Comparison of Relative Mean Concentric Force, Duration, and Impulse Between Flywheel and Traditional Squats

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Introduction

Flywheel inertial training uses a pulley system to provide continuous resistance throughout the exercise (1). Using this method of training, external loads are added or removed in the form of inertial wheels that may increase or decrease the intensity of training, respectively (2). Researchers have shown that flywheel inertial training may enhancement the force production characteristics of an individual during various movement patterns (3). Despite the potential benefits of flywheel inertial training, limited research has examined the differences between flywheel training and traditional resistance training exercises. Given that wide variety of exercises can be perform on flywheel devices (1), it is important that practitioners understand the potential differences in training stimuli between flywheel and traditional exercises. Therefore, the purpose of this study was to compare the propulsion force-time characteristics between traditional back squats and flywheel inertial squats.

Methods

- 17 resistance-trained adults completed three testing sessions
  - 9 Men – age: 24.7 ± 4.0 years, height: 171.7 ± 5.8 cm, body mass: 79.3 ± 11.4 kg, relative one repetition maximum (1RM) back squat: 1.95 ± 0.30 kg/kg
  - 8 Women – age: 23.0 ± 2.1 years, height: 167.6 ± 8.6 cm, body mass: 71.5 ± 7.7 kg, relative 1RM back squat: 1.43 ± 0.25 kg/kg
- The first session required the subjects to complete a 1RM back squat protocol and flywheel squat familiarization.
- The remaining sessions had the subjects perform either three repetitions each of 40, 50, 60, 70, and 80 of their 1RM back squat or five flywheel squats using 0.01, 0.025, 0.050, 0.075, and 0.10 kgm^2 inertial wheels.
- Each squat repetition was performed on dual force plates sampling at 1000 Hz and the raw force-time data were used to calculate propulsion mean force, phase duration, and impulse.
- A series of 2 (condition) x 5 (load) repeated measures ANOVA tests were used to examine the differences between squat conditions.
- Hedge's g effect sizes were calculated to determine the magnitude of the differences.

Methods

Figure 1. Traditional back squat performed on the dual force plate set up.

Figure 2. Flywheel squat performed on the dual force plate set up.

Results

Table 1. Propulsion relative mean force, phase duration, and impulse during traditional and flywheel squats.

Load (% 1RM Back Squat)	Traditional Mean Force (N/kg)	Duration (s)	Impulse (Ns)
40	21.6 ± 2.6*	0.47 ± 0.09	757.4 ± 169.7*
50	22.7 ± 2.6*	0.51 ± 0.08	933.7 ± 220.7
60	24.0 ± 3.0*	0.63 ± 0.12	1146.5 ± 311.9
70	25.3 ± 3.7*	0.74 ± 0.20	1398.1 ± 492.1
80	26.0 ± 3.4*	1.03 ± 0.30	2030.4 ± 739.8
Inertia (kgm^2)	Flywheel		
0.010	18.0 ± 2.0	0.49 ± 0.13	647.7 ± 159.1
0.025	19.9 ± 2.3	0.75 ± 0.16#	1092.0 ± 168.4#
0.050	20.9 ± 3.0	1.14 ± 0.28#	1723.3 ± 274.0#
0.075	21.0 ± 3.9	1.40 ± 0.28#	2129.9 ± 317.1#
0.100	21.0 ± 3.6	1.64 ± 0.30#	2509.4 ± 341.8#

* = significantly greater than flywheel corresponding load ($p < 0.01$); # significantly greater than traditional corresponding load ($p < 0.05$)

Conclusions

- Greater forces were produced during traditional back squats than flywheel squats with large effect sizes (g = 1.60-2.63) existing between conditions.
- The propulsion duration and impulse were greater for flywheel than back squat with large-very large effect sizes (g = 1.60-2.63) existing between conditions.

Practical Applications

- Traditional back squats may provide a superior training stimulus for propulsive rapid force production as greater forces are produced over shorter durations across the entire loading spectrum.
- However, flywheel squats may be used to train individuals to create large propulsive impulses.
- Practitioners should note that the examined traditional and flywheel loads may not be direct equivalents and thus, further research is needed to determine what loads may correspond with each other.

References

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