The influence of pacing strategy on $\dot{V}O_2$ and supramaximal kayak performance

DAVID BISHOP, DARRELL BONETTI, and BRIAN DAWSON

Department of Human Movement and Exercise Science, University of Western Australia, Crawley, WA, AUSTRALIA

ABSTRACT

D. BISHOP, D. BONETTI, and B. DAWSON. The influence of pacing strategy on $\dot{V}O_2$ and supramaximal kayak performance. *Med. Sci. Sports Exerc.,* Vol. 34, No. 6, pp. 1041–1047, 2002. **Purpose:** The purpose of this study was to investigate the effects of manipulating pacing strategy on $\dot{V}O_2$ and kayak ergometer performance in well-trained paddlers. **Methods:** Eight well-trained kayak paddlers (500-m time = 115-125 s) first performed a graded exercise test for determination of $\dot{V}O_{2max}$ and lactate (La^-) parameters. On subsequent days and in a random, counterbalanced order, subjects performed a 2-min, kayak ergometer test using either an all-out start or even pacing strategy. **Results:** There was a significantly greater peak power (747.6 ± 152.0 vs 558.3 ± 110.1 W) and average power (348.5 ± 47.6 vs 335.5 ± 44.8 W) using the all-out start strategy, when compared with the even-paced strategy. There was however, no significant difference between the two pacing strategies for peak $\dot{V}O_2$, accumulated oxygen deficit (AOD), peak [La^-], or posttest pH. Using the all-out start, total $\dot{V}O_2$ was significantly greater (7.3 ± 0.8 vs 6.9 ± 0.8 L). **Conclusion:** The results of this study indicate that 2-min kayak ergometer performance is significantly greater following an all-out start strategy when compared with an even-paced strategy. The improved performance appears to be attributable to faster $\dot{V}O_2$ kinetics, without a significant change in the total AOD (although the AOD distribution was altered). **Key Words:** ACCUMULATED OXYGEN DEFICIT, METABOLIC ACIDOSIS, PCR SPLITTING, $\dot{V}O_2$ KINETICS.

The K1 500 m (K_{500}) sprint kayak event is contested at both Olympic and World Championship level. The margins of victory in this event are often very small. For example, in the 1997 Canoe World Championships held in Canada, first and second place in the men's K_{500} were separated by only 0.01 s. With such small margins separating medallists in this event, variations in pacing strategy have the potential to affect an athlete's performance and subsequent placing.

While no research has specifically investigated the influence of pacing strategy on kayak performance, limited research has investigated the influence of pacing strategy on other modes of supramaximal exercise (i.e. cycling and speed skating). Foster et al. (7) studied the effects of various pacing strategies on a 2-km cycle ergometer time trial performance (approximately 150–180 s). The subjects completed the first kilometer of each time trial using a predetermined pacing strategy ranging from very slow to nearly as fast as the athlete could ride for 1 km. The last kilometer of the race was completed as quickly as possible in all trials. The evenly paced trial produced the fastest total time, and the authors suggested negative consequences for even small variations in this strategy.

More recent research, however, supports the use of fast-start strategies over even-pace strategies. In a follow up to their 1993 study, Foster et al. (6) investigated elite speed skaters during experimentally paced 1500-m competitions (approximately 110 s). In contrast to their previous study, an even-pace strategy did not produce the best performance. In fact, their data suggested that the faster the skater could start, the better the eventual outcome would be in the 1500-m event.

The use of fast-start strategies is also supported by research investigating the effect of pacing strategies on computer-simulated 1000-m and 4000-m track cycling (4). In the 1000-m simulations, three strategies were used: an all-out strategy; a fast-start for the first 30 s followed by even pacing, and even pacing for the entire test. The best result for the 1000-m simulations (approximately 60 s) was obtained using an all-out strategy. In the 4000-m simulations three strategies were also used: an all-out strategy, a fast-start for 12 s followed by even pacing, and even pacing for the test duration. The best result for the 4000-m time-trial (approximately 260 s) was obtained with a fast-start, followed by even pacing. This research suggests that shorter duration supramaximal exercise performance (<60 s) is optimized when an all-out strategy is used, whereas for longer duration supramaximal exercise performance (~ 260 s), a fast-start with a quick transition to even pacing may be the best strategy.

Interestingly, kayak athletes and coaches generally agree that a fast-start followed by a transition to even pacing is a preferred race strategy. In fact, the strategies adopted by most kayak athletes are very similar to the fast-start strategy used to optimize 4000-m cycle performance in the study by de Koning et al. (4). However, while a fast-start followed by a quick transition to even pacing seems to be a preferred pacing strategy and is supported by limited research, the

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mechanisms behind the potential success of this strategy remain to be established.

Recent research provides a scientific rationale for the adoption of fast-start pacing strategies by athletes. According to McCreary et al.(10), there is a direct proportionality between the products of phosphocreatine (PCr) splitting and muscle or pulmonary $\dot{V}O_2$. In addition, it is also known that greater rates of PCr breakdown occur at higher intensities of exercise (11). Therefore, it would be expected that the faster an athlete starts a race, the faster the $\dot{V}O_2$ kinetics are likely to be. Assuming no change in the anaerobic production of ATP, faster $\dot{V}O_2$ kinetics may improve supramaximal performance by increasing the total ATP available to fuel exercise of fixed duration.

However, while a fast-start may help to speed $\dot{V}O_2$ kinetics, it also has the potential to cause premature fatigue. It is known that disturbances in muscle pH become greater as the intensity of exercise increases (11). Therefore, greater disturbances in muscle pH, as a result of a fast start, may impair supramaximal performance via inhibition of anaerobic glycolysis (9) and/or interference with muscle contractile processes (5). Furthermore, it has also been suggested that a reduction in muscle pH, as a result of a fast start, may impair performance via the loss of technique that may accompany fatigue (7).

While a fast-start followed by a quick transition to even pacing appears to be a preferred pacing strategy and has some support from previous studies, the mechanisms behind the potential success of this strategy remain to be established. Currently, it is not known whether the extra effort required to speed the $\dot{V}O_2$ kinetics (when using a fast start) will cause premature fatigue, thus adversely affecting performance in the latter stages of a race. Further study is therefore needed to investigate the effects of various pacing strategies on the $\dot{V}O_2$ at the onset of a simulated K_{500} race, to determine to what degree $\dot{V}O_2$ can be enhanced and how this may affect performance over the remainder of the race. It was hypothesized that a fast-start strategy (maximal effort for 10 s, followed by a 5 s transition to even pace) would result in greater total work completed in a 2-min test on a kayak ergometer than an even-pacing strategy (accelerate to even pace as quickly as possible) in well-trained kayak athletes.

METHODS

Subjects

Eight experienced and currently training male kayak paddlers volunteered to participate in this study. Their mean ($\pm$ SD) age was 22 $\pm$ 4 yr, mass was 80.6 $\pm$ 7.4 kg, and kayak $\dot{V}O_{2max}$ was 4.0 $\pm$ 0.5 $L \cdot min^{-1}$. During the time of the study, all subjects were encouraged to undertake their normal training and diet but not to train on the day before each test. They were instructed to be adequately hydrated and not to have eaten for three hours before each test.

Experimental overview

After being fully informed of the risks associated with participation, all subjects gave their written consent. The testing procedures were approved by the Research Ethics Committee of The Western Australian Institute of Sport. The testing took place over a 3-wk period. For each subject, all tests were conducted at the same time of day and separated by at least 48 h.

In the first week, each subject performed a graded exercise test (GXT) on a wind-braked kayak ergometer (K1 ergo, Garran, Australia) for determination of maximum oxygen uptake ($\dot{V}O_{2max}$) and lactate parameters. Later in the week, subjects completed two familiarization trials of the fast-start, 2-min kayak ergometer test, using their normal pacing strategy. The athletes' best 2-min test result (average power) recorded during the tests was used as the determinant of even pace during the experimental tests that followed. During the second and third weeks, and in a random, counterbalanced order, each subject performed four, 2-min, kayak ergometer tests, using two different pacing strategies (even pace or all-out start). Five minutes before all 2-min tests, subjects completed a 15-min intermittent, high-intensity warm up (1).

Pacing strategies

The all-out start strategy required each athlete to work at a maximum effort for 10 s, followed by a 5 s transition to even pace, which was then held for the remainder of the first minute. In the final minute, the athlete was encouraged to complete as much work as possible. For the even strategy, athletes were required to accelerate to even pace as quickly as possible and hold this pace for the remainder of the first minute. In the final minute, the athletes were again encouraged to complete as much work as possible. The best 2-min test result (average power) using each pacing strategy was recorded.

Kayak ergometer

All physiological testing was conducted on a calibrated, wind-braked kayak ergometer (K1 Ergo). The foot-bar position of the kayak ergometer was adjusted to resemble the paddler's own kayak before each test. The ergometer was interfaced with a computer that continuously measured, calculated, and stored accumulated work and other associated work indices using specifically designed software. The stroke rate was freely chosen.

Heart rate

A heart rate monitor (Polar Vantage NV, Polar Electro Oy, Kempele, Finland) was used to monitor and store heart rates every 5 s during the physiological tests.

Blood analysis

Arterialised capillary blood (100 μL) was sampled from a hyperemic earlobe. Hyperaemia was induced by smearing

TABLE 1. Group mean (± SD) values for power output (W) recorded during the 2-min test for both the all-out start and even pacing strategies.

Pacing strategy	Peak Power (W)	Average Power (W) 2-min test	Average Power (W) First 60 s	Average Power (W) Second 60 s	Total Work First 60 s (%)
All-out start	747.57 ± 151.95*	348.48 ± 47.62*	373.68 ± 62.61*	323.19 ± 36.35	53.62
Even	558.25 ± 110.08	335.51 ± 44.75	334.51 ± 49.92	336.55 ± 41.88*	49.93

* $P < 0.05$ between conditions.

the earlobe with a cutaneous vasodilator (Finalgon, Boehringer Ingelheim, Ingelheim, Germany) 10 min before the start of each test. Capillary blood samples were taken 5 min before the warm up period, 1 min after the warm up, in the minute before the 2-min tests, and 1, 4, and 7 min after the 2-min test. Whole blood lactate concentration ($[La^-]$) was determined using the Micro Stat LM3 (Analox Instruments Ltd., London, GB). Whole blood pH was determined using a Ciba Corning blood gas analyser (#865, Chiron Diagnostics, Walpole, MA). Both instruments were calibrated and both were routinely assessed by external quality control.

Gas measurements

During the incremental test, both warm up conditions, and the 2-min tests, expired gas samples were continuously monitored for O_2 and CO_2 concentrations using Ametek gas analysers (SOV S-3A and COV CD3A, respectively, Pittsburgh, PA). Data were then averaged over 15-s intervals. Ventilation (V_I) was also recorded every 15 s using a turbine ventilometer (Morgan, Model 096, Kent, England). The gas analyzers were calibrated immediately before and verified after each test, using a certified gravimetric alpha-grade gas mixture (BOC Gases, Chatswood, Australia); the ventilometer was calibrated preexercise and verified postexercise using a 1-L syringe in accordance with the manufacturer's instructions.

Incremental test

An incremental test was used to determine both $\dot{V}O_{2Max}$ and the thresholds. The incremental test commenced at an initial workload of 50 W, and increments of 25 W were applied at 5-min intervals until exhaustion. A 1-min rest period between each increment allowed for the sampling of capillary blood. The test continued until the athlete could no longer maintain the required power output. The $\dot{V}O_2$ values for the last 2 min of each 5-min step were recorded and used to determine the linear relationship between $\dot{V}O_2$ and power output for each subject. The highest four consecutive 15-s $\dot{V}O_2$ values were summed to determine $\dot{V}O_{2Max}$. The lactate threshold (LT) was calculated using the modified D_{max} method (2). The LT was determined by the point on the polynomial regression curve that yielded the maximal perpendicular distance to the straight line formed by the lactate inflection point (first increase in lactate concentration above the resting level (13)) and the final lactate point.

2-min test

Subjects completed a 2-min fast-start test on the kayak ergometer. The test length was chosen based on research reporting the validity of a fast-start procedure for estimating accumulated oxygen deficit (AOD) (8) and research indicating that AOD is maximized when the test is similar in duration to that of the criterion event (3). Individual relationships between the oxygen cost and power output were established during the last 2 min of each submaximal stage during the incremental test. The estimated oxygen cost for the 2-min fast-start test was then determined by extrapolation (8). The AOD was then calculated as the difference between the estimated oxygen cost of exercise and the actual oxygen uptake. Average power output, estimated oxygen cost of exercise, and actual oxygen uptake were calculated over 15-s intervals. The oxygen deficit for each 15-s interval was accumulated over time to give AOD.

Statistical analysis

The data was analyzed to determine whether any significant differences existed between the 2-min tests using the two different pacing strategies. Analysis of the means of the data for average power, peak power, peak $\dot{V}O_2$, total VO_2, aerobic contribution, AOD, peak blood lactate, and blood pH during the athletes' best 2-min test (under each pacing strategy) was conducted using a paired-samples *t* test (one group x two strategies). Statistical significance was set at the $P < 0.05$ level of probability. All statistical analyses were conducted using the SPSS statistical package (SPSS, version 8.0).

RESULTS

Power Output

Group results for average power and peak power recorded in the athletes' best 2-min test using both pacing strategies are summarized in Table 1. When compared to the even pacing strategy, average power in the first 60 s of the 2-min test and overall was significantly greater using the all-out start strategy ($P < 0.05$). However, in the second 60 s, average power was significantly greater when the even-pacing strategy was used ($P < 0.05$). When analyzed in 15-s intervals (Figure 1), average power was significantly greater in the first 15-s interval when the all-out start strategy was used ($P < 0.05$). In contrast, in the fifth and sixth 15-s intervals, average power was significantly greater when using the even pacing strategy ($P < 0.05$). Peak power recorded during the 2-min tests was significantly greater using the all-out start strategy ($P < 0.05$).

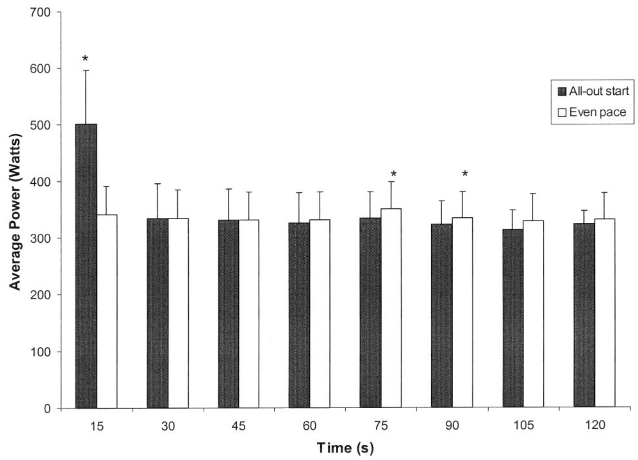

FIGURE 1—Group mean (± SD) values for average power (W) recorded every 15 s during the 2-min test for both the all-out start and even pacing strategies. * $P < 0.05$ between conditions.

Oxygen Uptake

Group results for peak $\dot{V}O_2$ and total VO_2 recorded in the 2-min tests using both pacing strategies are summarized in Table 2. No significant differences were found for measures of peak $\dot{V}O_2$ ($P > 0.05$). However, total VO_2 was significantly greater when the all-out start pacing strategy was used ($P < 0.05$). Figure 2 illustrates mean $\dot{V}O_2$ utilized every 15 s in the 2-min tests. Mean $\dot{V}O_2$ was significantly greater in the second and third 15-s intervals, when the all-out start pacing strategy was used ($P < 0.05$).

Accumulated Oxygen Deficit.

Group results for the AOD recorded during the 2-min tests using both pacing strategies are also summarized in Table 2. There was no significant effect of pacing strategy on AOD. When analyzed in 15-s intervals (Figure 3), the AOD was significantly greater in the first 15-s interval when the all-out start strategy was used ($P < 0.05$). In the third and fifth 15-s intervals, AOD was significantly greater when the even strategy was used ($P < 0.05$).

Blood lactate concentration and pH

Group results for blood lactate concentration and pH, before and following the 2-min tests, using both pacing strategies are summarized in Table 3. No significant differences were found for blood lactate concentration and blood pH, before or after each 2-min test, using either pacing strategy.

DISCUSSION

The results of the present study have shown that, when compared to an even pacing strategy, an all-out start strategy produced significantly greater average power during a 2-min kayak ergometer test. The all-out start strategy also resulted in significantly greater $\dot{V}O_2$ at 30 and 45 s, and significantly greater total VO_2. While no significant differences in AOD were observed, the pattern of AOD distribution was altered by pacing strategy. It was hypothesized that the significant improvements in 2-min kayak ergometer performance, using the all-out start strategy, were due to a greater $\dot{V}O_2$ without a change in the total AOD.

When compared to the even pacing strategy, the all-out start strategy resulted in greater average power during the 2-min test (348.5 ± 47.6 vs 335.5 ± 44.8 W; $P < 0.05$). This is consistent with the findings of two previous studies that have investigated the effects of pacing strategy on computer simulated 4000-m cycle performance (approximate time = 260–280 s) (4,12). However, our performance results are in contrast with those of Foster et al.(7), who reported that, compared with fast- and slow-start strategies, an even-paced strategy produced a significantly faster 2-km cycle time trial performance (approximately 150–180 s). A number of methodological differences may explain these contrasting findings.

One of the major differences between the study by Foster et al. (7) and both the present study and the two computer simulation studies (4,12) was how the fast start was achieved. In the study by Foster et al.(7), the fast start was determined as a percentage of the average 2-km time trial pace. This starting intensity was then held constant for the first half of the 2-km trials (approximately 95–105 s). However, the fast start strategies employed by De Koning et al. (4) and the present study were maintained for approximately 10–12 s and completed at an all-out intensity. Thus, the fast start employed by Foster et al. (7) was performed at a lower intensity and maintained for a greater period of time when compared with all-out start strategies that have been proposed to improve supramaximal performance.

Differences in start strategy may also explain why Foster et al. (7) reported no effect of pacing strategy on $\dot{V}O_2$. In contrast, in the present study, both initial and total VO_2 during the 2-min test were significantly greater when using the all-out start strategy compared with the even strategy (Table 2). The significantly greater $\dot{V}O_2$ during the all-out start strategy, may have been due to greater rates of PCr breakdown at the onset of the 2-min test. Research has shown that there is a direct proportionality between the products of PCr splitting and muscle or pulmonary $\dot{V}O_2$

TABLE 2. Group mean (± SD) values for peak $\dot{V}O_2$, total VO_2, aerobic energy contribution and accumulated O_2 deficit (AOD) recorded during the 2-min test for both the all-out start and even pacing strategies.

Pacing Strategy	Peak $\dot{V}O_2$ ($L \cdot min^{-1}$)	Total VO_2 (L)	Aerobic Contribution (%)	AOD (L)
All-out start	4.37 ± 0.48	7.27 ± 0.83*	62.27 ± 6.32	4.46 ± 1.05
Even	4.29 ± 0.43	6.89 ± 0.76	60.92 ± 5.21	4.45 ± 0.84

* $P < 0.05$ between conditions.

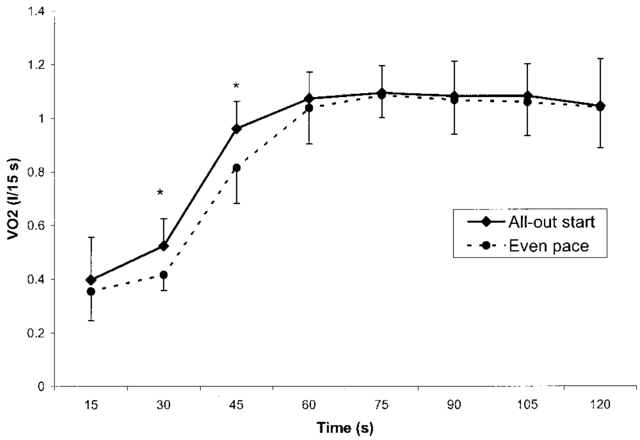

FIGURE 2—Group mean (± SD) values for $\dot{V}O_2$ every 15 s during the 2-min test for both the all-out start and even pacing strategies. * $P <$ 0.05 between conditions.

(10). Furthermore, it is well known that greater rates of PCr breakdown occur at higher intensities of exercise (11). In the present study, both peak and average power output during the initial 15-s period were significantly greater using the all-out start strategy when compared with the even-pacing strategy. Therefore, it is likely that greater rates of PCr breakdown would have been required during the all-out start strategy to fuel the significantly greater power output during the initial 15 s of the 2-min test. Furthermore, it is likely that greater PCr breakdown at the onset of the 2-min test, when using the all-out start strategy, was a stimulus for the increased $\dot{V}O_2$.

While Foster et al.(7) reported no effect of pacing strategy on total $\dot{V}O_2$, it is important to note that they did not employ an all-out start procedure but made small changes to the amount of work completed in the first half of their tests. Therefore, rates of PCr breakdown at the start of their time trials may not have varied sufficiently between pacing strategies to elicit significant changes in initial or total $\dot{V}O_2$. The $\dot{V}O_2$ results in the present study are, however, consistent with previous findings of greater $\dot{V}O_2$ in the first 30 s of exercise when an all-out protocol was compared to a constant load protocol (8). The results of the present study and previous studies (8) therefore indicate that $\dot{V}O_2$ during supramaximal exercise can be increased with an all-out start strategy. This may be attributable to greater PCr breakdown at the onset of exercise when using an all-out start procedure.

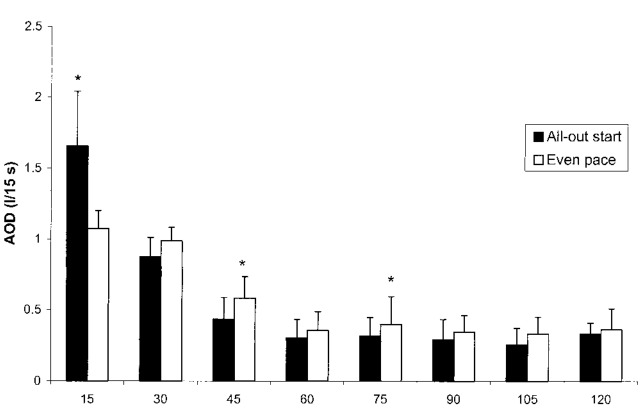

FIGURE 3—Group mean (± SD) values for accumulated oxygen deficit (AOD) recorded every 15 s during the 2-min test for both the all-out start and even pacing strategies. * $P <$ 0.05 between conditions.

There were however, no significant differences in peak $\dot{V}O_2$ between conditions. This is consistent with previous findings of no significant differences in peak $\dot{V}O_2$ when using either a fast-, even- or slow-start strategy (7). Similarly, no significant differences in peak $\dot{V}O_2$ were reported when using an all-out start strategy or constant-workload (even-pace) strategy during supramaximal cycling (8). Thus, while pacing strategy can affect total VO_2, it does not appear to affect peak $\dot{V}O_2$ during supramaximal exercise.

In addition to significantly altering average power and total $\dot{V}O_2$, pacing strategy also had a significant effect on the distribution of power output during the 2-min test (Figure 1). Compared with the even pace strategy, average power was 10.5% greater in the first half of the test when using the all-out start strategy. This difference could be attributed to the extra power output generated in the first 15-s interval during the all-out start (502 vs 340 W). Average power output was not significantly different between conditions for the remainder of the first minute when subjects were required to maintain a predetermined even pace. Therefore, while significantly improving initial power output, the all-out start strategy did not impair power output during the remainder of the first minute of the 2-min test.

In contrast, during the second half of the 2-min test, average power was 4% less when using the all-out start strategy (Table 1). Analysis of 15-s power outputs revealed that when athletes were allowed to self-pace from the 60-s mark, power was significantly lower in the next two 15-s intervals, using the all-out start strategy, but was not significantly different between conditions in the final two 15-s intervals (Figure 1). The significantly lower power during the second half of the 2-min test, when using the all-out start strategy, may have been due to greater initial disturbances in muscle pH. However, this hypothesis cannot be verified as we were unable to obtain muscle samples.

When compared with the even pacing strategy, both average power and AOD during the first 15-s interval were significantly greater using the all-out start strategy. This suggests that the initial 15 s of the all-out start strategy would also have been associated with greater rates of glycolysis and greater disturbances in muscle pH. Thus, lower muscle pH induced by the all-out start may have contributed to the significantly impaired second half performance via inhibition of anaerobic glycolysis (9) and/or interference with muscle contractile processes (5). However, despite significantly impaired performance during the second half of the 2-min tests, overall performance was still superior using the all-out start strategy.

Despite performance differences, there was no significant effect of pacing strategy on total AOD (Table 2). This is consistent with previous reports of no significant differences in total AOD when using either an all-out or constant-

TABLE 3. Group mean (± SD) values for blood lactate concentration and blood pH prior to and following the 2-min test for both the all-out start and even pacing strategies.

Pacing strategy	Blood Lactate Concentration+ (mmol·L−1)			Blood pH		
	Resting	Post Warm-up	Post Test	Resting	Post Warm-up	Post Test
All-out start	1.4 ± 1.3	3.3 ± 1.3	13.0 ± 3.2	7.44 ± 0.04	7.40 ± 0.07	7.20 ± 0.07
Even	1.3 ± 0.5	4.0 ± 1.9	13.0 ± 3.0	7.46 ± 0.04	7.41 ± 0.05	7.18 ± 0.09

+ n = 7, Problem with lactate analyzer for subject 8.

workload strategy (8). Foster et al. (7) also reported no significant effect of pacing strategy on total AOD, despite a significant effect of pacing strategy on performance. Gastin et al. (8) suggested that, as the anaerobic capacity is a well defined entity, only a set amount of anaerobic work can be completed, regardless of the pacing strategy adopted. Consistent with this hypothesis and the results of previous studies, total AOD in the present study was unaffected by variations in pacing strategy.

While total AOD was unaffected by pacing strategy, the distribution of the AOD was significantly altered by pacing strategy. When compared with even pacing, the AOD was significantly greater in the first 15 s using the all-out start strategy. However, AOD was significantly greater from 30–45 s, 60–75 s and 90–105 s when using the even-pace strategy. These results suggest that initially the all-out start strategy relies on a greater anaerobic energy contribution to produce ATP when compared with the even strategy. However, as the duration of exercise increases, the anaerobic energy contribution becomes greater during the even-pace strategy when compared with the all-out start strategy.

Despite a significantly greater average power using the all-out start strategy, neither pacing strategy resulted in a significant difference in peak blood lactate or pH. This is consistent with the results of previous studies. Foster et al. (7) reported no significant effect of variations in pacing strategy on peak blood lactate concentration, despite significant differences in 2-km cycle performance. Similarly, Gastin et al. (8) observed no significant differences between peak blood lactate concentration whether following constant load or all-out exercise of similar duration. The blood pH and lactate results of the present study may be indicative of a similar anaerobic contribution to ATP production during the 2-min tests. This notion is further supported by the similar AOD values obtained during the 2-min tests using either pacing strategy. Thus, the nonsignificant differences in blood lactate and pH possibly reflect the similar anaerobic demand that existed between the two pacing strategies during the 2-min tests.

The results of this study have shown that kayak-ergometer performance is significantly greater following an all-out start pacing strategy when compared with an even pacing strategy. However, further research is required to determine if an all-out start pacing strategy remains the optimal pacing strategy for on-water kayak performance. Small decreases in power output are more likely to result in significant deceleration in water-based activities than in largely air-resisted activities like kayak ergometry. While the effects of medium-specific slow down are important to consider, it is important to note that there were no significant differences in power between the two pacing strategies in the final 30 s of the 2-min test.

In summary, an all-out start strategy for 10 s followed by a transition to even pacing resulted in a significantly greater 2-min, all-out kayak ergometer performance when compared with an even pacing strategy. Furthermore, average power was significantly greater during the first half of the test using the all-out start strategy, and significantly lower in the second half of the tests when compared with the even strategy. The all-out start strategy resulted in significantly greater $\dot{V}O_2$ at 30 and 45 s and a significantly greater total VO_2. While, no significant differences in AOD were observed, the pattern of AOD distribution was altered. No significant differences were observed between either pacing strategy for measures of peak blood lactate or pH. It was hypothesized that greater initial PCr breakdown and a consequent increase in $\dot{V}O_2$ without changing the AOD may have been responsible for the improved supramaximal performance using the all-out start strategy.

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Address for Correspondence: David Bishop, PhD, Department of Human Movement and Exercise Science, University of Western Australia, Crawley, WA. 6009, Australia; E-mail: dbishop@cyllene.uwa.edu.au.

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