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ERGOMETRIC TESTING FOR TOP-LEVEL KAYAKERS: VALIDITY AND RELIABILITY OF A DISCONTINUOUS GRADED EXERCISE TEST

ERGOMETRIČNO TESTIRANJE ZA VRHUNSKE KAJAKAŠE: ZANESLJIVOST IN VELJAVNOST STOPNJEVANEGA OBREMENITVENEGA TESTA S PREKINITVAMI

Abstract

The aim of this study was to determine the validity and reliability of a graded exercise test on a specific kayak ergometer (Dansprint®) in which certain physiological and technical parameters that can to define kayaking performance were assessed. Fourteen male top-level kayak paddlers (all members of the Spanish National Kayaking Team) participated in this investigation. All subjects carried out two ergometric tests (Ergo1 and Ergo2) and one flat water test (FWT) in random order. At anaerobic threshold (AnT) intensity, the results showed acceptable levels of reliability (comparison between data of Ergo1 and Ergo2 tests) in the assessment of velocity ($r=0.784$; $p=0.004$), stroke frequency ($r=0.976$; $p<0.001$), heart rate ($r=0.964$; $p<0.001$), and blood lactic acid concentration ($r=0.899$; $p<0.001$). Validity coefficients showed a strong relationships between Ergo2 and FWT tests in all physiological and technical parameters with the exception of velocity ($r=0.498$; $p=0.121$). It can be concluded that specific ergometry can be used to evaluate and to prescribe training AnT intensities of top-level kayakers, regarding parameters such us heart rate, whole blood lactic acid concentration, and stroke frequency. Nevertheless, the training prescription through specific ergometry must be taken cautiously when velocity is the parameter of reference.

Key words: kayaking, testing, ergometry

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Izvleček

Cilj raziskave je ugotoviti veljavnost in zanesljivost stopnjevanega obremenitvenega testa na specifičnem kajakaškem ergometru (Dansprint®), v okviru katerega smo ocenjevali določene fiziološke in tehnične parametre, ki opredeljujejo kajakaško uspešnost. V raziskavi je sodelovalo 14 vrhunskih kajakašev (vsi so bili člani španske kajakaške reprezentance). Vsi preizkušanci so v naključnem vrstnem redu opravili dva ergometrična testa (Ergo1 in Ergo2) ter test na mirni vodi (FWT). Pri intenzivnosti anaerobnega praga (AnT) so rezultati pokazali sprejemljive ravni zanesljivosti (primerjava podatkov testa Ergo 1 in Ergo2) pri oceni hitrosti ($r=0,784$; $p=0,004$), frekvenci zavesljaja ($r=0,976$; $p<0,001$), srčnemu utripu ($r=0,964$; $p<0,001$) in koncentraciji mlečne kisline v krvi ($r=0,899$; $p<0,001$). Koeficienti veljavnosti so pokazali močno povezavo med testi Ergo2 in FTW v vseh fizioloških in tehničnih parametrih, z izjemo hitrosti ($r=0,498$; $p=0,121$). Zaključimo lahko, da se specifična ergometrija lahko uporablja za ocenjevanje in oblikovanje vadbe vrhunskih kajakašev z AnT intenzivnostjo, s poudarkom na parametrih, kot so utrip srca, skupna koncentracija mlečne kisline v krvi in frekvenca zavesljaja. Zaradi možnih negativnih posledic, je pri oblikovanju vadbe preko referentnega parametra hitrosti, potrebna previdnost.

Ključne besede: kajakaštvo, testiranje, ergometrija

INTRODUCTION

Flat-water kayaking is an Olympic sport that combines different types of boats (canoe and kayak) and distances (500 m for female and 500 m and 1000 m for male competition). The contribution of aerobic metabolism in individual races has been established between 60 and 80% for 500 m and 1000 m, respectively (Van Someren, 2000). In this sense, an accurate assessment of optimal kayaking training intensities to develop aerobic and anaerobic metabolisms is needed. This assessment can be achieved through field tests (flat water environment) or under simulated conditions in laboratory environment using specific kayak ergometers. Since 1973, when Pyke, Baker, Hoyle and Scrutton (1973) designed and developed a specific kayak ergometer, a great number of engineers and researchers have tried to simulate the real conditions of paddling using both air-braked and mechanical resistance systems. Analysis of technical actions on these ergometers has shown a high level of coincidence between ergometer and flat water paddling when wrist, elbow and shoulder motions were compared (Dal Monte & Leonardi, 1976; Campagna, Brien, Holt, Alexander, & Greenberger, 1982). Moreover, a comparative analysis taking into account physiological variables were also performed (Larsson, Larsen, Modest, Serup, & Secher, 1988), showing that air-braked kayak ergometers lead to reach the same ventilation, VO_2 peak, and heart rate (HR) values that those observed on flat water kayaking. Furthermore, Bourgois, Vrijens, Verstuyft, Zinzen and Clarijs (1998) reported similar blood lactate concentrations and HR values after comparing kayak ergometry and flat water paddling. Muscular power expressed on mechanical braked ergometer and on flat water channel was also very similar (Witkowski, Wychowanski, & Buczek, 1989).

Despite of all of the above-mentioned studies, it is very difficult for ergometry to exactly reproduce the metabolic demands of simulated sport activity. In this sense, several investigations have questioned the use of specific ergometers as an alternative to field testing. Van Someren and Dunbar (1996) reported a lack of correspondence between kayak ergometry and flat water paddling when muscular power and blood lactate concentration were compared, advising against the use of this kind of devices for monitoring kayakers' training adaptations. Kruger, Schulz, Berger and Heck (1997) observed how HR response to an effort on air-braked kayak ergometer was lower than that registered on flat water paddling at the same exercise intensity.

Therefore, the aim of this study was to determine the validity and reliability of a graded exercise test on a specific kayak ergometer, attending to physiological and technical parameters that can define kayaking performance.

METHODS

Participants

Fourteen top-level male kayak paddlers (all members of the Spanish National Kayaking Team) participated voluntarily in this investigation. Participant characteristics were as follows: age: M = 25.2 years, SD = 2.3 years; height: M = 1.81 m, SD = 0.05 m; body mass: M = 84.7 kg, SD = 5.3 kg; training experience: M = 11.1 yrs, SD = 2.1 yrs; VO_{2max}: M = 67.7 $mL \cdot kg \cdot min^{-1}$, SD = 2.5 $mL \cdot kg \cdot min^{-1}$.

Instrument and procedure

All subjects carried out two graded exercise tests on a specific ergometer (Ergo1 and Ergo2) and one flat water test (FWT) in random order and separated by 48 h. Ergo1 and Ergo2 were performed with a Dansprint® ergometer (Dansprint ApS, Denmark) using a drag resistance coefficient of 35. After a 5 min warm-up at a speed of 9 $km \cdot h^{-1}$, the first stage was set at 11.5 $km \cdot h^{-1}$ and the speed increments were 0.5 $km \cdot h^{-1}$ every 3 min, including pauses of 30 s between work intervals. Each kayaker was allowed to freely adjust his stroke rate (SR) as needed, being continuously recorded by a stroke counter (Interval 2000, Nielsen-Kellerman, USA). Heart rate (HR) was monitored using standard HR telemetry (S610i; Polar Electro Oy, Finland) and recorded every 5 s. Capillary whole blood samples were also taken from each kayaker's earlobe during test pauses, just at the end of the effort, and during recovery period (min 1, 3, 5 and 7). In all cases, paddlers were encouraged to give maximal effort and to complete as many stages as possible. The test concluded when the subjects voluntarily stopped paddling, or when they were unable to maintain the imposed speed.

FWT was performed on a flat water channel and its structure was similar to the Ergo1 and Ergo2 tests. Environmental conditions were also similar in all testing sessions and velocity was monitored thorough FWT using a GPS (Garmin mod.305).

Anaerobic threshold (AnT) was calculated from blood lactate concentrations (LP20 mini-photometer; Dr. Lange, France) according to the D-max method (Cheng at al., 1992). At this key point, HR, SR, paddling velocity (PV), and blood lactate concentration were assessed.

Standard statistical methods were used for the calculation of means and standard deviations (SD). The Kolmogorov-Smirnov test was performed to evaluate conformity to a normal distribution, and a one-way ANOVA was applied to compare testing sessions for physiological and kayaking performance variables. After that, the Pearson's correlation coefficient was calculated to check both reliability (Ergo1 vs. Ergo2) and validity (Ergo2 vs. FWT). Significance was accepted at $p<0.05$ level.

RESULTS

At AnT intensity level, no statistical differences were observed between the testing sessions for any physiological or kayaking performance variables registered. Moreover, the results showed acceptable levels of reliability (comparison between data of Ergo1 and Ergo2 tests) in the assessment of PV ($r=0.784$; $p=0.004$), SR ($r=0.976$; $p<0.001$), HR ($r=0.964$; $p<0.001$), and blood lactic acid concentration ($r=0.899$; $p<0.001$). Validity coefficients showed a strong relationships between Ergo2 and FWT tests in all physiological and technical parameters with the exception of velocity ($r=0.498$; $p=0.121$) (Table 1).

Table 1. Physiological and kayaking performance variables registered in both ergometric and flat water tests.

	Ergo1 *M* *(SD)*	*Ergo2* *M* *(SD)*	***r1; p1***	*FWT* **M** **(SD)**	***r2; p2***
Paddling velocity (km/h^{-1})	12.99 (0.22)	13.05 (0.32)	0.784; 0.004	13.30 (0.31)	0.496; 0.121
Stroke rate (st/min^{-1})	79.5 (5.7)	79.5 (5.6)	0.976; 0.000	73.9 (5.0)	0.985; 0.000
Heart rate (bp/min^{-1})	173.0 (6.6)	174.5 (6.3)	0.964; 0.000	172.0 (4.7)	0.924; 0.000
Lactate (mMol/L^{-1})	2.98 (0.56)	3.21 (0.50)	0.899; 0.000	3.13 (0.37)	0.920; 0.000

Legend: r1 and p1 show the Pearson correlation coefficient between Ergo1 and Ergo2, and its level of significance, respectively. r2 and p2 show the Pearson correlation coefficient between Ergo2 and FWT, and its level of significance, respectively.

DISCUSSION

Several investigations have attempted to test the validity of kayak ergometers, comparing flat water kayaking and kayak ergometry. The results of some of these studies showed a lack of correspondence between physiological responses to open water and ergometric tests. However, there have been advancements in the development of air-braked kayak ergometers that can offer new possibilities in the application of laboratory test for the prescription and evaluation of kayak paddlers. This is the case of the Dansprint® kayak ergometer, a new air-braked device that gives new possibilities to improve kayak testing.

In the present investigation, we proposed a discontinuous graded exercise test on Dansprint® ergometer (Ergo1 and Ergo2) that was also applied on flat water channel (FWT). The main aim of this test was to assess AnT from blood lactate concentrations (D-max method) determining PV, SR, and HR at this key point, since AnT is a valid criteria to determine kayaking performance. After comparing physiological and kayaking performance variables from the Ergo1 and Ergo2 testing sessions, we observed high levels of reliability in the assessment of PV, SR, HR, and blood lactic acid concentration at AnT paddling intensity. However, when validity indexes were calculated (Ergo 2 vs. FWT), we observed high values of Pearson correlation coefficients for SR, HR, and blood lactic acid concentration at AnT intensity. Although the validity level for PV was acceptable, and a significant relationship was established, these data suggest certain differences in paddling velocity calculation. The different devices used for PV calculation (on-board computer and GPS terminal in ergometric and FWT, respectively) probably induced a lower value for this kayaking performance variable.

Our results are the opposite of those described by Van Someren and Dunbar (1996), and Kruger et al. (1997), who reported a lack of correspondence between kayak ergometry and flat water paddling when blood lactate concentration and HR were compared. However, our data are in agreement with the previous report by Bourgois et al. (1998) and Oliver (1999), who registered similar blood lactate concentration and HR values after comparing kayak ergometry and flat water paddling.

It can be concluded that Dansprint® ergometry show acceptable levels of reliability and validity when parameters such us HR, whole blood lactic acid concentration, and SR are used to assess AnT training intensities of top-level kayakers. Nevertheless, and to facilitate the training prescription process, more studies are needed to test the reliability and validity of PV scores obtained in kayak ergometry evaluation.

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