

The Contribution of Phosphocreatine during the Wingate Anaerobic Test in Men and Women.

Running Head: Phosphocreatine Role at Peak Cycling Bouts

Saghiv, M.

Human Performance Department,
University of Texas Permian Basin, Texas, USA.

Sagiv, M.

Sports Medicine and Rehabilitation Division,
Wingate Academic College, Netanya, Israel

ABSTRACT

Purpose: the purpose of this study was to compare the relative contribution of phosphocreatine to the overall energy supply during the Wingate Anaerobic Test in men and women. **Methods:** Forty well trained cyclist, 20 men (23.0 ± 1.1 years) and 20 women (23.4 ± 1.1 years) performed the Wingate Anaerobic Test to estimate the relative contribution of the phosphocreatine. **Results:** In both groups, first 5 second power output peaked significantly ($p < 0.05$), differences were noted between men and women in: pedaling revolutions for first 10 seconds (28.0 ± 0.7 and 23.4 ± 1.0 respectively), revolutions per 30 seconds (64.5 ± 1.7 and 55.9 ± 1.9 respectively), Lactate levels at 10th, 15th and 30th seconds (3.2 ± 0.3 , 5.4 ± 0.4 and 12.2 ± 0.7 Vs. 2.8 ± 0.3 , 4.8 ± 0.4 and 10.4 ± 0.5 mmol·L⁻¹ respectively). **Conclusions:** Gender differences in the absolute muscle mass involved in the activity and workload performed during the Wingate Anaerobic Test might explain the significant differences in absolute power output and fatigue rate. During the Wingate Anaerobic Test phosphocreatine is the predominant energy system in men and women contributing 40% of the total energy expenditure. However, since there is less amount of stored CP and ATP in women's skeletal muscles involved, fatigue occurs earlier than in men. Metabolism and adaptive response to cycling training, may reduce gender-related differences in performance.

Keywords: Power output, ATP sources, all-out effort, anaerobic cycling bouts

INTRODUCTION

During the Wingate Anaerobic Test (WAnT), three energy sources exist: phosphocreatine, glycolysis, and oxidative phosphorylation. At the commence of the bout, ATP is supplied solely from phosphocreatine (CP; PCr; Creatine Phosphate) and ATP stored in the working muscles. This a-lactic process is oxygen-independent and last for up to about 10 seconds (1). Following phosphocreatine as the dominant energy supplier, either glycolysis or oxidative phosphorylation become the major energy source for the resynthesize of ATP. Lactic acid production accompanies due to the imbalance between oxygen demand and supply. (2). Power produced glycolytically peaks within the first 15 seconds of the Wingate Anaerobic Test (3). Oxidative phosphorylation, is the slowest process to resynthesize ATP, contributing during the

Wingate Anaerobic Test 10-20% out of the total energy expenditure (4,5). The Wingate anaerobic test is widely accepted and used to determine anaerobic performance capacity. It may alter the metabolic pattern in healthy young adult subjects (6). Metabolic responses during incremental exercise and anaerobic bouts differ between men and women despite a similar fitness (3,7).

Little data are available on the percentage that phosphocreatine contributes in maintaining metabolic need for this kind of an anaerobic bout in men and women. Therefore, the purpose of the present study was to observe the effect of gender on phosphocreatine's contribution during the 30-s all-out Wingate Anaerobic Test.

METHODS

Subjects

Twenty well trained men (23.0 ± 1.1 years) and twenty well trained women (23.4 ± 1.1 years), all cyclists, volunteered for this study. All were in good health, aerobically (biking) active (5 times·wk⁻¹) for at least 24 months; all participated in cycling competitions. Subjects were judged free of coronary artery disease by clinical history, absence of major risk factors, and by normal graded exercise stress test to peak oxygen uptake. A written informed consent was obtained from each subject, which was approved by the Clinical Science Center Committee on Human Subjects.

Procedure and Measurements

Subjects reported 3 times to the laboratory. The 1st session was devoted to accustoming the subjects to the study's procedures and equipment and underwent a maximal oxygen uptake test. Following warm up, subjects underwent a graded maximal bicycle exercise test on a mechanical weight-adjusted Monark cycle-ergometer (Model 818). Oxygen uptake was determined breath by breath utilizing the Medical Graphics (St. Paul, MN) metabolic cart. The metabolic cart was calibrated before each test with known primary standard quality gases. Heart rate and electrocardiogram were monitored continuously, using a Burdick Eclipse 400 3-channel, 12-lead ECG recorder system, and oscilloscope. Five-second recordings were obtained at rest and at peak exercise. Blood pressure was taken using a standard sphygmomanometer cuff and mercury manometer mounted at eye level, in the sitting position at rest and at peak exercise.

Maximal test was terminated according to the guidelines of the American College of Sports Medicine (8).

During the 2nd session, following warm-up, subjects performed a 10 second all-out Wingate Anaerobic Test, utilizing a weight-adjusted Monark cycle-ergometer (Model 864). The subjects were seated on the ergometer with their feet fastened to the pedals by means of racing-type toe-clips, and seat height was adjusted. The Wingate Anaerobic Test consisted of 10 seconds supramaximal pedaling against a resistance determined relative to the subject's body mass at $80 \text{ g} \cdot \text{kg}^{-1}$ for both groups (9). Subjects commenced cranking as fast as they could against the ergometer's inertial resistance only. The full, predetermined resistance load was applied within 3-4 seconds once the inertial resistance had been overcome. Pedal revolution count started at that instant by means of an electro-mechanical counter and subjects maintained an all-out effort throughout the test. Strong verbal encouragement was given to ensure maximal

effort. Following the 10-second test only, Lactate was measured. Tests were performed at the same time of the day in order to avoid diurnal variations. During the 3rd session, the full Wingate Anaerobic Test was performed for 30 seconds (9). Following the test Lactate levels were measured.

Calculations

Peak power (PP; watts) for the five highest revolutions in 5 seconds, this value is the highest mechanical power output.

PP was calculated as follows:

$$PP \text{ watts} = [(D \cdot \text{kg}) / 6.12]$$

Whereas: D = distance (rpm in 5 sec · 6m); kg = pedaling resistance; 6.12 kgm = 1 watt.

Mean Power (MP; watts) represents the average throughout the Wingate Anaerobic Test.

MP was calculated as follows:

$$MP \text{ watts} = [(D \cdot \text{kg}) / (6.12 \cdot 12)]$$

Whereas: D = distance (rpm in 30 sec · 6m); kg = pedaling resistance; 6.12 kgm = 1 watt; 12 = is 5 sec out of one minute.

Fatigue Index (FI; %): was calculated as the absolute difference between the highest and the lowest revolutions (for 5 sec) expressed as a percent of the highest revolutions.

$$FI (\%) = 100 \cdot (PP - LP) / PP$$

Energy Fraction Contribution (%) of phosphocreatine to the total energy expenditure was calculated as follows:

$$\text{Energy fraction contribution (\%)} = (\text{Phase 1} + \text{phase 2 revolutions}) / \text{total revolutions}$$

Lactate Concentration: A 25 µl fingertip blood sample was taken at rest and during the 2nd minute post exercise for the determination of Lactate concentration at peak anaerobic effort. The sample was immediately transferred to a micro-tube containing 100 µl of 7% perchloric acid. The tubes were centrifuged after standing for at least 1 hour. Twenty microliter aliquots of the supernatant were subsequently used for Lactate analysis on the Analox LM3 analyzer (Analox Instruments, England; Reagent Kit No. GMRD-071).

Statistical Methods: One-way ANOVA with repeated measures was employed for each of the variables measured in order to detect variations in the experimental parameters. In addition, the Students Newman-Keuls procedure was used for specific post-Hoc comparisons.

RESULTS

All subjects completed the 30 seconds study without any difficulties or clinical abnormalities. Descriptive data of the subject's physical characteristics are given in table 1. It reveals that weight, height, body surface area, and maximal oxygen uptake were all significantly ($p < 0.05$) higher for the men compared to that of women.

Table 1: Physical characteristics of the subjects (mean $\pm$ SD).

VARIABLE	MEN	WOMEN	SIG
Weight (kg)	63.5 $\pm$ 3.7	54.6 $\pm$ 4.1	$P < 0.02$
Height (cm)	179.4 $\pm$ 5.3	171.3 $\pm$ 4.0	$P < 0.05$
Age (Years)	23.0 $\pm$ 1.1	23.4 $\pm$ 1.1	
Body surface area (m ²)	1.8 $\pm$ 0.1	1.6 $\pm$ 0.1	$P < 0.05$
Body fat (%)	11.5 $\pm$ 2.1	12.4 $\pm$ 3.0	
VO ₂ max. (mL·kg ⁻¹ ·min ⁻¹)	61.5 $\pm$ 5.7	54.3 $\pm$ 4.4	$P < 0.05$
Heart rate max. (beats·min ⁻¹)	207 $\pm$ 6.6	201 $\pm$ 7.3	

Table 2 reveals that revolutions in stages 1 and 2 (phosphocreatine contribution) of the Wingate Anaerobic Test, mean power in men compared to women (321.5 $\pm$ 4.7 and 239.4 $\pm$ 5.8 watts respectively), power output (908 $\pm$ 7.4 and 633 $\pm$ 8.9 watts respectively), and fatigue index (50.6 $\pm$ 2.2 and 46.8 $\pm$ 1.8 %) were significantly ($P < 0.05$) higher in men than in women. No significant differences were found between both men and women regarding phosphocreatine energy fraction contribution to total energy in the first 10 seconds. Men compared to women exhibited significantly ($P < 0.05$) higher Lactate levels at 10th, 15th, and 30th seconds (3.2 $\pm$ 0.3, 5.4 $\pm$ 0.4, and 12.2 $\pm$ 0.7 Vs. 2.8 $\pm$ 0.3, 4.8 $\pm$ 0.4, and 10.4 $\pm$ 0.5 mmol·L⁻¹ respectively).

Table 2: Revolutions for the six stages (each 5 sec) of the Wingate Anaerobic Test and fraction percentage of total energy contributed by phosphocreatine in men and women (mean $\pm$ SD).

Leg	Men		Women	
	Revolts	% Fraction	Revolts	% Fraction
1.	15.2 $\pm$ 1.0	23.6 $\pm$ 1.7	12.4 $\pm$ 1.1 ^a	22.2 $\pm$ 1.4
2.	13.5 $\pm$ 0.9	20.9 $\pm$ 1.5	11.5 $\pm$ 1.0 ^a	20.6 $\pm$ 1.5
3.	10.9 $\pm$ 1.0	16.9 $\pm$ 1.1	9.9 $\pm$ 0.9	17.7 $\pm$ 1.3
4.	9.0 $\pm$ 0.8	14.0 $\pm$ 1.1	8.1 $\pm$ 1.0	14.5 $\pm$ 1.6
5.	8.4 $\pm$ 1.0	13.0 $\pm$ 1.5	7.4 $\pm$ 1.0	13.2 $\pm$ 1.1
6.	7.5 $\pm$ 0.9	11.6 $\pm$ 1.4	6.6 $\pm$ 0.8	11.8 $\pm$ 1.2
Total	64.5 $\pm$ 1.7	100%	55.9 $\pm$ 1.9 ^a	100%

a = Significant $P < 0.05$ differences between groups.

DISCUSSION

The present study tested the hypothesis that sex may influence the relative contribution of phosphocreatine as an energy source during the Wingate anaerobic Test in healthy well-trained

cyclists. It seems that exercise energy output in both groups is maintained due to a balance between the metabolic pathways.

The present study revealed differences between men and women, in resistance applied, maximal power output, and mean power values of the working muscles during Wingate Anaerobic Test due to sex. In spite of the significant higher workload and total energy expenditure in men, both groups, attained similar energy fraction contribution of total energy expenditure during the 10 seconds alactic phase. Previous findings (10) indicated that in a normal population, men have larger muscle fibers than women, but similar fiber composition. Although sex-related differences exist in the size of individual skeletal fibers, possibly influencing metabolism and the adaptive response to training (11), women in the present study, seem to have recruited enough fast fibers in order to contribute a large energy fraction during the alactic phase as men did. This may be due to the muscle fibers adaptations to training regimes containing aerobic and anaerobic training elements such as biking, by changes in the absolute or relative cross-sectional area of the type II fibers (12).

Fatigue index in women was significantly lower than that of men. This may be due to differences in fiber's velocity contraction. From in vitro studies, it has been observed that the efficiency of different fiber types is closely related to the velocity of contraction (13). At low contraction velocities as in the women of the present study, the efficiency of slow twitch fibers is higher than for fast twitch fibers and the reverse is observed at high speeds (14).

In the present study, the three Lactate measurements were significantly higher in the men compared to women. Compared to women, males perform higher absolute and mean power output during all-out sprint cycling (15,16), Yet, normalizing power output with muscle mass involved in sprinting, females resemble males (17). Thus, the gender difference in lactic acid may be due to localized muscular fatigue.

Conclusions: sex differences in the absolute muscle mass involved in the activity and workload performed during the Wingate Anaerobic Test might explain the significant differences in absolute power output and fatigue rate. During the Wingate Anaerobic Test, phosphocreatine is the predominant energy system in men and women contributing 40% of the total energy expenditure. However, since there is less amount of stored CP and ATP in women's skeletal muscles involved, fatigue occurs earlier than in men. In addition, our findings suggest that metabolism and adaptive responses to cycling exercise training regimes containing aerobic and anaerobic elements, may reduce sex-related differences in performance.

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