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THE RELATIONSHIP BETWEEN 500 M AND 2000 M SIMULATED ROWING TIMES FOR SCHOOLBOY ROWERS OVER A TRAINING PERIOD OF THREE YEARS

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ABSTRACT
Purpose. Available data finds that for schoolboy rowers the 2000 m on-water or laboratory rowing distance causes fatigue and depresses their ability to train during the following days. Thus, looking for a less demanding test we evaluated the relationships between 500 m and 2000 m laboratory performance in schoolboy rowers. **Basic procedures.** A total of 10 boys participated in the study. All of the subjects simulated rowing "all-out" in either the 500 m or 2000 m rowing distance using a Concept II ergometer (Morsville, VT, USA). The tests were performed in November (transition phase), in January (general preparation phase), in March (specific preparation phase) and in June (competitive phase) throughout three successive years of training. **Main findings.** The mean power output during the 2000 m row gradually increased in the second year of training vs. the first one, and in the third year of training vs. the second one ($p < 0.001$). The times markedly improved in each year of training ($p < 0.001$). The mean power output and the time of the 500 m distance improved significantly in each year of training. In each training phase during the three years of training there were significant correlations between the rowing times in the 500 m and 2000 m distances. The coefficients of determination ($r^2 \times 100$) in the first year varied from 66.9 to 85.6%, in the second year – from 62.0% to 92.3%, and in the third year – from 76.4 to 89.5%. **Conclusions.** The relationship between the times measured in the of the 500 m and that of 2000 m one is affected by both the annual training phase and training experience. Thus, the 500 m laboratory rowing test may be useful in assessing the ability of schoolboy rowers to perform a competitive distance, but the results require careful interpretation.

Key words: adolescent athletes, laboratory rowing, training

Introduction

It is well documented that rowing is primarily a strength-endurance sport which in order to succesfully perform requires a high level of both aerobic and anaerobic capacities [1]. In elite rowers the physiological determinants of aerobic performance such as maximal oxygen uptake (VO_2 max), lactate and ventilatory thresholds reach high values during exertion [2–4]. Recent data have indicated that during a competitive 2-km distance aerobic energy is responsible for about 87% of total energy demands [5]. In addition, a close correlation has been found between rowing performance and VO_2 max [6].

On the other hand, the importance of an athlete's anaerobic capacity to perform successfully should not be neglected. It has been found that time of a simulated 2000 m rowing is in 75.7% related to the peak power output during 30 s of all out exercise [7]. In addition, a significant and positive correlation between the time of a simulated 2000 m rowing and maximal power output during 5 s all out exercise has also been noted [8]. Furthermore, isokinetic and isometric knee extension strength and power during simulated rowing exercises are also correlated with ergometric rowing performance [9, 10]. Recently anaerobic energy sources were found to provide 13% of total energy demands during on-water 2000 m rowing with similar contribution to the lactic and alactic pathways (6 % and 7%, respectively) [5].

The data cited above concern themselves with elite national and international junior or senior rowers. However, rowing training starts at the age of 12–14 years, during a period of intensive growth and development [11, 12].

It is clearly recognized that the early participation of children and adolescents in elite sports through intensive training programs led to an increase in the risk of thermal strain, cardiac disorders, injuries and overexertion [13]. Raglin et al. [14] have found that 35% of young athletes had been overtrained at least once. In addition, Kenttä et al. [15] have noted that incidence rates of overtraining in individual sports are higher than in team sports. Thus, the training of youths has to be carefully monitored to prevent any adverse effects [16].

However, to the best our knowledge, data on the training of adolescent rowers are scarce and fragmen-

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tary. The training of adolescent rowers was found to be stressful for muscle cells inducing a significant elevation in plasma creatine kinase (CK) activity and in the fatty acid binding protein level [17]. In addition, in rowers aged 12–13 years, their 1000 m ergometer rowing performance was found to be significantly and positively correlated with the maximal oxygen uptake and body size to those athletes with longer training experience [18, 19]. Recent data have demonstrated that in rowers aged 12–14 years, sport-specific training stimulates significant improvement in anaerobic performance during 30 s all-out exercise even after an athlele's body size is taken into consideration [20].

It should be pointed out that the Olympic rowing distance of 2000 m, lasting 6–7 min, is extremely exhausting especially for adolescent rowers. Thus, it is why rowers aged 12–13 years compete and undergo laboratory testing in the 1000 m distance [12]. Our observations indicate that even for schoolboy rowers aged 14–15 years the 2000 m on-water or laboratory rowing causes fatigue and depresses their ability and motivation for training during the following days.

Similarly, an analysis of rowing speed strategy in elite rowers has indicated that the performance of the first and last 500 m of the Olympic rowing distance are characterized by the highest speed and may be critical for achieving the best performance [21].

Thus, looking for a reliable, but less exhausting test, we undertook this study which evaluated the relationships between the 500 m and 2000 m performance of schoolboy rowers in laboratory trials during different annual training sessions over three years of training.

Material and methods

The prospective subjects were recruited among male students aged about 15 years. Because of their age, of each subject's parents (or legal guardians) were asked to give their consent prior to any tests. All the participants underwent medical examination including rest and post-exercise (30 sit downs done at maximal speed) electrocardiography, and anthropometric measurements. The preliminary procedures took place in March, in August the accepted subjects participated in a training camp where they took part in different types of physical activity such as sports, running, gymnastics, as well as ergometer and on-water rowing. A total of 10 boys were accepted by their coach for further participation in rowing training. All experimental procedures were in compliance with internationally accepted policy statements regarding the use of human subjects.

The subjects were asked not to participate in any physical activity in the 24 h before testing and to abstain from eating for 2 h before testing. All the participants were familiarized with the laboratory procedures to be carried out during a training camp in September of their first year of training. In each of the 3 years of training that was monitored, simulated rowing was undergone four times – in November (transition phase), in January (general preparation phase), in March (specific preparation phase) and in June (competitive phase). The tests were performed on two separate days of the same week and began at 9:00 a.m. Before testing, the subjects' weight and height were measured using medical scales. The warm-up consisted of using a Concept II ergometer (Morsville, VT, USA) on a damper setting of 4–5 lasted 14 min, thereafter all the participants simulated "all-out" rowing in either the 500 m or 2000 m distance with verbal encouragement to provide maximal effort. The readings of mean power and time of the distance were taken from the ergomete's registration system. Intra- and inter-coefficients of variation in 500 m trials did not exceed 5%.

Throughout the trials, the training loads expressed as hours of training were precisely registered by the coach and expressed as the percentage of total training volume in the respective years of training an athlete had.

The Shapiro-Wilk test was used for data distribution evaluation. The one-way ANOVA for repeated measures and the post-hoc Tukey test were used for data comparison. Correlations between the time performance for in the 500 m and 2000 m distances were calculated as according to Pearson. Data are presented as means and standard deviations, with the statistical significance set at $p < 0.05$. All calculations were performed using Statistica v. 7.1 software (StatSoft, USA).

Results

The training volume increased gradually in each year of training. In the second year of training total volume was greater by 7% vs. the first year (Tab. 1). In the third year of training the total volume was greater by 11.4% and 4.3% in comparison with the first and second year. The third year constituted the most of total training volume and training. In the first year, training was rather non-specific, consisting of gymnastics, running, games and swimming, however, in the subsequent years of training there was a gradual increase in rowing-specific training.

The subjects' anthropometric data are shown in Table 2. Their weight and height significantly increased in the successive years of training being greater in the second year vs. first ($p < 0.001$) and in the third vs. first ($p < 0.001$) and second ($p < 0.02$) year of training. Similarly,

Table 1. Total training volume and the contribution of different training modalities to overall training in schoolboy rowers

	I*	II*	III*
Total training volume (h)	454	485	506
Training modality		% ^	
On-water rowing	27	38	35
Ergometer rowing	4	14	17
Pool rowing	15	4	4
Strength training	11	17	18
Alternative training[a]	43	27	26

* denotes year of training; ^ percent of total volume in each year of training; [a] including games, gymnastics, running, and swimming

the subjects' BMI increased in the successive years of training. However, only minor changes in subjects' weight, height and BMI were noted in different training sessions during the same year of training.

Mean power output during the simulated 2000 m distance gradually increased in the second vs. first year of training and in the third vs. second year of training ($p < 0.001$) (Tab. 3). In consequence, the times markedly improved in each year of training ($p < 0.001$). Similarly, the mean power output and times during the simulated 500 m distance significantly improved in each year of training (Tab. 4).

In each training phase during the three years of training there were significant correlations between the times measured in the 500 m and 2000 m distances, and correlation coefficients did not significantly differ with respect to the training phase. (Tab. 5). However, coefficients of determination ($r^2 \times 100$) in the first year of training varied from 66.9 to 85.6 %, in the second year – from 62.0% to 92.3%, and in the third year – from 76.4 to 89.5%.

Discussion

The physical characteristics of our subjects at the beginning of the study were similar to those reported by Huang et al. [22] in club rowers with the mean age of 17.4 years. At the beginning of the study the mean power output during the 2000 m ergometer rowing in our subjects was lower, but in the third year of training it was higher, than in experienced rowers aged 18.1 years [23]. The time of the 2000 m distance in the first year of training was longer, that in schoolboy rowers aged 16.9 years [24], but in the competitive phase of the second year of training it was shorter.

Table 2. Anthropometric characteristics of the subjects (means ± SD)

	November	January	March	June
I*				
Age (years)	15.4 ± 0.3	15.6 ± 0.3	15.8 ± 0.3	15.9 ± 0.3
Weight (kg)	67.2 ± 9.6	72.0 ± 7.6[a]	70.4 ± 8.3	71.0 ± 6.5
Height (cm)	181.9 ± 0.5	181.9 ± 0.5	182.6 ± 0.4[b]	182.6 ± 0.4[b]
BMI	20.3 ± 2.3	21.8 ± 1.8[c]	21.1 ± 2.0	21.3 ± 1.5
II*				
Age (years)	16.4 ± 0.3	16.5 ± 0.3	16.7 ± 0.3	16.9 ± 0.3
Weight (kg)	72.6 ± 6.7[d]	74.0 ± 6.9[e]	74.6 ± 6.5	74 0 ± 6.5
Height (cm)	186.7 ± 0.5[k]	186.7 ± 0.5[k]	187.3 ± 0.5[k]	187.3 ± 0.5[k]
BMI	20.8 ± 1.2	21.2 ± 1.4[h]	21.3 ± 1.5	21.0 ± 1.1
III*				
Age (years)	17.4 ± 0.3	17.5 ± 0.3	17.7 ± 0.3	17.9 ± 0.3
Weight (kg)	75.6 ± 6.6	76.6 ± 7.8[f]	76.8 ± 8.2[g]	76.8 ± 8.1[i, j]
Height (cm)	187.6 ± 0.5[k]	187.6 ± 0.5[k]	187.6 ± 0.5[k]	187.6 ± 0.5[k]
BMI	21.4 ± 1.1[l]	21.8 ± 1.4	21.8 ± 1.5	21.8 ± 1.5

* denotes year of training

[a] $p < 0.007$ – significantly higher vs. November of the same year; [b] $p < 0.05$ – significantly higher vs. January of the same year; [c] $p < 0.007$ – significantly higher vs. November of the same year; [d] $p < 0.03$ – significantly higher vs. November of the first year of training; [e] $p < 0.007$ – significantly higher vs. November of the first and second year of training; [e] $p < 0.05$ – significantly higher vs. January of the first year of training; [f] $p < 0.006$ – significantly different vs. January of the first and second year of training; [g] $p < 0.006$ – significantly different vs. March of the first year of training; [h] $p < 0.007$ – significantly different vs. June of the first year of training; [i] $p < 0.02$ – significantly higher vs. June of the second year of training; [j] $p < 0.007$ – significantly higher vs. June of the first year of training; [k] $p < 0.006$ – significantly higher vs. respective months of the first year of training; [l] $p < 0.005$ – significantly higher vs. November of the second year of training

Table 3. Mean power output and 2000 m times of distance in schoolboy rowers during a laboratory Concept II trial, performed during different periods over three years of training (means ± SD)

	November	January	March	June
I*				
Mean power (W)	288.9 ± 24.4	299.6 ± 29.9[a]	306.3 ± 21.7[a]	311.7 ± 22.6[a]
Time (s)	429.9 ± 11.9	422.1 ± 14.5	418.8 ± 10.1[e]	416.2 ± 10.3[e]
II*				
Mean power (W)	329.1 ± 21.7[d]	327.5 ± 22.7[d]	328.3 ± 25.1[d]	337.8 ± 27.9[b, d]
Time (s)	412.49 ± 9.6[g]	409.4 ± 9.7[g]	409.2 ± 10.2[g]	405.0 ± 9.7[f, g]
III*				
Mean power (W)	343.2 ± 24.9[d]	337.6 ± 24.3[d]	352.7 ± 32.0[d]	360.1 ± 26.7[c, d]
Time (s)	403.1 ± 9.9[g, h]	405.1 ± 9.7[g]	399.1 ± 12.3[g, h]	396.9 ± 9.8[g, h]

* denotes year of training

[a] $p < 0.001$ – significantly higher vs. November of the same year of training; [b] $p < 0.04$ – significantly higher vs. November of the second year of training; [c] $p < 0.004$ – significantly higher vs. March of the same year of training; [d] $p < 0.001$ – significantly higher vs. respective month of the previous year of training; [e] $p < 0.03$ – significantly different vs. November and January of the same year of training; [f] $p < 0.02$ – significantly different vs. November of the same year; first year of training; [g] $p < 0.001$ – significantly different vs. respective months of the first year of training; [h] $p < 0.04$ – significantly different vs. respective months of the second year of training

Table 4. Mean power output and 500 m times of schoolboy rowers during a laboratory Concept II trial, performed during different periods over three years of training (means ± SD)

	November	January	March	June
I*				
Mean power (W)	405.2 ± 41.5	425.6 ± 43.6	432.9 ± 34.7	447.7 ± 46.3[a]
Time (s)	95.4 ± 3.2	93.9 ± 3.3	93.3 ± 2.5[d]	92.3 ± 3.2[d]
II*				
Mean power (W)	463.7 ± 42.9[c]	479.5 ± 41.0[c]	494.6 ± 52.7[c]	495.9 ± 53.0[c]
Time (s)	91.4 ± 2.9[f]	90.2 ± 2.7[f]	89.3 ± 3.2[e, f]	89.3 ± 3.[e,f]
III*				
Mean power (W)	506.9 ± 44.7[c]	520.9 ± 53.4[c]	536..5 ± 51.3[c]	559.0 ± 54.2[b, c]
Time (s)	88.5 ± 2.8[f, g]	87.9 ± 3.2[f, g]	86.9 ± 2.8[f, g]	85.6 ± 2.9[f, g]

* denotes year of training

[a] $p < 0.003$ – significantly higher vs. November of the same year of training; [b] $p < 0.001$ – significantly higher vs. November and January of the same year of training; [c] $p < 0.004$ – significantly higher vs. respective months of the previous year of training; [d] $p < 0.001$ – significantly different vs. November and January of the same year of training; [e] $p < 0.05$ – significantly different vs. November of the same year of training; [f] $p < 0.001$ – significantly different vs. respective months of the first year of training; [g] $p < 0.02$ – significantly different vs. respective months

Table 5. Pearson correlation coefficients between 500 m and 2000 m laboratory times of schoolboy rowers

	November	January	March	June
I*				
r	0.899[a]	0.879[a]	0.818[b]	0.925[a]
$r^2 \times 100$	80.8	77.3	66.9	85.6
II*				
r	0.868[c]	0.961[a]	0.788[d]	0.883[a]
$r^2 \times 100$	75.3	92.3	62.0	77.9
III*				
r	0.874[a]	0.901[a]	0.946[a]	0.886[a]
$r^2 \times 100$	76.4	81.1	89.5	78.5

* denotes year of training
[a] $p < 0.001$; [b] $p < 0.004$
[c] $p < 0.002$; [d] $p < 0.007$

The mean power output during the 500 m rowing distance throughout our study was markedly lower and the times significantly longer than in elite senior rowers aged about 24 years [25, 26]. These differences were due to the subjects' shorter training experience, but also to their markedly smaller body size (both in mass and height) of our participants vs. elite senior rowers. However, the 500 m time performance of our subjects was significantly better than those reported in untrained university students who participated in 500 m indoor rowing championships [27].

The significant relationships between the mean power and times for both the 500 m and 2000 m simulated rowing distances are in accordance with other studies. According to Smith [25], elite rowers' best times for the 500 m distance strongly correlated with their 2000 m test performance ($r = 0.960$). Thus, the study found the 500 m time performance could account for 92.2% of the time variable of the 2000 m distance.

Our study confirmed that significant correlations existed between the time performance in the 500 m and 2000 m distances in schoolboy rowers and this relationship was affected neither by their training period nor training experience. On the other hand, the coefficients of determination ($r^2 \times 100$) differ with respect to the annual training period and years of training. Thus, the 500 m rowing time may be useful in predicting the performance of adolescent rowers in the 2000 m distance, however, if any doubts exist on the effectiveness of any training, the 2000 m test has to be recommended. Additionally, it should be pointed out that the results of any laboratory rowing cannot predict the outcome in on-water competition [28, 29].

Conclusion

Our study revealed that the performance of schoolboy rowers in both the 500 m and 2000 m distances markedly improved throughout their three years of training. In addition, the times of both distances significantly correlated with each other, but the coefficients of determination differ in each annual training period and the year of training. Thus, the 500 m laboratory rowing test may be useful in a brief assessment of schoolboy rowers ability to perform the 2000 m distance, however, its results require careful interpretation.

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