



Monitoring Changes of Cardio-Respiratory Parameters During 2000m Rowing Performance

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ABSTRACT

International Journal of Exercise Science 12(2): 483-490, 2019. The purpose of this study was to characterize the kinetics of cardio-respiratory parameters of elite male rowers during 2000m rowing time trial. 16 lightweight category (LWC) and 11 open category (OC) elite male rowers attending National camp were included in the study. Pulmonary gas exchange and heart rate (HR) during 2000m rowing ergometer test was determined through breath-by-breath analysis, with a portable metabolic gas analyzer and HR monitor. Time to completion, HR, oxygen uptake (VO_2), minute ventilation (VE) and respiratory exchange ratio (RER) were recorded at 500m, 1000m, 1500m and 2000m intervals. No significant ($p > 0.05$) difference was observed in the HR kinetics during 2000m rowing between the groups. However, split HR during the entire course was on the higher side in OC than LWC. Relative VO_2 at 1000m ($p < 0.01$), 1500m ($p < 0.05$) and 2000m ($p < 0.01$) was significantly less in OC rowers compared to LWC. However, VE was significantly higher for the OC group at 1500m ($p < 0.05$) and 2000m ($p < 0.01$) whereas RER was only significantly higher at 2000m ($p < 0.05$). %change in absolute and relative VO_2 , VE and RER at each 500m interval showed no significant difference among the groups. OC rowers had taken significantly less time ($p < 0.05$) to complete first 500m, 500m to 1000m and last 500m distance than LWC rowers. This detailed insight of rower's physiological responses can help coaches and support staff to determine the physiological working capacity of rowers at different levels, predicting performance and provided normative ranges for developing a representative physiological profile of elite Indian rowers.

KEY WORDS: Lightweight category, open category, split VO_2 , minute ventilation, respiratory exchange ratio, heart rate, split time

INTRODUCTION

Olympic rowing is a typical power-endurance sport conducted over a 2000m course, with 70-80% of energy contribution coming from the aerobic pathways and 20-30% from anaerobic pathways (8, 26). A race typically last approximately 5 to 7 minutes, where rowers are required to use both lower and upper body to overcome drag and to complete each rowing stroke. It is the norm to see a higher stroke rate during the start phase and again at the finish followed by execution of explosive power. Blood flow, energy requirement and substrate utilization varies depending on rower's training adaptation and performance (19, 24).

Competitive rowing involves abrupt transitions from rest/static phase to high-intensity exercise. Successful rowers cope up with the rapid increase in energetic demand requires a high level of coordination between the cardio-respiratory and muscular systems. Within seconds-to-minutes following the onset of severe intensity exercise, pulmonary VO_2 may increase from a resting value of ~ 0.25 - 0.5 liters/min to its maximum value for the individual. A faster VO_2 kinetics response is important for performance by reducing the initial oxygen deficit. Pulmonary oxygen uptake kinetics have been described for a variety of modes of exercise including running (2, 3, 13), cycling (20, 23, 33), swimming (6), arm cranking (4, 17, 18), and leg extension exercise (16, 21). However, studies on the kinetics of cardio-respiratory parameters in rowing are limited. Considering the growing popularity of rowing and the number of events or medals at International arena, it is imperative to emphasize applied research on rowing.

Nowadays for enhancing rower's ability, it is necessary to understand what physiological changes occur during rowing. Furthermore, by establishing a thorough understanding of the 'working' physiology of rowing, coaches and support staff will be able to make informed decisions on the training prescription specific to the needs of the individual for their sport and better predict performance enhancements in their athletes. In addition, the magnitude of variation in cardio-respiratory response on rowers can help to optimize pacing strategies.

We hypothesized that body mass affects the physiological responses and those responses affects performance. Therefore, the purpose of the present study was to determine the physiological responses to a 2000m time trial in Olympic level lightweight and open category rowers.

METHODS

Participants

16 lightweight category (LWC) (age: 24.2 ± 0.65 years; height: 182.69 ± 0.87 cm; weight: 70.93 ± 0.36 kg) and 11 open category (OC) (age: 25.73 ± 0.46 years; height: 185.91 ± 1.0 cm; weight: 79.59 ± 0.62 kg) elite male rowers were selected in this study. The rowers were attending the National training camp in preparation for the Asian rowing championship 2017 to be held in Thailand and Asian junior rowing championship 2017 in Singapore. All the study participants had more than 5 years of training experience and competed regularly at National level championships. Moreover, all the rowers were well versed in all testing procedures, as they regularly attend

National training camps, where they undergo a full physiological test battery. The study was timed to coincide with the end of the general base preparation phase of the fifth micro-cycle of the periodized training plan. The institutional ethical committee approved this study and written informed consent was taken from participants before testing.

Protocol

Changes in weather and water conditions make it difficult to compare on-water testing data in rowing and drawing valid conclusions. The ability to perform a rowing movement in a controlled environment made the rowing ergometer an attractive tool for assessing physiological variables. The rowers had gone through proper warm up prior to the test which includes stretching activities followed by 15 minutes ergometer rowing at different stroke rate. The participants then performed an all out effort 2000m time trial on air resistance Concept II model D (USA) rowing ergometer. Pulmonary gas exchange was determined breath-by-breath by a portable metabolic gas analyzer (Metamax® 3B, Cortex, Leipzig, Germany) and heart rate (HR) using a standard HR monitor (Polar WearLink® coded transmitter 31, Finland). HR, oxygen consumption (VO_2), minute ventilation (VE), respiratory exchange ratio (RER) and split times at the end of every 500m were recorded. Verbal encouragement was given during testing.

Statistical Analysis

Assumptions of statistical tests such as normal distribution and sphericity of data were checked as appropriate. Physiological parameters of LWC and OC rowers were compared to each other by Student t-test using SPSS version 15.0 statistical software (Statistical Package for Social Science, Chicago, Illinois, USA). All the data are presented as mean \pm standard error of mean (SEM). The magnitude of change (Δ) between the before values and after values of each interval was calculated using the equation: $\{(\text{after value} - \text{before value}) / \text{before value}\} * 100$. The value of $p < 0.05$ was considered to be statistically significant.

RESULTS

No significant ($p > 0.05$) difference was observed in the kinetics of HR during 2000m rowing between the groups. However, split HR at the end of 500m, 1000m, 1500m and 2000m was 3.2%, 2.2%, 1.9% and 3.0% higher in OC rowers than LWC. Percent increase in HR from 500m to 1000m, 1000m to 1500m and 1500m to finish were 5.3%, 2.3% and 1.0% in LWC and 4%, 2.4% and 1.5% in OC, respectively. HR response of LWC and OC rowers during 2000m rowing is presented in Figure 1.

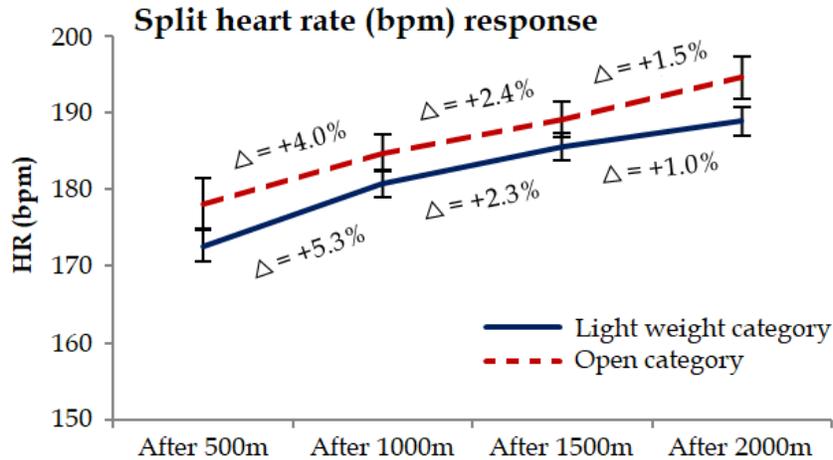


Figure 1. Heart rate kinetics of LWC and OC rowers during 2000m rowing. (Δ = difference between before values and after values of each interval)

Results showed that split relative VO_2 after 1000m ($p < 0.01$), 1500m ($p < 0.05$) and 2000m ($p < 0.01$) was significantly higher in LWC when compared to OC rowers. Split VE after 1500m ($p < 0.05$) and 2000m ($p < 0.01$) and split RER at 2000m ($p < 0.05$) were significantly higher in OC (Figure 2). Percent change in absolute and relative VO_2 , VE and RER after every 500m also showed no significant difference among the groups.

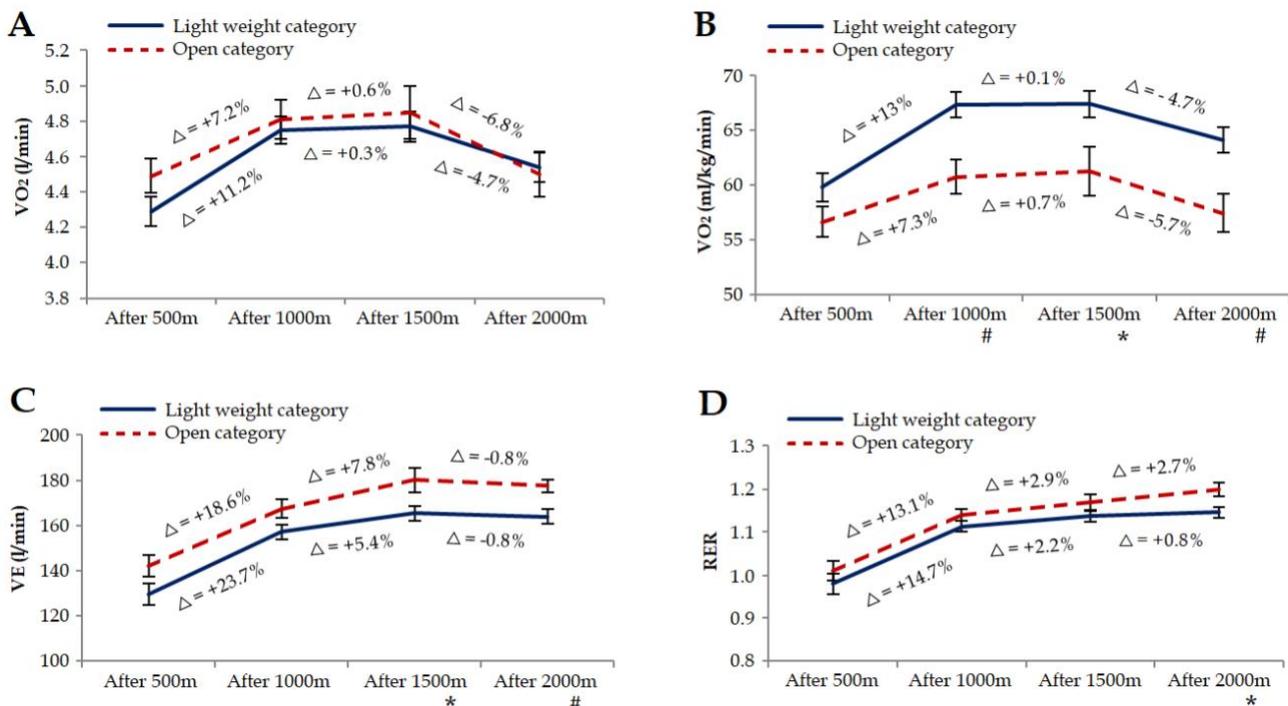


Figure 2. Changes in A) absolute VO_2 , B) relative VO_2 , C) VE and D) RER during 2000m rowing categorically. (*= $p < 0.05$ and # = $p < 0.01$ when compared between the groups; Δ = difference between before values and after values of each interval)

Differences in time dynamics were observed when sectors within groups were compared. The average split time profile showed that rowers performed the first 500m of the race faster than subsequent sectors (Figure 3). Each group showed a race profile that significantly differed from the other – that is, OC rowers time to completion of each split interval were 2.5% ($p < 0.05$), 2.4% ($p < 0.05$), 2.1% and 2.6% ($p < 0.05$) less than LWC rowers for the first 500m, 500m to 1000m, 1000m to 1500m and 1500m to 2000m, respectively. Total time also showed significant ($p < 0.05$) difference between the groups. Total time taken to complete 2000m rowing was 2.4% less in OC (average time: $413.63 \pm 5.03\text{sec}$) than LWC (average time: $423.86 \pm 2.37\text{sec}$).

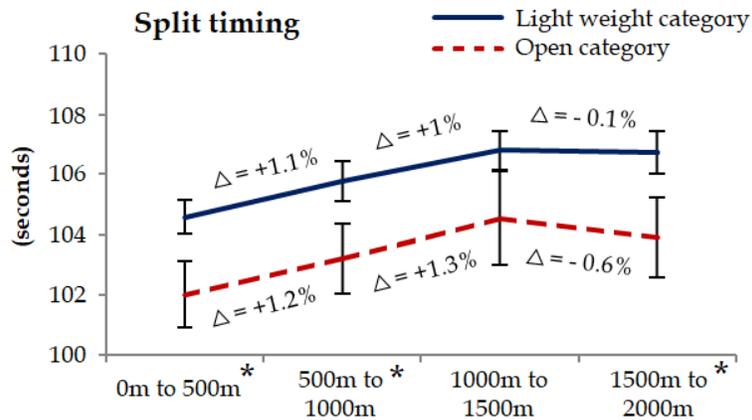


Figure 3. Split timing of LWC and OC rowers during 2000m rowing. (*= $p < 0.05$ when compared between the groups; Δ = difference between before values and after values of each interval)

DISCUSSION

Variations within the cardio-respiratory kinetics were observed during competitive rowing between the groups. Heart rate is a key indicator of how acute cardiovascular demands are being met during exercise. Central nervous mechanisms play a dominant role in the regulation of cardiovascular adjustments to rowing exercise. Maximal heart rates for men during simulated as well as competitive rowing are similar, averaging between 185 to 200 beats/min (10, 11). Peak HR in the present study for both lightweight and open category rowers was within this range. No significant difference was observed in split HR. But split HR after every 500m during 2000m rowing was slightly higher in the open category compared to the lightweight category. Literature suggests that maximal heart rate depends upon the muscle mass involved in exercise (15, 32). Greater body weight and muscle mass of open category rowers might be the reason behind this difference in HR response.

Previous studies analyzed VO_2 curve of oarsmen during 2000m rowing has reported that except for the first minute of exercise, oarsmen perform near their maximal aerobic capacities for the entire duration (7, 27, 30). Jackson and Secher (1976) were among the first to measure oxygen consumption during rowing and reported average VO_2 values of between 5.8 and 6.0 l/min for a pair-oared crew during 7 to 8 minutes of strenuous work (11). These results are somewhat higher than the average VO_2 values of Indian rowers. No significant difference was observed in

the kinetics of absolute VO_2 during 2000m rowing. However split relative VO_2 after 1000m, 1500m and 2000m showed significant differences and was lower in open category compared to the lightweight category, which is likely due to the higher body weight. VO_2 of Indian rowers reached the peak at 1000m and plateaued until 1500m. However, both absolute and relative VO_2 was decreased after 1500m until the finish.

The increases in oxygen uptake during simulated rowing were accompanied by significant elevations in ventilation. Literature suggests that ventilation greater than approximately 70 l/min is achieved through increase in breathing frequency and not by the increase in tidal volume (31). The initial increase in ventilation is produced by the mechanics of body movement. Literature suggests that as exercise begins, but before any chemical stimulation occurs, the motor cortex becomes more active and transmits stimulatory impulse to the inspiratory center, which responds by increasing respiration (14). As exercise progresses, increased metabolism in the muscle produces more CO_2 , H^+ and heat. All these factors enhance O_2 unloading in the muscles and increases a-v O_2 difference and activate chemoreceptors, which in turn stimulate the inspiratory center followed by increasing rate and depth of respiration (14). In this study, a gradual increase of VE was observed to 1500m and reached plateau until the finish during the 2000m rowing. Furthermore, the kinetics was similar for both groups. But significantly high VE was observed in the open category during 2000m rowing at 1500m and 2000m. However, no significant difference in VE at 500m and 1000m was observed but the mean value was higher in open category rowers. Previous study reported higher respiratory minute volumes typically greater than 200 l/min (8, 9, 22) and sometimes as high as 250-270 l/min (22, 29). It has been argued that the cramped body position in rowing may constrict the abdominal muscles and limit their ability to aid the expiratory phase of each breathing cycle (5). Literature also suggests no difference in ventilation whether the subjects rowed the single or double sculls (25).

Gradual increase of RER in both categories was observed in this study during entire course of 2000m simulated rowing. Although a higher RER after 500m, 1000m and 1500m was observed in open category rowers, the difference was negligible. A significantly higher RER was observed at 2000m in open category rowers. RER determined from exhaled carbon dioxide and inhaled oxygen represents the ratio of lipid to carbohydrate utilization as a fuel source during exercise (12). As the workload level increased, a corresponding increase in RER values was observed, in line with the metabolic shift to carbohydrates as the main energy substrate. Hence the difference in RER observed between the groups in this study indicates a difference in substrate utilization during simulated rowing.

Literature suggests that the most economical way to row the 2000m would be to keep an average velocity throughout the race (25). It appears that rowing velocity is greatest at the beginning of a race and then diminishes gradually during the next 1500m to increase to near the average velocity for the final 500m (25, 28). Indian open category rowers had taken less time to complete each 500m distance and split timing of both category rowers found in this study has followed the same trend. An initial spurt is required to break the inertia of the rowing shell which causes increase in oxygen uptake and greater power output at the onset of exercise (1, 20).

In conclusion, monitoring kinetics of cardio-respiratory parameters studied on elite Indian lightweight and open category rowers during 2000m rowing has provided an insight of rower's physiology. The current study showed body mass affects the cardio-respiratory response to rowing. Those responses are also translated for the variation in 2000m performance. Therefore, the information of time dynamics, HR, VO₂, VE and RER kinetics during rowing can help coaches and support staff to determine the physiological working capacity of each rower, predicting performance, aid in planning and modification of training programs and provided a database for developing a representative physiological profile of the successful Indian rowers.

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