



Original Research

Effect of a Flying Versus Stationary Start on Wingate Test Outcomes Using an Electromagnetically-Braked Cycle Ergometer in Advanced Resistance-Trained Males

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ABSTRACT

International Journal of Exercise Science 11(4): 980-986, 2018. The purpose of this study was to compare power outputs of the flying start to the stationary start method on an electromagnetically-braked cycle ergometer. Twenty advanced resistance-trained men (age 24.6 ± 4.5 years; 25.4 ± 2.5 kg/m²) volunteered to participate in this study. A counter-balanced, repeated-measures design was utilized to randomly assign participants to either the flying start or the stationary start for their first Wingate test. Paired t tests were used to evaluate mean differences between start methods. Peak power (PP), mean power (MP), total work (TW), peak cadence (PC), mean cadence (MC), and time to reach peak power (TPP) were recorded. Start method revealed significant differences for PP ($p < 0.01$; flying start = $1,111 \pm 42$ W vs. stationary start = 854 ± 41 W) and PC attainment ($p < 0.01$; flying start = 167 ± 7 RPM vs. stationary start = 128 ± 5 RPM). Start method did not significantly affect MP ($p = 0.73$; flying start 673 ± 30 W vs. stationary start 657 ± 34 W) or MC ($p = 0.61$; flying start 102 ± 5 RPM vs. 99 ± 4 RPM). The flying start method allowed for not only a greater PP but also a faster TPP (0.24 ± 0.02 seconds). In contrast, TPP was not attained until approximately one-third of the stationary start test (10.3 ± 0.4 seconds). This study showed that the traditional flying start allowed higher PP and PC outputs when compared to the alternative stationary start method in a sample of advanced resistance-trained male participants.

KEY WORDS: Velotron, anaerobic capacity, anaerobic power, CrossFit.

INTRODUCTION

The Wingate test is a widely used assessment tool of supra-maximal, short-term work capacity and maximal power (21). Consisting of a 30-second all-out cycling performance trial, traditionally performed from a rolling start (4,16), this 40-year-old test has been directed to a wide range of populations (25,32). Presently, with the expanding popularity of high intensity interval training, it has seen an increase in use for monitoring changes in performance (8). Accordingly, Hofman et al. (18) has shown the administration of Wingate tests, from an alternative stationary start, to be a strong predictor of winter race performance in elite speed skaters. The authors concluded, after a 3-year observation period, that even the smallest meaningful improvements in race performance could be predicted by increases as small as 0.9–

2.1% on the Wingate test outputs obtained from an electromagnetically-braked cycle ergometer (EE).

Cycle ergometers are a fundamental part of a standard exercise physiology laboratory. Therefore, different braking models (e.g. air-braked, mechanically-braked, electronically-braked) have been extensively studied and developed to reduce random and systematic errors commonly related to heat accumulation (hysteresis effect) and sampling rate (5,19,21,24,26,30). Consequently, newer EE have become a suitable option for many research groups not only for enhancements in the braking system (22,24), but also due to the ease of use, such as in calibration and testing (e.g., not having to handle weights to load the braking system) (15). Among EE options, the Velotron by Racermate® has been increasingly viewed as a criterion ergometer (14), and was recently validated as accurate (1) and reliable (7,11,23). Astorino and Cottrell (3) tested the reliability of the Velotron during the Wingate test and reported good agreement for mean power (MP) (ICC = 0.90, $p < 0.01$, SEM = 0.18, MD = 0.11 W/kg) and peak power (PP) (ICC = 0.70, $p < 0.05$, SEM = 0.71, MD = 0.44 W/kg) in tests performed from a rolling start, traditionally referred to as the flying start method.

In its original form, the Wingate test start method consists of a flying start with maximal cycling for 3–4 seconds against the ergometer isoinertial load before the predetermined individual workload is applied (16). This start method was first designed as a way to minimize the effect of not considering the flywheel acceleration during the test start (15). However, Bassett (5) noted that this methodology did not account for the kinetic energy accumulated prior to test start, thereby overestimating power outputs. Additionally, Lakomy (19) also revealed that the lack of moment of inertia calculation significantly altered power outputs throughout the test. Since then, several amendments have been suggested to improve validity and reliability of the test (15,17). For this purpose, the stationary start method was initially intended to offer a more standardized and equal condition at the beginning of the test, and later supported to provide a more realistic parameter to most sports, because acceleration is usually an important component for sport success (18,21,31). First proposed by Coleman et al. (12), this start method has been widely applied and preferred by many research teams.

To our knowledge, Macintosh et al. (21) were the first to compare the stationary to the flying start method, with and without moment of inertia calculation. Authors found that the stationary start increased the total work during the Wingate test. In a second study by Robergs et al. (29), also utilizing mechanically-braked cycle ergometers (ME), higher PP was demonstrated for the flying start. Further, it is important to note that only ME have been investigated in the existing studies, making the generalizability to EE limited. A key point that still needs to be documented is how different start methods influence the power outputs of advanced resistance-trained males. Because of the confounding literature and the lack of studies comparing start methods on an EE, the aim of this study was to compare peak power (PP), mean power (MP), peak cadence (PC), total work (TW), mean cadence (MC), and time to peak power (TPP) of the stationary start method versus the flying start method using an EE on advanced resistance-

trained males. We hypothesized that the flying start method would elicit higher power outputs due to momentum gain and greater cadence before the test start.

METHODS

Participants

Twenty-two advanced resistance-trained males volunteered to participate in this study. Twenty (24.6 ± 4.5 years; 25.4 ± 2.5 kg/m²; 178 ± 7 cm; 80.3 ± 7.8 kg) completed all testing and their data were included for analysis. Participants were college students participating in the same CrossFit®-like routines for at least the past 6 months (14.9 ± 9.2 months) with self-reported training frequency of 4–7 times/w. Participants were considered advanced because they had more than one year of experience with resistance training and were capable of executing advanced training routines (2). Program was designed to increase muscular force, power, and local muscular endurance utilizing predominantly multiple-joint exercises (e.g., snatch, clean and jerk, squat, deadlift). After completing the Physical Activity Readiness Questionnaire (PAR-Q), they signed a written informed consent. The Institutional Review Board of the university approved this study (protocol #6546).

Protocol

Participants were randomly assigned to either the flying or the stationary start methodology for their first Wingate test. The second Wingate trial consisted of the opposite start method at the same time range of the day with a minimum of 48-hours, but no more than one week from the first test. All testing took place at the university's exercise physiology laboratory (barometric pressure of ~642 mmHg and temperature of ~21°C). Participants were instructed to avoid strenuous exercise 24 hours prior to testing and to attempt to eat the same meals before testing days.

Prior to the first Wingate test, participants' heights were measured using a wall-mounted stadiometer (Seca 216, Seca Corp., Ontario, CA), and weights were measured using a digital scale (Seca 869, Seca Corp., Ontario, CA) with participants wearing shorts and T-shirt, but no shoes. Anthropometric data were entered in the Wingate test software (RacerMate®, Seattle, WA) for individual settings of resistance along with preferred adjustments for seat setback, handlebar height, and handlebar reach. Seat height was recorded at approximately the trochanter height as suggested by previous review (17). These adjustable settings were matched for both trials. Velotron Dynafit Pro (Racermate, Inc., Seattle, WA) EE equipped with toe straps and the standard 62-tooth chainring was used for testing (10,27). Before every test, participants were reminded of the "all-out" characteristic of the Wingate test and verbally encouraged to perform at their maximum effort throughout the test.

Each test day included a 5-min warm-up at a constant work rate of 100 W and cadence between 60-100 rpm, a 3-min rest, the 30-s Wingate test, and a 5-min cool-down at no load. The flying start consisted of 20-s at 50-70 rpm followed by 6-s sprint to achieve maximal cadence at no resistance before load application. This start method is standard for Velotron's software and has

been utilized previously (3,11,14). The stationary start method consisted of a standstill start from a 6-s countdown. The resistance applied to the flywheel during the test was set at 8.5% of body mass as recommended and utilized by previous studies testing active individuals (11,13,16,21,31).

Statistical Analysis

All analyses were conducted with the Statistical Package for Social Sciences (SPSS version 22, IBM, Armonk, NY). Paired t tests were used to evaluate mean differences between the flying start and the stationary start trials. Means and standard errors were calculated for PP, MP, TW, PC, MC, and TPP. Alpha level was set a priori at $p < 0.05$, and 95% confidence intervals (CI) were calculated to estimate meaningfulness of the findings. Effect size to t tests were calculated using Cohen's d as proposed by Rhea (28) using the following scale for highly trained individuals interpretation: < 0.25 [trivial]; 0.25 to < 0.5 [small]; 0.5 to < 1.00 [moderate]; > 1.0 [large].

RESULTS

Measured values for all four trials are represented in Table 1. There were no differences in MP, MC, and TW between the flying and the stationary start trials ($p > 0.05$); however, the flying start produced significantly greater PP and PC ($p < 0.01$). Additionally, TPP was significantly prolonged for the stationary start ($p < 0.01$). No significant differences were observed for the variables of interest between participant's first and second trials, suggesting no evidence of learning effect between the two tests ($p > 0.05$).

Table 1. Differences (mean \pm SE) in variables of interest between start methods.

Variable	Flying start	Stationary start	p-value	Effect size	95% CI
PP (W)	1111 \pm 42	854 \pm 41	$< 0.01^*$	1.38 [large]	-132 to 381
PP (W/kg)	13.9 \pm 0.6	10.7 \pm 0.4	$< 0.01^*$	1.44 [large]	1.7 to 4.9
MP (W)	673 \pm 30	657 \pm 34	0.73	0.11 [trivial]	-81 to 112
MP (W/kg)	8.5 \pm 0.4	8.2 \pm 0.4	0.65	0.16 [trivial]	-0.9 to 1.5
TW (J)	20,199 \pm 909	19,758 \pm 1,010	0.75	0.10 [trivial]	2,456 to 3,338
PC (rpm)	167 \pm 7	128 \pm 5	$< 0.01^*$	1.46 [large]	20 to 58
MC (rpm)	102 \pm 5	99 \pm 7	0.61	0.14 [trivial]	-11 to -18
TPP (s)	0.24 \pm 0.02	10.3 \pm 0.4	$< 0.01^*$	8,9 [large]	-11 to -9

PP = peak power; PP (W/kg) body weight; MP = mean power; MP(W/kg) body weight; TW = total work; PC = peak cadence; MC = mean cadence; TPP = time to peak power

DISCUSSION

The current investigation revealed that PP and PC were greater for the flying start in comparison to the stationary start method for advanced resistance-trained males using the Velotron EE. While no significant differences were found for MP, MC, and TW, the stationary start method revealed a significantly longer TPP in comparison to the flying start method. These results are in contrast to MacIntosh et al. (21) findings for the stationary start performed on ME. Accounting

for the moment of inertia of the flywheel in both methods did not elicit higher power outputs for the test starting from a motionless start.

The results from the present study are similar to the findings of Robergs et al. (29); however, this study uses the EE. Accordingly, this study also found the unloaded acceleration phase of the flying start to be a key component in PC attainment, which explains the observed PP (Table 1). Furthermore, the momentum attained before test start is also believed to explain the nearly instantaneous TPP. In contrast, Lunn et al. (20) reported lower power outputs for the Wingate test performed from an “all-out” flying start compared to a moderate cadence standardized at approximately 80 rpm. Results obtained from the ME Monark™ Anaerobic Test Software showed higher power outputs for the moderate cadence start method. According to the authors, this start method allowed participants to reach an appropriate cadence that was assumed to have elicited the observed higher outputs. However, it is important to notice the much lower sampling rate of the ME Monark software (1 Hz against 10 Hz of the Velotron software) and extensive heat related losses observed in ME could have influenced the results (30).

Nevertheless, it is important to acknowledge that although higher speed cycling has resulted in higher PP for the flying start, such results may not necessarily reflect an increased muscular power input (6,11). Likewise, Robergs et al. (29) compared the stationary and the flying start method and showed significantly reduced pedal force input and electromyographical activity of the limb muscles during the first 10 seconds of the flying start. Authors concluded that power outputs attained during the first third of the test should not be representative of muscular input. Driss and Vanderwalle (17) also demonstrated, by the use of theoretical models, the influence of high cadences in increasing gravitational forces that can ultimately enhance power output. Additionally, the assertion that moderate cycling cadence can best represent muscular power is well documented in the literature, and; therefore, should be considered for the purpose of this start method comparison (7,8,13,24).

However, the test from a stationary start may also offer some limitations for power output interpretation. In this case, the fact that participants had to accelerate against the predetermined load appears to have affected PC, ultimately resulting in a lengthy TPP of around 10 seconds. This extremely long TPP may have influenced participants to experience fatigue before reaching what can be considered a better representation of the anaerobic alactic system. Although this may be true, we agree that the stationary start method represents a more applicable setting because of the acceleration phase with the additional advantage of standardizing the test start and, therefore, reduce possible differences in cycling efficiency among participants.

In summary, data from the present study indicate that cadence is the most influenced variable by start method choice that can directly affect power output. While participants were able to reach sprint speed and reach maximum power at the beginning of the Wingate test from a flying start, the stationary start resulted in a prolonged acceleration portion of the test, almost one-third. As both start methods have been shown reliable in the literature, we suggest that future

studies choose the start method according to the variable of interest and/or physical profile of the sample being tested.

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