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RESEARCH ARTICLE

The Relationship between Anaerobic Power Output and Race Performance during Marathon Canoe and Kayak Competition

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Abstract

Paddle sports are low impact activities that result in high aerobic demand. Although this sport relies on the aerobic system, with the addition of shorter distances in competition settings it has led to interest in the importance of anaerobic capacity. The purpose of this study was to identify the relationship between anaerobic power and endurance paddle race performance. Fifty (n = 50) endurance paddle athletes completed a 13-mile course either by kayak or canoe. A modified Wingate anaerobic power assessment protocol was conducted using a canoe or kayak paddling adaptor. Canoers completed one 30 second bout on their strong side followed by a 2-minute rest and a second 30 second bout on the opposing side. The kayakers performed one 30 second maximal bout given the bilateral nature of the stroke. Results revealed that anaerobic power for both left and right-side canoe strokes and kayak strokes was significantly correlated to endurance paddle race performance. In conclusion, it was determined that improvements in anaerobic power output may translate to increased efficiency in endurance paddle events.

Keywords

Anaerobic power, Kayak, Canoeing, Paddle sports, Training

Introduction

Marathon paddle competitions are low impact, aerobic endeavors that range in distance depending upon venue and may include obstacles which the competitors must navigate and/or sections of portage [1]. Traditionally, competitors would race from one point to another across combinations of river, lake, estuary, and sea. More recently, shorter courses are covered repeatedly in laps to be more spectator-friendly [2]. In addition to aerobic capacity, physiological requirements include muscular strength and endurance, particularly from the muscles of the back, shoulders, chest, arms, torso, and legs [3]. The sport also requires significant technical ability, including water knowledge, navigation skills, and a powerful and efficient paddling technique [4].

Previous research has described both the canoe and kayak paddling technique with variability in execution being attributed to differences in body type and equipment [5,6]. Additionally, anthropometric, morphological, and physiological characteristics of paddle sport athletes have been described with many of these characteristics demonstrating relationships with race performance outcomes [7]. One such variable of interest is anaerobic power output. Elite paddlers exhibited a well-developed anaerobic capacity, indicating a significant anaerobic contribution to kayak performance [8]. Significant correlations of power output and race performance have been demonstrated for 1000 m outrigger canoeing [9] and various sprint distance flat-water kayaking [10,11], however, the relationship of anaerobic power and endurance paddle race performance has yet to be reported. As such, the purpose of this research was to examine and report any such relationship for both canoe and kayak athletes. The authors hypothesized that anaerobic power would be significantly correlated with endurance paddle race performance.

Methods

Study design

The 2016 United States Canoe Association (USCA)

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Marathon National Championships were held on the Connecticut River in Northfield, Massachusetts, USA, between August 11 and August 14. Prior to competition, race registration and check-in were held. It was during race registration and check-in that competitors were solicited for research participation. Athletes willing to participate received a brief but thorough explanation of research parameters, and any questions were answered by the researchers. An informed consent document was read and signed by all research participants. A team of USCA officials reviewed and approved the data collection procedures proposed by the researchers in a manner consistent with other endurance events [12]. All data collection procedures were consistent with criteria detailed by the Center for Disease Control and Prevention, Human Participant Protection standards.

Participants

Fifty (n = 50) endurance paddle athletes competing in either canoe or kayak races at the event served as the study participants. The racecourse was a 13-mile looped course that provided athletes the opportunity to compete in a number of races including individual, pair, and mixed-pair events over the four days of competition. The event attracted high level endurance canoe and kayak athletes from across the United States of America and Canada, including previous national champions and at least one former Olympic athlete. All participants provided written informed consent prior to participating in data collection.

Data collection

Participant age, height, and weight were recorded. Body mass index was calculated from height and weight values. Additionally, body composition was assessed using a handheld bioelectrical impedance device [13].

A modified Wingate anaerobic power assessment protocol was conducted using a canoe or kayak paddling adaptor (Paddles port Training Systems, East Hardwick, VT, USA). These paddling adaptors integrate with Concept 2 indoor rowing and ski ergometers respectively. The PM5 computers on the Concept 2 equipment were utilized to record the average Watts produced by the athlete during the 30 second maximal effort. Canoers completed one 30 second effort on their side of preference, were allowed a 2-minute rest period and then completed a 30 second effort on the opposing side. Kayakers performed one 30 second all-out effort due to the bilateral nature of the kayak paddle stroke. These assessment procedures are similar to those previously reported [14].

Following race competition, the data collected was compared to individual race outcomes to establish any potential relationship between anaerobic power and race performance. Functional Movement Screening (FMS) variables were included in the data collection.

Statistical analyses

Pearson correlations were used to compare anaerobic power values with finish time in the individual race con-

Table 1: Characteristics of race participants (*n* = 50).

Variable	Minimum	Maximum	Mean	SD
Age (yrs)	21	94	53.96	17.37
Height (cm)	156.21	193.04	173.58	8.92
Weight (kg)	55.34	115.67	75.11	12.71
BMI (kg/m^2)	20.41	32.21	24.85	2.92
Body Fat %	6.41	35.61	22.21	6.31
Finish Time (min)	119.15	169.57	135.75	13.33

Table 2: Characteristics of race participants by gender.

Gender	Variable	Minimum	Maximum	Mean	SD
Female (*n* = 15)	Age (yrs)	23.00	76.00	50.86	17.26
	Height (cm)	156.21	177.80	165.59	6.60
	Weight (kg)	55.79	85.00	63.81	7.48
	BMI (kg/m^2)	20.40	32.20	23.72	2.98
	Body Fat %	17.01	35.61	25.86	6.47
	FinishTime (min)	119.65	154.45	133.99	11.52
Male (*n* = 35)	Age (yrs)	21.00	94.00	55.14	18.02
	Height (cm)	160.02	193.04	176.81	7.87
	Weight (kg)	55.34	115.67	79.78	11.88
	BMI (kg/m^2)	20.40	32.00	25.32	2.89
	Body Fat %	6.41	32.10	20.82	5.83
	Finish Time (min)	119.15	169.57	135.98	14.27

tests. Male and female athletes were combines for data analysis. Data were analyzed with descriptive statistics, and the results were reported as mean ± SD. Power outputs were correlated to race performance using a Pearson product-moment coefficient, and significance was indicated as $p \leq 0.05$. All statistical analyses were performed using SPSS Version 24 (SPSS Inc, Chicago, IL USA).

Results

Participant characteristics are presented in Table 1 and Table 2. Significant correlations were found between race event finish time and both left ($r = 0.449$, p = 0.041) and right side ($r = 0449$, p = 0.041) canoe power outputs respectively. There was also significant correlation found between kayak power output and race event finish time ($r = 0.632$, p = 0.021). Correlational data between power output and race performance is presented in Table 3.

Discussion

The aim of this study was to determine the relationship of anaerobic power output to endurance paddle race performance. The primary findings of this research are that anaerobic power for both left and right-side canoe strokes and kayak strokes were significantly correlated to endurance paddle race performance. This is the first research to demonstrate that anaerobic power output is related to endurance paddle race performance. These findings are consistent with previous research establishing a positive relationship between anaerobic power output and sprint distance paddle performance. The findings of the study suggest that greater anaerobic power results in greater mechanical work at a lower physiological cost (Table 4, Table 5 and Table 6).

In a previous study, higher total FMS scores correlated to a better finish time and there were also significant sub-scores related to functional capability in areas related to the kinetic chain and lumbo-pelvic-hip complex of a paddle stroke [7] Results from this study correspond to significant relationships between FMS ratings such as shoulder mobility and hurdle step. The findings suggest a significant correlation between canoe power average and kayak power average with power output and finish time. There was also a statistically significant relationship between higher total FMS scores and power output.

In view of the significant correlations reported in canoe and kayak data sets, it can be deduced that enhancing anaerobic efficiency contributes to a better endurance paddle race performance. The bouts of anaerobic power output were short in duration; however, these bouts of power output were statistically significant and contribute to the overall performance. Despite the aerobic nature of the sport, an emphasis should be placed on the anaerobic component in training protocols in support of the data obtained. The results also indicate potential applications for strength and conditioning programming for canoe and kayak athletes. Based upon this infor-

Table 3: Correlational data between assessed power output and finish time.

Variable	Significance	r value	Z transformation	95 % CI Lower	95 % CI Upper
Power Canoe Left (n = 35)	0.041	0.449	0.483	0.179	0.703
Power Canoe Right (n = 35)	0.041	0.449	0.483	0.179	0.703
Power Average Canoe (n = 35)	0.034	0.548	0.615	0.355	0.786
Power Kayak (n = 15)	0.021	0.632	0.745	0.377	0.909

Table 4: Significant correlational data between FMS variables and assessed power for canoe left (n = 35).

Variable	Significance	r value	z transformation	95% CI Lower	95% CI Upper
Shoulder Mobility Left	0.043	0.421	0.449	0.137	0.681
Shoulder Mobility Right	0.039	0.384	0.405	0.083	0.65
Hurdle Step Left	0.046	0.349	0.364	0.035	0.621

Table 5: Significant correlational data between FMS variables and assessed power for canoe right (n = 35).

Variable	Significance	r value	z transformation	95% CI Lower	95% CI Upper
Shoulder Mobility Left	0.036	0.405	0.429	0.112	0.667
Shoulder Mobility Right	0.045	0.582	0.665	0.427	0.817
Hurdle Step Right	0.044	0.364	0.382	0.056	0.634

Table 6: Significant correlational data between FMS variables and assessed power kayak (n = 15).

Variable	Significance	r value	z transformation	95% CI Lower	95% CI Upper
Shoulder Mobility Left	0.024	0.506	0.557	0.063	0.831
Shoulder Mobility Right	0.026	0.517	0.572	0.085	0.838

mation, anaerobic training could be of benefit to these athletes when properly incorporated into training protocols.

Limitations presented during the study was the inequality in gender pooling amongst the subjects which would have an impact on physiological processes that occur since the number of males was greater than the number of female participants. Additionally, there was an inequality in the sample sizes of canoe versus kayak participants.

Conflicts of Interest

The authors declare no conflict of interest.

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