000). The results of the current study showed that higher CON and ECC power values were achieved with lower inertial loads (0.083 and 0.132 kg·m²) in both males and females (Figures 2 and 3). These results are in line with those obtained in previous studies, where the maximum values for CON and ECC peak power were obtained with low inertial loads (Sabido et al., 2018). This fact is of significant practical use, as greater transference to sport-specific actions has been observed after a training program using light (0.025 kg·m²) inertial loads compared to high (0.075 kg·m²) inertias (Sabido et al., 2019). Therefore, although more research is required, it seems that lower inertial loads are appropriate to produce greater power output, and subsequently, lead to greater performance adaptations. However, it should be noted that although both males and females showed the same tendency towards a decrease in CON and ECC power when increasing the inertial load, the slope of this decrease was higher in males. Although speculative, these results may be linked to the gender differences in muscle fatigability, which is greater in males than females (Semler et al., 1999).

Previous studies have shown that higher inertial loads (*e.g.*, 0.075 and 0.100 kg·m²) are necessary to obtain the maximal ECC/CON ratio during FW exercises (Martinez-Aranda et al., 2017; Sabido et al., 2018). In this sense, the results of the present study are not in line with those showing that higher loads are necessary to maximize the eccentric overload variable, as this study failed to report significant differences between ECC/CON ratios using different inertial loads. Of note is that the inertia loads used in the present study were higher than the loads used by previous studies analyzing the ECC/CON ratio in leg extension exercises. It could be hypothesized that all the inertias used in the present study were high enough to be an effective load to achieve greater eccentric overload values. Despite no differences in the ECC/CON ratio between different inertia values, males showed a greater difference from the lowest to the higher inertia (1.37 to 1.51) than females (1.41 to 1.47). It should be reminded that both males and females were tested using the same inertial load. Due to the lower strength level showed by female participant, that means that they performed all testing sessions using a higher relative load. The lower difference in the ECC/CON ratio found between light and high inertia in females may be explained by their greater resistance to fatigue, especially at high relative intensities (Ansdell et al., 2019).

This study reports *high* to *very high* reliability scores during CON and ECC power production, but not in the ECC/CON ratio. An increase in power reliability in CON and ECC phases were found across the testing sessions, with $\alpha > 0.90$, *very high*, for all inertial loads in session 4. However, inconsistent differences among inertial loads were observed in the ECC-CON ratio. Previous research has investigated the reliability of power outcomes during FW exercises (Sabido et al., 2018). In this sense, similar reliability values (0.79–0.93) were observed by Sabido et al. (2018) during FW squat exercise. However, the α scores reported in the current study cannot be compared with that previous study, since different FW exercises were used. The lower α values (*poor* to *moderate*) found for the ECC/CON ratio in the present study are in line with those reported by Sabido et al. (2018), highlighting that this variable is not reliable and should not be used. The need for a familiarization process with FW devices was first clarified by Tous-Fajardo et al. (2006) who compared performance of athletes with and without experience in FW training. Such a familiarization process during strength exercises or tests, which required complex movements, has been clearly described in the literature (Impellezzeri et al., 2008). These authors confirm the necessity of gaining a certain amount of coordination by a familiarization procedure (*e.g.*, 2-4 FW sessions), in order to execute the exercise with *high* to very *high* reliability (Table 3). In this sense, in the present study, both males and females presented higher CON and ECC power values in session 4 compared to the other sessions, although based on reliability scores, it could be argued that two sessions are sufficient to obtain a reliable measure (Sabido et al., 2018). However, when subjects with little experience are involved in FW trials or tests, longer FW familiarization might be needed. Furthermore, future studies should investigate the influence of the initial level of strength on the familiarization process with FW devices. It remains to be determined whether after prolonged familiarization and learning periods, the ECC/CON ratio will be reliable enough to allow its monitoring as an index of training adaptation. Tous-Fajardo et al. (2006) showed that subjects with previous experience in FW training achieved a higher ECC/CON ratio during the FW leg curl exercise than inexperienced ones, suggesting that this variable may be sensitive to resistance training background. The greater eccentric loading provided by FW devices may be an optimal stimulus for mechanical and muscle-tendon unit morphological and structural adaptations (Douglas et al., 2017). Previous research has shown greater strength gains in ECC than CON actions following FW training (Norrbrand et al., 2008, 2010), which allows us to hypothesize that individuals will show greater ECC/CON ratio values as an adaptative response to FW training.

This study is not without limitations, firstly, the sample enrolled is composed of amateur subjects, therefore, the findings reported here cannot be fully extended to professional athletes. In addition, participants in the present study were from five different sport disciplines. The specific characteristics of these disciplines may have influenced power output responses. Future studies should therefore assess how different inertial loads affect power output in different sport populations. Secondly, the subjects enrolled in this study were not strongly familiarized with the device, therefore 3-4 sessions were needed to obtain *high to very high* reliability scores. It is possible that athletes who are accustomed with such a technology may report higher reliability scores compared to the subjects enrolled in this study, also less sessions would be needed to obtain *high* reliability. Finally, the analysis of electromyographic (EMG) activity would have provided interesting information about how muscle activation is modified by the use of different inertial loads, and whether changes in this EMG activity are responsible for the changes in power output observed in the study.

In conclusion, the current study highlights that manipulation of the inertial setting using FW devices can modify the power generated, eliciting higher CON and ECC output values with lower inertial loads (*e.g.,* 0.083 and 0.132 kg·m²). However, the ECC/CON ratio does not significantly change with the variation of the inertial load used. The current study reports that male subjects generate greater CON and ECC power compared to females, therefore, practitioners should take into consideration such differences related to the gender. Moreover, this study suggests that a familiarization process with FW leg curl exercise is required with inexperienced subjects. However, this is not the case for the ECC/CON ratio, which should not be used since its reliability is not acceptable. These findings should be used as a guide for FW training prescription in order to optimize power production (*e.g.*, CON and ECC power). The authors suggest to use and monitor CON and ECC power output, but to avoid the utilization of ECC/CON ratios (with any inertial load). Sport practitioners should consider the evidence reported in the current research in order to optimize FW training and performance of their athletes.

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