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VELOCITY VARIATIONS OF AN INTERNATIONAL LEVEL SINGLE SCULLER

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1 INTRODUCTION

The rowing cycle is a repetitive biomechanical action that engages both the upper and lower limbs, with the oars serving as the primary instrument for generating the propulsive force to accelerate the boat [1]. From a biomechanical standpoint, the enhancement of rowing performance can occur by increasing the propulsive forces or decreasing the resistance opposing the boat during each rowing cycle. Recent advancements in instrumentation technology have enabled to quantify various biomechanical variables that are critical to rowing performance optimization, including mean velocity, cycle rate, distance per cycle and intra-cycle velocity variation [2]. The aim of the current study was to analyze these selected rowing biomechanical variables and assess their relationship during a standard 2000 m race.

2 MATERIALS AND METHODS

Data from an international level male single sculler were collected during a 2000 m race in an official competition. Boat position, velocity and acceleration were recorded using a unit with a 15 Hz GPS that included 12 channel receivers and a tri-axial accelerometer with a 100 Hz sampling rate (GPSPORT, Canberra, Australia) mounted on the boat bow deck. A validated and self-developed MATLAB routine was employed to calculate the mean velocity, intra-cycle velocity variation, cycle rate and distance per cycle. Intra-cycle velocity variation was obtained by the difference between the maximum and the minimum velocity in each rowing cycle. The 2000 m race was divided into 250 m splits to observe cycle variations across different race segments, allowing a more detailed analysis of the competition. In addition, the percentage of change between splits were also calculated. After checking data normality using the Shapiro-Wilk test, a Spearman relation was applied ($\alpha \leq 0.05$). All analyses were performed using SPSS 27 (Chicago, IL, USA) and MATLAB R2023a (The MathWorks Inc., Natick, MA, USA).

3 RESULTS

The biomechanical data from the 2000 m test and the percentage of change observed across each 250 m split are presented in Table 1. After an initial increase due to the start phase of the race, a gradual decrease in velocity, cycle rate, and intra-cycle velocity variation percentage was observed until the 1250 m mark, followed by an increase during the remainder of the race. The percentage of change in the distance per cycle increased in the first 500 m (9.3%) and small decreases were observed until the completion of the 2000 m. The correlation values between velocity, cycle rate and intra-cycle velocity variation were very strong ($\rho = 0.97$ and 0.99, $p < 0.001$, respectively) and a strong negative correlation value with distance per cycle ($\rho = -0.67$, $p < 0.001$) was observed. There were also a moderate negative correlation values ($\rho = -0.57$, $p < 0.001$) between cycle rate and distance per cycle and a very strong association between cycle rate and intra-cycle velocity variation ($\rho = 0.99$, $p < 0.001$).

Table 1. Biomechanical variables mean ± SD during the 2000 m race and per 250 m.

	Total	250 m	500 m	750 m	1000 m	1250 m	1500 m	1750 m	2000 m
Mean velocity ($km.h^{-1}$)	16.55 ± 0.45	17.40 ± 2.35	16.70 ± 2.17	16.30 ± 2.16	16.10 ±2.13	16.04 ± 2.11	16.30 ± 2.16	16.77 ± 2.17	16.79 ±2.21
Mean velocity % ($km.h^{-1}$)	-0.54 ± 2.37		-4.21%	-2.52%	-1.23%	-0.42%	1.61%	2.80%	0.11%
Rowing cycle rate ($cycles.min^{-1}$)	35.88 ± 2.23	41.13±4.01	35.63 ± 0.66	34.77±0.47	34.42 ± 0.44	34.26±0.47	34.99 ± 0.60	36.10 ± 0.41	36.30 ± 0.52
Rowing cycle rate % ($cycles.min^{-1}$)	-2.01 ± 5.74		-13.91%	-2.90%	-2.91%	0.01%	2.91%	2.82%	0.02%
Distance per cycle (m)	7.70 ± 0.24	7.10 ± 0.24	7.83 ± 0.33	7.81 ± 0.13	7.82 ± 0.24	7.80 ± 0.22	7.76 ± 0.20	7.73 ± 0.26	7.71 ± 0.24
Distance per cycle % (m)	1.11 ± 3.63		9.30%	0.32%	0.13%	-0.31%	-0.52%	-0.44%	-0.31%
ICVV ($km.h^{-1}$)	6.31 ± 0.23	6.61 ± 0.71	6.32 ± 0.44	6.21 ± 0.32	6.12 ± 0.33	6.13 ± 0.32	6.22 ± 0.31	6.52 ± 0.41	6.50 ± 0.31
ICVV % ($km.h^{-1}$)	-0.261 ± 2.93		-4.80%	-1.61%	-1.61%	0.02%	1.61%	4.63%	0.01%

4 DISCUSSION

The increase in mean velocity, and cycle rate are correlated with higher peaks of velocity within each rowing cycle, as greater cycle rates are associated with higher intra-cycle velocity variation [3]. During the first 250m, mean velocity, intra-cycle velocity variations, and cycle rate reached their highest values. Both mean velocity and cycle rate then decreased until 1000m before increasing again by the 2000m mark. Distance per cycle increased initially but declined over the last 750m. Thus, the increase in intra-cycle velocity variations seems to be a consequence of the enhancement of mean velocity and cycle rate, possibly due to the relationship between cycle rate and power directly which influences mean velocity [2]. The main limitation of the current study is that no data of rowing power was obtained to further assess its impact on intra-cycle velocity variation.

5 CONCLUSION

Although an increase in rowing cycle rate enhances boat velocity, it also increases the intra-cycle velocity variations, potentially reducing efficiency by increasing drag forces [3]. Hence, both rowers and coaches should consider this information to adopt a more efficient race strategy. Some limitations in our study should be acknowledged, since this was a pilot study caution should be used when extrapolating the results to grater sample sizes. Future research should include other boat classes in a competitive setting, using specialized boat instrumentation to measure the velocity profile, power output.

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