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# The Physical Characteristics of Elite and Qualified Female Canoe Paddlers in China

Gao Xueyan[1], Guo Pengcheng[2], Kong Xianglin[2], Olga Rusanova[1], Andrii Diachenko[1] and Mykola Kudria[1]

[1]National University of Ukraine on Physical Education and Sport, Kyiv, Ukraine, [2]Jiangxi Normal University, Jiangxi, China

**Abstract**

The main objective of this research was to determine the physical characteristics of elite and qualified female canoe paddlers in China. Seventeen paddlers, leading athletes of Shandong and Jiangxi provinces, winners, prize winners and participants of the final races of the China Canoe Racing Championship took part (age 21±2; height=167±2 cm; mass 53.5±1.1 kg). The article shows that female canoe paddlers have superior aerobic and anaerobic qualities and have reported maximal oxygen consumptions of around 56.8 ml·kg-1·min-1 and lactate values of around 12.01 mmol·l-1 during laboratory testing. The range of individual differences of  as in the range of 107.00–116.00 for elite female canoe paddlers, 99.5–103.5 for female canoe paddlers (province team) and 85.0–91.0 for female canoe paddlers (reserve team) ($p<0.05$). The range of individual differences of La max, mmol·l-1 as in the range of 9.55–12.01 for elite female canoe paddlers, 9.67–11.11 for female canoe paddlers (province team) and 6.36–10.69 for female canoe paddlers (reserve team) ($p<0.05$). The research has shown that all physiological characteristics are reduced in relation to the model characteristics of sports (competitions), similar in duration and intensity of work in the canoe. There is no normative basis for outstanding operability in the process of modelling competitive activity and in implementing the components of the energy supply structure.

***Keywords:*** *female canoe paddlers, aerobic power supply capacity, functionality testing, $VO_2$ measurement max, working capacity*

## Introduction

Women's canoe is a new kind of rowing competition. The popularity of it, the high level of competition, and as a consequence, the intensity of the competition requires a certain level of functional readiness of female athletes, in particular for the effective energy supply of work at a distance of 200 m (single) and 500 m (two) (Borges, Dascombe, Bullock, & Coutts, 2015).

Traditionally, the determination of a physical profile in a given sport involves the use of predictive testing as a measure of power and strength (Cronin & Hansen, 2005), speed, aerobic fitness or flexibility (Simoneau, 1998).

Traditionally, research in kayaking is primarily focused on athletes' physiological testing in order to determine fitness levels and then designing training programs to optimize physiological fitness (Aitken & Neal, 1992). Early studies only analysed $VO_{2max}$ to monitor and assess the physiological capacity of elite kayakers (Tesch, 1983). However, this is not the only possible determinant of performance. While characteristics of the sport require that kayakers paddle most of the race at or around peak $VO_2$ (Bishop, Bonetti, & Dawson, 2002), requiring high aerobic power, the anaerobic aspects should not be overlooked (Fry & Morton, 1991; Tesch, 1983).

The previous research had significantly indicated higher $VO_{2max}$ levels than those observed here in both ergometer and treadmill tests, reporting values not lower than 54 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ in either case (Fry & Morton, 1991; Shephard,

Correspondence:

O. Rusanova
National University of Ukraine on Physical Education and Sport, Faculty of Sport and Management, Fizkul'tury St, 1, Kiev, Ukraine
E-mail: rusanova2080@gmail.com

1987). However, any comparison between studies must be carefully regarded due to the different protocols applied to estimate Oxygen uptake.

Elite kayakers demonstrate superior aerobic and anaerobic quantities and have reported maximal oxygen consumptions of around 58 ml·kg$^{-1}$·min$^{-1}$ (4.7 L·min$^{-1}$) and lactate values of around 12 mM during laboratory and on-water testing (Michael, Rooney, & Smith, 2008).

The literature on functional preparedness comprises little information on the specificity of energy supply and performance characteristics in women's canoe (Borges et al., 2015, Hagner-Derengowska et al., 2014, Hartmann, 2015, López-Plaza et al., 2018, Paquette, Bieuzen, & Billaut, 2018, Sheykhlouvand et al., 2018).

All this does not enable evaluating and interpreting indicators as model characteristics of preparedness and use in the process of managing rowers' physical fitness.

The primary objective of this research was to determine the physical characteristics of elite and qualified women in canoeing in China.

## Methods

*Subject*

Seventeen elite and qualified female canoe paddlers (female canoe paddlers of reserve team n=4; female canoe paddlers of province team, n=6; elite female canoe paddlers, n=7), leading athletes of Shandong and Jiangxi provinces, winners and participants of the final races of the China Canoe Racing Championship took part (age=21±2; height 167±2 cm; mass 53.5±1.1 kg). The reserve team includes female athletes who have a track record of rowing 1.5–2 years, and before they had been engaged in other sports.

All participants were informed of the requirements prior to the study, and their parents and coaches gave their informed written consent for them to participate. The local research ethics committee approved all procedures in the spirit of the Declaration of Helsinki.

*Research protocol*

For standardizing the measurements of special performance, the Dansprint canoe ergometer was used. $VO_{2\ max}$, the blood lactate concentration (La), and ergometric power (EP) of work were recorded. The specialists of the Scientific Sports Management Research Centers in Shandong Province (Jinan) and Jiangxi (Nanchang) carried out the measurements of the reaction of the cardiorespiratory system and blood sampling for lactate measurement.

*Physical Characteristics*

Gas exchange, HR, and blood lactate measurements. Oxygen consumption (V˙O2), CO2 production (V˙ CO2), minute ventilation (V˙E), and respiratory exchange ratio (RER) were determined on a breath-by-breath basis using an Oxycon mobile (Jaeger) metabolimeter. The metabolic unit was calibrated a gas of known composition (16.00% $O_2$, 4.00% $CO_2$), respectively.

The heart rate (HR) was recorded every 5 s with an HR monitor (S610 Polar Electro, Kempele, Finland).

The blood lactate concentration ([La]b) was determined using a portable lactate analyser (Biosen S. line lab +) on a blood sample obtained from the ear lobe at the end of the submaximal test and at three to five minutes of recovery after the maximal 120 s test (100% of the race speed).

All the women in canoeing performed an incremental exercise test on a canoe ergometer (Dansprint, I Bergmann A/S, Hvidovre, Denmark) on separate days, with at least 24 hours and no longer than 3 days between tests. The incremental exercise test was designed to establish the linear relationship between the work intensity (power in W) and the $VO_2$ for each individual.

It was important to preserve the individual maximum parameters of the ergometric power of work and the length of the rest intervals. The rest interval between 10 and 30 s work was one minute, between 30 s and 120 s work (i.e., five minutes), which provided a full recovery and diagnostics of the structure of the reaction of sprint rowers' anaerobic energy supply (i.e., anaerobic alacate and lactate (glycolytic) power, and anaerobic capacity). The test program also created the conditions for the display of the cardiorespiratory system reactive properties and the power of aerobic energy supply for the work.

To assess the power of the aerobic energy supply, we analysed the highest $VO_2$ values in the steady state period within ± 0.1 l / min ($VO_{2\ max}$ / kg) with a duration of at least 20 s.

*Statistical Analysis*

In order to assess and analyse the data received, the Statistical Package (SPSS 10.0)(SPSS 10.0) was used. Descriptive statistics suggested defining arithmetical average M standard deviation SD, as well as median (Me), maximal (Max) and minimal (Min) indices, 25% and 75% indices. The data were verified in accordance with the normal probability law (applying the Shapiro-Wilk criteria). If the data allocation complied with the normal probability law, then in order to define the statistical validity of discrepancies, the student criteria were applied. If the data did not comply with the normal probability law, non-parametric criteria of Wilkinson were applied to define the statistical validity of discrepancies. The error probability during the statistical analysis was set at the level of p=0.05 (significance level).

## Results

The energy and powers indicators in the 30- and 120-second time trials are presented in Table 1.

Significant differences in female athletes' performance indicators were established, which is indicated by the average values of the rowers' from a homogeneous group performance indicators, as well as by the data characterizing the functional abilities of female canoe paddlers who have the best results in the Chinese national arena.

Female canoe paddlers demonstrate superior aerobic and anaerobic quantities and have reported maximal oxygen consumptions of around 56.8 ml·kg$^{-1}$·min$^{-1}$ and lactate values of around 12.01 mmol·l$^{-1}$ during laboratory testing.

The range of individual differences of  as in the range of 107.00–116.00 for elite female canoe paddlers, 99.5–103.5 for female canoe paddlers (province team), and 85.0–91.0 for female canoe paddlers (reserve team) ($p<0.05$).

The range of individual differences of La max, mmol·l$^{-1}$ as in the range of 9.55–12.01 for elite female canoe paddlers, 9.67–11.11 for female canoe paddlers (province team) and 6.36–10.69 for female canoe paddlers (reserve team) ($p<0.05$).

**Table 1.** The energy and powers indicators in the 30- and 120-second time trials

| The energy and powers indicators | Statistic indicators | | | | | |
|---|---|---|---|---|---|---|
| | M±SD | Me | Min | Max | 25% | 75% |
| **Female canoe paddlers (reserve team), n=4** | | | | | | |
| $\overline{W}$ mean 10 s,W | 116.33±17.69 | 117.00 | 86.00 | 137.00 | 111.00 | 130.00 |
| $\overline{W}$ mean 30 s,W | 112.17±17.14 | 115.00 | 87.00 | 137.00 | 100.00 | 119.00 |
| $\overline{W}$ mean 120 s,W | 86.67±5.61* | 87.50 | 77.00 | 92.00 | 85.00 | 91.00 |
| $VO_2$ peak, l·min$^{-1}$ | 3.02±0.16* | 3.00 | 2.80 | 3.20 | 2.90 | 3.20 |
| $VO_2$peak, ml·min$^{-1}$·kg$^{-1}$ | 44.47±5.25 | 44.70 | 36.60 | 53.00 | 42.80 | 45.00 |
| La max, mmol·l$^{-1}$ | 8.81±2.49* | 9.61 | 5.17 | 11.42 | 6.36 | 10.69 |
| **Female canoe paddlers (province team), n=6** | | | | | | |
| $\overline{W}$ mean 10 s,W | 139.25±6.70 | 140.50 | 130.00 | 146.00 | 135.00 | 143.50 |
| $\overline{W}$ mean 30 s,W | 131.25±11.24 | 133.00 | 116.00 | 143.00 | 124.00 | 138.50 |
| $\overline{W}$ mean 120 s,W | 101.50±2.65* | 102.00 | 98.00 | 104.00 | 99.50 | 103.50 |
| $VO_2$ peak, l·min$^{-1}$ | 3.33±0.34 | 3.25 | 3.00 | 3.80 | 3.10 | 3.55 |
| $VO_2$peak, ml·min--1·kg$^{-1}$ | 50.58±4.52 | 49.30 | 46.90 | 56.80 | 47.25 | 53.90 |
| La max, mmol·l$^{-1}$ | 10.39±1.02* | 10.27 | 9.30 | 11.72 | 9.67 | 11.11 |
| **Elite female canoe paddlers, n=7** | | | | | | |
| $\overline{W}$ mean 10 s,W | 162.00±27.20 | 160.00 | 123.00 | 200.00 | 138.00 | 191.00 |
| $\overline{W}$ mean 30 s,W | 147.29±18.14 | 150.00 | 120.00 | 167.00 | 126.00 | 166.00 |
| $\overline{W}$ mean 120 s,W | 113.43±8.54* | 111.00 | 106.00 | 131.00 | 107.00 | 116.00 |
| $VO_2$ peak, l·min$^{-1}$ | 3.29±0.17 | 3.30 | 3.00 | 3.50 | 3.20 | 3.40 |
| $VO_2$peak, ml·min$^{-1}$·kg$^{-1}$ | 46.66±4.29 | 47.40 | 41.30 | 52.80 | 43.00 | 50.30 |
| La max, mmol·l$^{-1}$ | 11.30±1.81* | 11.25 | 9.47 | 14.67 | 9.55 | 12.01 |

Legend: *Significant difference from the 120-s trial (p<0.05).

## Discussion

The primary objective of this research was to determine the physical characteristics of elite and qualified women-canoers in China. It should be highlighted that this is the first comparative, interdisciplinary study in women in canoeing. The main result was the significantly greater physical fitness level by the elite women canoeing in China. These results provide normative data about the status of women canoeing in China competing at a high level, which enables identifying an optimal profile for each discipline.

The majority of studies in canoe and kayak paddlers has been focused on upper body aerobic capacity and its development because the paddlers spend the majority of their race at or around their $VO_{2peak}$ (Fernandez & Terrados, 1995). Methods and testing protocols to determine valid $VO_{2peak}$ values using kayak and canoe ergometer protocols and/or arm cranking protocols are frequently discussed (Forbes & Chilibeck, 2007; Michael & Smith, 2008).

The differences in physical performance capacity have been investigated more extensively for lower body performance, and less is known about the sex- and age-related differences in aerobic and anaerobic capacity as regards upper body exercise. In aerobic upper body exercise, untrained females attain at about 60 to 70% and specifically trained females at about 80 to 85% of the performances (related to kg of body mass) of their male untrained and/or trained counterparts (Heller, Vodicka, & Pribanova, 2002).

The maximum oxygen uptake has been the main physiological variable studied in the kayak literature due to its relationship with race times (Shephard, 1987; Tesch et al., 1976). However, in young athletes, it seems that $VO_{2max}$ values and performance in a given sport are not significantly related. Unsurprisingly, the kayakers exhibited significantly larger estimated $VO_{2max}$ values that confirm their greater aerobic capacity. Expressing $VO_{2max}$ relative to body mass has also revealed superior aerobic endurance of the kayakers regardless of their size and higher maturity levels. The previous research had indicated significantly higher $VO_{2max}$ levels than those observed here in both ergometer and treadmill tests, reporting values not lower than 54ml•kg-1•min-1 in either case (Fry & Morton, 1991; Shephard, 1987). However, any comparison between studies must be carefully undertaken due to the different protocols applied to estimate Oxygen uptake.

This study Borges and Coutts (2015) aimed to profile the physiological characteristics of junior sprint kayak athletes (n=21, $VO_{2max}$ 4.1±0.7 L/min, training experience 2.7±1.2 y) and to establish the relationship between physiological variables ($VO_{2max}$, $VO_2$ kinetics, muscle-oxygen kinetics, paddling efficiency) and sprint kayak performance. $VO_{2max}$, power at $VO_{2max}$, power, weight ratio, paddling efficiency, $VO_2$ at lactate threshold, and whole-body and muscle oxygen kinetics were determined on a kayak ergometer in the laboratory. Multiple regression showed that 88% of the unadjusted variance for the 200-m TT performance was explained by $VO2_{max}$, peripheral muscle deoxygenation, and maximal aerobic power (p<.001), whereas 85% of the unadjusted variance in 1000-m TT performance was explained by $VO_{2max}$ and deoxyhemoglobin (p<.001).

However, in contrast to aerobic exercise testing, there is an inconsistency in the modes and protocols and test duration of anaerobic tests used in canoe and kayak paddlers. For example, Fry and Morton (1991) used a 60-s lasting all-out test, while Bishop et al. (2002) and van Someren and Palmer (2003) have studied maximum accumulated oxygen deficit in a 2-min lasting all-out test, whereas Sitkowski has tested kayak paddlers by a 40-s upper body exercise test, and/or van Someren and Dunbar and Heller et al. (1997) used a 30-s lasting supramaximal test.

The research has shown that all female canoe paddlers' (reserve team) physiological characteristics are reduced in relation to the characteristics of elite female canoe paddlers, similar in duration and intensity of work in the canoe. There is no normative basis for female canoe paddlers' special operability in the process of modelling competitive activity and in implementing the components of the energy supply structure if the different protocols are applied to estimate Oxygen uptake.

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**Conflict of Interest**
The authors declare that there are no conflicts of interest.

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