THE VALIDITY OF A PREDICTION MODEL OF COMPETITION PERFORMANCE IN DOWNHILL WHITE WATER KAYAKING

Anton Ušaj*

VELJAVNOST NAPOVEDI MODELA TEKMOVALNE ZMOGLJIVOSTI V KAJAKU NA DIVJIH VODAH – SPUST

ABSTRACT

To ascertain whether predicted competition results in a white water downhill sports event are valid if they are predicted by using tests on flat water, 11 top ranked national level kayakers performed three tests, twice in the period of two international competitions (one month). The predictors were: paddling speed and heart rate determined by Onset of Blood Lactate Accumulation (v_{OBLA} and HR_{OBLA}), average speed, HR and Lactate concentration in the test over 4000 m (v_{4000}, HR_{4000}, LA_{4000}) and 500 m (v_{500}, HR_{500}, LA_{500}). A combination of v_{OBLA}, v_{4000} and v_{500} was selected as the best prediction combination. This combination predicted a competition time of 902±20.5 s in the first experiment, similar to the real competition results (903±20.6 s). In the second experiment, the calculated competition result (862±45 s) is also similar to the real one (862.8±48.4 s). Regardless of this precise prediction of the specific competition results, it is not possible to use each of both prediction models as universal in order to calculate competition results in both experiments with satisfactory accuracy and precision. The very different duration of competitions caused an unpredictability of the universal model. Irrespective of this flaw, which was characteristic for both of the models, the basic principles by which the models predicted competition results were very similar. This general characteristic may be used for estimation of qualitative changes in performance during the competition season.

Key words: kayak, white water, downhill, predictive tests, multiple regression models

IZVLEČEK

Enajst najboljših kajakašev, državnih reprezentantov v spustu na divjih vodah, je opravilo tri teste, dvakrat, v obdobju enega meseca, med dvema mednarodnima tekmama. Namen tega preizkusa je raziskati možnost dovolj zanesljivega predvidevanja tekmovalne zmogljivosti v kajaku na divjih vodah, disciplini spust, na osnovi rezultatov testov na mirni vodi. Izbrani napovedni kazalci so: hitrost veslanja in frekvenca srca, ki ju določa kriterij OBLA (Onset of Blood Lactate Accumulation) (v_{OBLA} in HR_{OBLA}), povprečna hitrost veslanja, frekvenca srca in vsebnost laktata v testu na 4000 m (v_{4000}, HR_{4000} in LA_{4000}) in 500 m (v_{500}, HR_{500} in LA_{500}). Kombinacija kazalcev v_{OBLA}, v_{4000} in v_{500} je bila izbrana kot najboljši napovedni model. S pomočjo tega modela je izračunan teoretični čas 902 ± 20,5 s v prvem eksperimentu, kar je zelo podobno kot realno doseženi tekmovalni časi (903 ± 20,6 s). Podobno je bilo tudi v drugem eksperimentu, kjer je izračunan tekmovalni čas (862 ± 45 s) zelo podoben doseženemu (862.8 ± 48,4 s). Ne glede na to natančnost pri predvidevanju specifičnih rezultatov, ni mogoče uporabiti katerega koli od obeh modelov za univerzalnega: izračunati tekmovalne rezultate v enem od obeh eksperimentov, z uporabo modela iz drugega eksperimenta. Zelo različne tekmovalne proge namreč povzročajo napake v izračunih. Ne glede na to, pa je razvrščanje po izračunanih in dejanskih časih ohranjeno, ne glede na uporabljeni model, kar pomeni, da se mogoče le ohranja princip, po katerem se različno kvalitetni tekmovalci razvrščajo med seboj, vsebuje pa ga izračunan model. Tak način uporabe izračunanih modelov je lahko pot, po kateri je mogoče spremljati zmogljivost posameznika skozi tekmovalno sezono.

Ključne besede: kajak, divja voda, spust, prediktorski testi, regresijski modeli

*Faculty of Sport, University of Ljubljana, Ljubljana, SLOVENIA

INTRODUCTION

The competition result in each sport is the single and most important characteristic of the sportsmen's performance at the particular moment. It reflects the influence of the simultaneous effect of several biological, psychological, technical and tactical characteristics. These characteristics influence the competition results by their complex combination. It is of great importance for the training process that the most important characteristics should be known. However, changes of values of those characteristics throughout the competition season as a result of training should be assessed, and this can be done by repeating specific tests. The value of each test should be affected by a single factor. Therefore, a multifactoral system could be achieved in order to asses the competition performance of a particular sportsman at a particular moment. The idea of the study was to ascertain if the construction of a very simple multifactorial model can successfully predict competition performance in this sports event. The described idea can be realised by using a multiple regression model (3). Two preliminary conditions should be met before using this mathematical-statistical method. The first condition demands that the number of subjects should be large enough and the second one demands linear correlations between the tests and the competition results. These conditions have limited the application of the described method, because in studies in top level sports, there exists only a small number of subjects. In such situations the linearity of correlations is also in question. Regardless of such conditions, this method can be used for an assessment of how competition results depend on several basic characteristics of sportsmen determined by using specific tests. It is possible to calculate theoretical competition results with a prediction model also in the period out of the competition period. This is very important for planning and selecting proper methods in the training process. The estimation of the validity of prediction should be done before this kind of model can be used for that purpose. Validity seems to be especially critical, because of its dependence on a number of subjects used in calculations in the period of construction of the model. This is a specific problem in top level sports, where the number of subjects has been reduced to a team of less than 15. The competition result (time of racing) is very difficult to predict because of the different characteristics of water in the rivers, even in the same river. Nevertheless we would like to estimate how much variance can be predicted in white water kayaking on the basis of results of specific tests performed on flat water. We have not found any data in literature related to this topic except the results of Fry and Morton (4) who used a similar idea, but on flat water kayakers. We tested the hypothesis in spite of the non-standard competition conditions and small number of subjects. It is possible to predict an important part of the variance of competition results in white water downhill kayaking by results of tests performed on flat water in spite of the small number of subjects.

METHODS

Eleven top level kayakers from the national white water downhill team (also internationally well ranked competitors) voluntarily participated in the study, after they confirmed in writing their consent to take part. The average height was 177±5 cm, body mass 70±6 kg and age 22±5 years.

Each subject performed three tests on flat water, one week after the World Cup competition. The whole procedure was repeated twice, over a span of one month, both times a week after the same range competitions.

The OBLA TEST consisted of 5 repetitions of 1000 m on flat water with a predetermined increase in paddling intensity. For this purpose, continuous monitoring of Heart Rate (HR) was used. It was previously determined at five values: 110, 125, 140, 155 and 170 b/min. Resting periods between each 1000 m trials consisted of 8-10 min of slow intensity return to the starting position. The average speed was calculated by using the time for each 1000 m.

The endurance test over 4000 m (TEST 4000) consisted of one maximum effort trial on flat water. The average speed was calculated by using the time over the 4000 m distance.

The speed endurance test over a 500 m distance (TEST 500) consisted of one maximum effort trial on flat water. The average speed was calculated by using the time over the entire distance.

For competition results (CR) the official results were used (time of race + penalty time).

Heart rate (HR) was measured continuously using a PE3000 monitor (Polar Electro, Finland). Average HR in the OBLA TEST was calculated using the last 2 min interval of each 1000 m distance. In the TEST 4000 the last 10 min interval was used for calculating average HR. The interval of the last 30 s was used for calculating the average HR in the TEST 500.

Blood samples (20 μl) were taken from the hyperemied earlobe and analysed using an ANALOX GM7

(Analox, England) analyser. Blood samples were collected as soon as possible (usually 10-15 s after arrival through the finish line) after each 1000 m distance. Similarly, blood samples were collected before the test start and as soon as possible after the TEST 4000. By contrast, blood samples were collected after the 3 min resting period in the TEST 500.

The criterion OBLA applied the method described by Sjodin et al. (5), additionally adapted for kayaking by using the two-component model (8). The paddling speed (v_{OBLA}) and heart rate (HR_{OBLA}) were determined as potential predictors in the OBLA TEST. The average paddling speed (v_{4000}), heart rate (HR_{4000}) and lactate concentration (LA_{4000}) were used as the potential predictors in the TEST 4000. Similarly average speed (v_{500}), heart rate (HR_{500}) and blood lactate concentration (LA_{500}) were selected as the predictors in the TEST 500.

RESULTS

There were 6 members of the national team participating in the first experiment (EXPERIMENT 1), which consisted of the competition and tests. Nine kayakers participated in the second experiment (EXPERIMENT 2) which consisted of another competition and tests. The interval between the two experiments was one month.

Average paddling speed, v_{OBLA} is similar to v_{4000}, but significantly lower ($P< 0.05$) than v_{500} in EXPERIMENT 1 (Table 1). By contrast, HR_{OBLA} is significantly lower than HR_{4000} ($P< 0.05$). Surprisingly HR_{500} is similar to HR_{4000}, irrespective of different paddling speeds (Table 1).

The situation in EXPERIMENT 2 is similar to that in EXPERIMENT 1 (Table 1). Paddling speed v_{OBLA} was practically identical to v_{4000}. Both were clearly lower than v_{500} ($P< 0.05$). Heart rate HR_{OBLA} was lower than HR_{4000} ($P< 0.05$) but was similar to HR_{500}. Also [LA] in both tests, LA_{500} and LA_{4000} did not show any significant difference.

Table 1
Basic statistical data of both experiments.

CHARACTERISTICS	UNITS	EXPERIMENT 1 N=6	EXPERIMENT 2 N=9
v_{OBLA}	m/s	3.29±0.09	3.04±0.26
HR_{OBLA}	b/min	153±7	151±7
v_{500}	m/s	3.75±0.17	3.61±0.23
HR_{500}	b/min	178±5	177±4
LA_{500}	mmol/l	7.6±1.3	6.6±1.1
v_{4000}	m/s	3.30±0.18	3.04±0.26
HR_{4000}	b/min	178±6	179±9
LA_{4000}	mmol/l	8.8±4.7	5.9±1.1
CR	s	903±21	863±48

LEGEND: Values are means (standard deviations)

Table 2
Correlations between characteristics and competition results in both experiments.

CHARACTERISTICS	EXPERIMENT 1 CR	EXPERIMENT 2 CR
v_{OBLA}	−0.754?	−0.920**
HR_{OBLA}	0.252	−0.302
v_{500}	−0.908*	−0.879**
HR_{500}	−0.116	0.693
LA_{500}	−0.856*	0.429
v_{4000}	−0.776?	−0.912**
HR_{4000}	0.614	−0.503
LA_{4000}	−0.501	0.190

LEGEND: * – P< 0.05
** – P < 0.01
? – P (0.05 (0.06 – 0.08)

The one-month period of training between EXPERIMENT 1 and EXPERIMENT 2 affected the results in the tests applied (Table 1). Paddling speed v_{OBLA} decreased by about 0.25 m/s ($P<0.05$), and v_{500} showed an insignificant tendency to decrease. Similarly v_{4000} also showed an insignificant tendency to decrease. None of the heart rate characteristics used showed any significant change from the first to the second experiment.

The average time necessary to finish the race in EXPERIMENT 1 was significantly longer ($P< 0.05$) than in the second competition (EXPERIMENT 2) (Table 1) because of the different rivers and competition distance.

Correlations between selected characteristics and competition results (CR) in both experiments showed that only the speed v_{500} correlated significantly ($P= 0.01$) (Table 2). Both of the other selected speeds v_{OBLA} and v_{4000} correlated to CR significantly in EXPERIMENT 2 and were a little above the limit of significance at EXPERIMENT 1 ($P=0.08$ for v_{OBLA} and $P=0.07$ for v_{4000}) (Table 2).

According to the correlations between selected characteristics and CR we selected four combinations of predictors (Table 3). Linear multiple regression was used for selecting the best prediction combination of competition result in white water downhill kayaking (Table 3). The most powerful prediction combination in both experiments was selected according to multiple correlation values, adjusted for a small number of subjects in both experiments and according to their level of significance. That combination was rep-

Table 3
Prediction quality assessments using the multiple correlation values of different combination of characteristics as predictors and CR as criterions in both experiments.

	EXPERIMENT 1 N=6		EXPERIMENT 2 N=9	
Combination of predictors	Rmultip. adjust.	P	R multip. adjust.	P
$v_{OBLA} + v_{500} + v_{4000}$	0.965	0.02	0.784	0.01
$v_{OBLA} + HR_{OBLA}$	0.385	0.22	0.870	<0.01
$v_{500} + HR_{500} + LA_{500}$	0.583	0.239	0.951	0.029
$v_{4000} + HR_{4000} + LA_{4000}$	0.947	0.031	0.917	0.050

resented in all three paddling speeds used in the study (Table 3).

To ascertain if significant differences existed in prediction models of both CR in both experiments, both regression equations were compared:

$$CR_1 = 1554 - 97.5 * v_{OBLA} - 86.6 * v_{500} - 1.6 * v_{4000} \quad \text{(Equation 1)}$$

$$CR_2 = 1444 - 112.2 * v_{OBLA} - 44.3 * v_{500} - 26.5 * v_{4000} \quad \text{(Equation 2)}$$

The calculated competition results in EXPERIMENT 1 (CR_1) were 902±20.5 s. This is a similar value to the real competition results (903±20.6 s). Both were in close correlation (r = 0.99, P<0.001). In EXPERIMENT 2, the calculated competition results (CR_2) (862.3±45.0 s) were also similar to the real ones (862.8±48.4 s). The correlation between both is r = 0.93 (P<0.01). Regression equations predicted competition results accurately.

When the competition results in EXPERIMENT 1 were calculated in another way, by using Equation 2 and with the typical values of EXPERIMENT 1 (6 subjects), then this prediction significantly missed calculating the real results by about 83 s (P<0.05). Nevertheless, prediction preserves the interrelationship between the results (Fig. 1a). Similarly, when competition results in EXPERIMENT 2 were calculated using Equation 1 and the typical values from EXPERIMENT 2 (9 subjects), then this prediction significantly missed calculating the real results by about 78 s (P<0.05). This prediction preserved the interrelationship between results (Fig. 1b). The results show that this kind of prediction causes a systematic calculation error. Therefore the constants in both prediction equations were changed, predominantly because of the very different duration of white water downhill competitions. In our case this was about 40 s. A good correlation between theoretical and observed competition results (Fig. 1) however showed that basic principles of differentiation of paddling performance were preserved in both experiments.

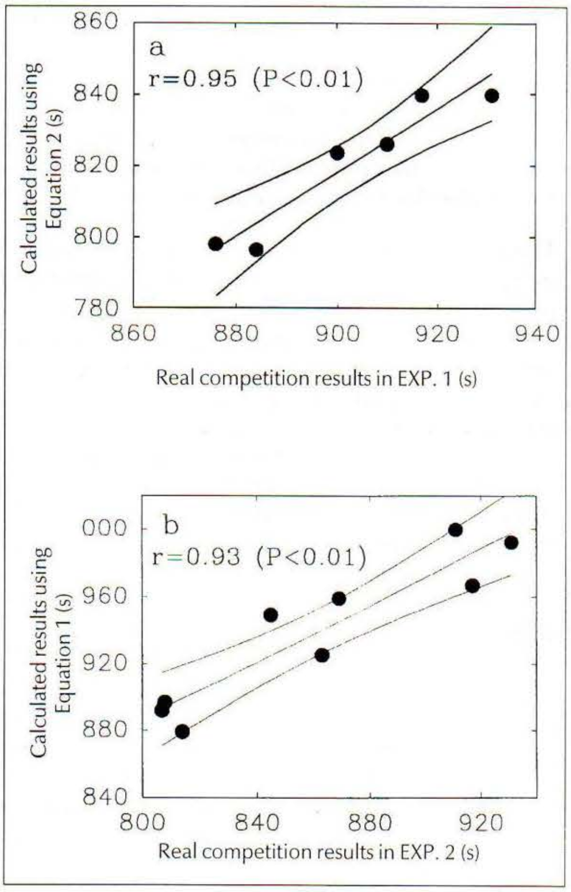

Fig. 1
Correlations between competition results in EXPERIMENT 1 and calculated results obtained using Equation 2 and test results of EXPERIMENT 1 (Fig. 1a) and between competition results in EXPERIMENT 2 and calculated results using Equation 1 and test results in EXPERIMENT 2 (Fig. 1b).

DISCUSSION

The instability of competition conditions in white water downhill kayaking influenced the belief that this sports event is unpredictable. It was caused particularly by the very different duration of competition and very unstable water conditions according to our results. However, the relatively long duration of effort (> 10 min in classical downhill competitions) and very similar technique and tactics among top performance competitors may influence the endurance and aerobic and anaerobic energetic processes that have become essential for competition success (1,6). This may be very similar to the situation in flat water kayaking of similar duration (2,4,7). The relatively high correlations between test results on flat water - v_{OBLA}, v_{4000}, and v_{500} – demonstrated in our study, proved this hypothesis. A caution should be added in generalising over whether this conclusion should be applied to technically very difficult and short competitions, which have also become very popular lately. According to time of competition (903±21 and 863±48 s), white water competitions were similar to the 4000 m distances on flat water. The relationship between endurance performance assessed by v_{4000} and by v_{OBLA}, and speed endurance assessed by v_{500}, with competition results (CR) were similar to the Ventilatory Threshold, Vo_2 max and 1 min all-out test correlation with 1000 m and 10000 m competitions on flat water (4). Prediction of about 90% of the known variance of competition results in both experiments was similar to the prediction of flat water competition results over 1000 m (92%) and over 10000 m (90%). The calculated prediction times showed satisfactory prediction only with specific models. The time differences of different downhill races were too large (140 s) and unpredictable. When a specific model was selected, then it predicted accurately only those competition results which were used for calculation of that model, but not if competition results of another experiment were used. Therefore the prediction of competition results cannot be sufficiently precise and accurate with a universal and simple model. Irrespective of these differences, the very good correlations between calculated and observed competition results have shown that models obtained in two different samples of subjects and in different parts of the competition season preserves the basic principles whereby kayakers were different in their performance. In this case, one of either models can be used for calculation of the theoretical competition results, based on tests results performed throughout the competition season. The purpose of such calculations can be to assess possible qualitative changes influenced by training. However, both models should be additionally approved before their use in practice. The present situation shows that the TEST 500 is not necessary in the group of tests. But this is not convenient, for two reasons. The first one is that the new trends in white water downhill show that competitions should be also shorter (<5 min), and with a parallel start. This means that speed and speed endurance (anaerobic lactate power and capacity) may dominate in those competitions, which was similar in the white water slalom (1,6). Therefore it is useful that one test assesses that performance. The second reason is related to the requirements of the training process. It should be necessary that each kayaker develops his overall performance with increased endurance, speed, speed endurance, strength and so on. Therefore the TEST 500 should be necessary as an indication of the effect of training on that particular performance.

REFERENCES

1. Astrand, P O: Textbook of Work Physiology. McGraw-Hill Book company, 1986.

2. Colli, R, Faccini P., Schermi C, Intraini E, Dal Monte A.: Valutazione funzionale ed allenamento del canoista. Scuola dello Sport 1990; 18: 27-37.

3. Draper N, Smith H.: Applied Regression Analysis, Second Edition. John Willey & Sons, 1981.

4. Fry R.W., Morton A.L: Physiological and kinanthropometric attributes of elite flat water kayakists. Med Sci in sports and Exer 1991; 23: 1297-1301.

5. Sjodin B, Schele R, Karlsson J, Linarsson D, and Wallensten R: The Physiological Background of Onset of Blood Lactate Accumulation (OBLA). In: Exercise and Sport Biology 1982; Vol. 12, 43-56.

6. Sydney K, Shephard R. Y: Physiological Characteristics and Performance of the White-Water Paddler. Europ J Appl Phisiol 1973; 32: 55-70.

7. Tesch P, Piehl K, Wilson G, Karlsson J: Physiological investigation of Swedish elite canoe competitors. Med. and Sci. in Sports and Exer. 1976; 8: 214-218.

8. Ušaj A, Starc V: Two concepts of Anaerobic Threshold and Running Endurance. In: Sports, Medicine and Health (GPH Hermans ed.) Elseiver Science Publishers B.V. 1990; 753-758.