LINEARITY OF MOVING VELOCITY ON VARIOUS WHEEL LOADS

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INTRODUCTION: Recently, inertial flywheel (kBox) research has gained momentum and has been suggested to be an alternative means of resistance training. This type of training relies on a device (i.e. the kBox) that provides resistance via inertial torque, the magnitude of which is a function of the radius, mass, and angular acceleration of the disc (Chiu & Salem, 2006). A greater radius and mass of the resistance or greater angular acceleration will result in greater inertial torques from the device. Therefore, the magnitude of the resistance is provided partially by the device (i.e., size and mass), but also due in part to the previous repetition's force and velocity outputs by the individual (Chiu & Salem, 2006). With a relationship between kBox and lifter-created resistance, the kBox may potentially be used in a prescription for resistance overload.

In a recent meta-analysis (Izquierdo et al. 2017), the findings indicate kBox training may have more advantageous training effects than traditional weight-stacked exercise. To the authors' knowledge, only one study has analyzed force outputs while using a kBox and showed high rep-to-rep consistency across multiple load conditions (Carroll et al, 2018). However, the specific changes to velocity while under the different loads has not been directly addressed. Thus, the purpose of this investigation was to assess velocity changes in the squat using the PUSH band (Toronto, Canada) under different wheel loads on the kBox.

METHODS: Eleven volunteers (10 males and 1 female) agreed to participate in the study. All participants signed a written informed consent approved by the University's Institutional Review Board. To assess the kinetic responses to various wheel loads using a kBox, participants completed two testing sessions.

A familiarization testing session that replicated the study protocol took place prior to the first collection period. The protocol consisted of two sets of 12 repetitions of squats with a PVC pipe. Six loading conditions were assessed using this protocol: L1 (0.010 kgm^2), L2 (0.025 kgm^2), L3 (0.050 kgm^2), L4 (0.060 kgm^2), L5 (0.750 kgm^2), L6 (0.100 kgm^2) on an inertial flywheel device (Exxentric, Sweden). The first two repetitions of each set were used to create momentum prior to the working repetitions and the last two repetitions were used for deceleration. Sets were completed in the order of lowest inertia to the highest. Each set was separated by two minutes of rest with three minutes of rest prescribed when inertia flywheels were changed.

Velocity data were collected using a PUSH band device (PUSH Inc., Toronto, Canada) strapped to the forearm of the participant (Sato et al, 2015 & Balsalobre-Fernández et al, 2016). Data were imported into a custom spreadsheet and analyzed using Microsoft Excel 2016 (Version 2010, Redmond, WA, USA). Squat repetitions three through eight were used for analysis, excluding the two initial and two final repetitions (Carroll et al, 2018). All participants wore standardized footwear (Supernova, Adidas, Germany) to eliminate footwear as a confounding factor for velocity output.

Descriptive statistics (mean, standard deviation, coefficient of variation) were calculated for peak velocity (PV) and average velocity (AV) at each load condition. Percent changes of PV and AV from between loading conditions were determined to further examine within set variation. Using SPSS, a one-way ANOVA with repeated measures was conducted with a Bonferroni post hoc analysis to assess significance ($p < 0.05$). Mean changes between each of the load conditions and mean changes from L1 to each load condition were analyzed and compared. Additionally, effect sizes were calculated using Hedge's g to account for the small sample size. Corresponding values were classified as: small effect (≤ 0.3), medium effect (0.3 to 0.74), large effect (≥ 0.75).

TABLE 1:Descriptive statistics for each inertial flywheel load.

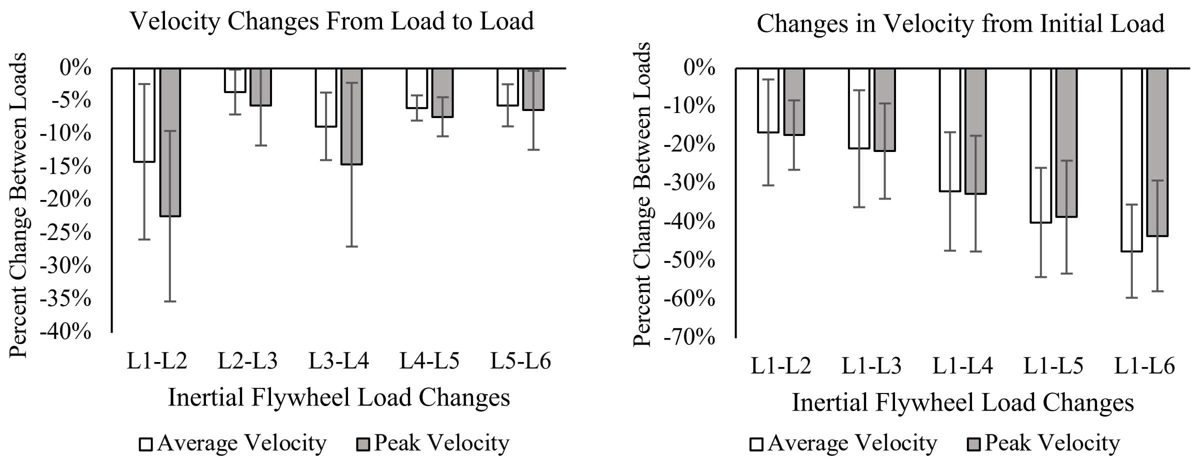
	Loads	Mean ± SD (*kgm^2*)	Mean Difference Between	Mean Difference from L1
Average Velocity	L1	0.777 ± 0.151		
	L2	0.636 ± 0.091	-0.141	
	L3	0.600 ± 0.078	-0.036	-0.177
	L4	0.512 ± 0.061	-0.088	-0.265
	L5	0.452 ± 0.064	-0.060	-0.324
	L6	0.397 ± 0.057	-0.056	-0.380
Peak Velocity	L1	1.243 ± 0.224		
	L2	1.019 ± 0.165	-0.223	
	L3	0.963 ± 0.161	-0.056	-0.279
	L4	0.818 ± 0.114	-0.146	-0.425
	L5	0.745 ± 0.119	-0.073	-0.498
	L6	0.681 ± 0.096	-0.063	-0.561

Notes: L1=0.010 kgm^2; L2=0.025 kgm^2; L3=0.050 kgm^2; L4=0.060 kgm^2; L5=0.750 kgm^2, L6=0.100 kgm^2

RESULTS: Each load had a negative linear impact on both AV and PV at a significant ($p < 0.05$) level (Table 1). Each increase in load had a significant ($p < 0.05$) effect on AV and PV except when comparing L2 to L3 ($p = 0.87$ & 0.187, respectively). While both PV and AV showed significant differences between most loads, PV appeared to be impacted slightly more than AV. Effect sizes showed that only two load condition changes (L1-L2 & L3-L4) had a strong effect (≥ 0.75) for PV, whereas AV showed strong effects for all but one condition (L2-L3) (Table 2). Mean changes to velocity at each load condition were -12.01% ± 4.19% for AV and -10.78% ± 4.84% for PV. There was a large degree of variations in load conditions, but L2-L3 only showed a change of -5.4% ± 5% for AV and -5.4% ± 5.5% for PV. Additionally, changes from L1 to L6 showed a decrease of 47.41% ± 12.09% for AV and 43.45% ± 14.37% for PV (Figure 1).

DISCUSSION: The purpose of this study was to assess the linearity of velocity changes with increasing wheel loads. These data show that loads on the kBox do impact velocity in a linear fashion (See Figure 1) and may have a role in training prescription methods, especially regarding velocity overloading. Both AV and PV were drastically decreased (>40%) from L1 to L6. However, it may be more efficient to forego either L2 or L3 as they did not have a statistically different impact on AV nor PV when compared.

FIGURE 1. Comparison of inertial flywheel load changes to velocity (L1 = 0.010 kgm^2; L2 = 0.025 kgm^2; L3 = 0.050 kgm^2; L4 = 0.060 kgm^2; L5 = 0.750 kgm^2, L6 = 0.100 kgm^2)



While the data indicate that between loads PV was not impacted as greatly as AV, this would be expected due to the nature of the squat movement (See Table 2). As individuals move through the sticking point, greater forces are produced at a higher rate leading to higher velocities. This mimics what is commonly observed in free weight squats. The kBox attempts to counteract the movement velocity, but the advantageous position may create a lag in torque resistance. This momentary lag may lead to a brief period allowing individuals to overcome the torque resistance and achieve a similar PV between conditions. While PV showed to have smaller effects (See Table 2), AV did show consistent linear changes with loads indicating that velocity decreased through the entire range of motion which is a greater indicator of increased work. This is evidence that the kBox can be prescribed in a training program to elicit a predictable workload change based on the wheel load. While these findings support the use of the kBox to overload velocity, more research is needed on this topic. Future research projects should focus on percent changes based on strength levels, differences between sexes, and comparisons to other training methods.

TABLE 2: Effect size (Hedge's g) changes between inertial flywheel loads

	Loads	Effect Size Between	Effect Size from L1
Average Velocity	L1		
	L2	0.935	
	L3	*0.349	1.215
	L4	1.037	1.896
	L5	0.793	2.308
	L6	0.759	2.746
Peak Velocity	L1		
	L2	0.941	
	L3	**0.284	1.186
	L4	0.865	1.978
	L5	*0.518	2.296
	L6	*0.484	2.696

***Small effect: ≤ 0.30; *Medium Effect: 0.31 to 0.74; Large Effect: ≥ 0.75. L1 = 0.010 kgm^2; L2 = 0.025 kgm^2; L3 = 0.050 kgm^2; L4 = 0.060 kgm^2; L5 = 0.750 kgm^2, L6 = 0.100 kgm^2*

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