tactics. First group – it is often used variants (1–2, 1–3, 1–4) and second group is seldom used variants (3–2, 4–2, 4–3). From the first group often used variants between man rowers most effective was type 1–2, 56.2% of crews won medals in Olympic Games. Among woman rowers most effective type was 1–3 and 54.6% of crews won medals.

It was detected that smaller difference between the first 1000 m section pacing time and the second one were detected in men crews who won medals than in crews who took 4–6 places, except 1988 Olympic Games, where differences were smaller in men crews that took 4–6 places. In Olympic Games 1996 and 2004, there were detected statistically significant differences (p<0.05) between crews that took 1–3 and 4–6 places between the first 1000 m section rowing time and the second one, differences between first and second 1000 m defeat time were smaller of prize-winner crews.

We found that at the Olympic Games 1988–1996 smaller differences were between the first 1000 m section pacing time and the second one were seen of women crews who had took 4–6 places, but at the Olympic Games 2000–2004 smaller differences were found of women crews who took 1–3 places. At the Olympic Games 2004 we found statistically significant differences (p<0.05) between the women crews that took 1–3 and 4–6 places between the first 1000 m section pacing time and the second one; differences between first and second 1000 m rowing time were smaller in prize–winner crews.

Keywords: Olympic Games, rowing, tactics, boat speed.

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Summary

The aim of this study was to compare the serum catabolic and anabolic hormones concentrations in relation to training volume and training intensity during pre-season and competitive season in male road cyclists. Ten subjects (age 23.4 ± 3.56 years, training for 7.2 ± 1.2 years) performed an incremental cycle ergometer exercise tests during the pre-season (PS) and in the competitive season (CS). Blood samples were obtained before and during the exercise protocol for determination hormones concentrations. The relationships between training workload in the pre-season, VO2max, and hormones concentrations were estimated in each test. There were significant differences in VO2max and maximal power output during the incremental cycling exercise in (CS) in relation to (PS) (p<0.05). The training did not significantly alter the resting concentration of serum testosterone and cortisol. In contrast, the exercise testosterone and cortisol concentration were significantly lower in competitive season in relation to pre-season (p<0.05).

The results suggest that the hormonal concentration and physiological variables expended during physical exercise differ during the successive training cycles.

Keywords: testosterone, cortisol, endurance training.

Introduction

The skeletal muscle undergoes morphological and functional changes in response to physical training (1,8,11). As has been previously described the muscle is able to adapt by increasing the size and amount of contractile proteins, leading to an increase in the size of the muscle fibres and their consequent force production (7, 13). This muscle hypertrophy in endurance athletes are dependent on several determinants including type of sport, training intensity and endocrine system reactions. Throughout exercise, circulating levels of both anabolic (T,GH) and catabolic (C) hormones increase with intensity (1, 8,15). Testosterone is known to promote hypertrophy, increase corticosteroids accelerate protein degradation. Due to this effects the insulin and growth factors increase to regulate the muscle protein synthesis (3). Endurance training is associated with decrease the blood levels of testosterone and an increase in the cortisol concentration what might lead to more protein catabolism in the muscle cells (6,12). In addition to cortisol’s role it also accelerates the mobilization of free fatty acids for energy during exercise. This mechanism is thought to be responsible for controlling the balance between carbohydrate and fat metabolism during and after exercise. There is controversy about the role of these hormones on synthesis and degrada-
tion pathways of protein turnover during successive training cycles. The aim of this study was to compare the serum catabolic and anabolic hormones concentrations in relation to training volume and training intensity during pre-season and competitive season in male road cyclists.

**Material and methods of the investigation**

Ten road cyclists volunteered for the research. Their basic characteristic included average age (23.4±3.56 years), body mass (72.18±5.37 kg), height (179.5±5.06 cm), training experience 7.2±1.2 years. All of them were informed of the purpose of the investigation and gave their written consent to participate. The studies were approved by the Ethical Committee at the Medical Research Centre. The training periods were considered and investigations were repeated as follows: at the end of pre-season period (PS) and in the competitive period (CS). During each period the individual training distance (km . month-1) and volume (hours . month-1) were measured. Furthermore, the training workload was calculated according the heart rate response to lactate threshold (hoursLT . month-1). The subjects performed an incremental cycle ergometer exercise test with graded intensity, starting at 40 W, with 40 W increments every three minutes until voluntary exhaustion which was determined when the subject could not maintain the required pedalling frequency. VO$_2$, ExCO$_2$ and VE were measured from the 6th min prior to exercise until the tests were completed. Gas exchange variables were measured continuously breath-by-breath using the Oxycon apparatus (Jae-ger, Germany). Blood samples were obtained from finger tip before and during the exercise (at one minute intervals) for determination of lactate concentration. Serum testosterone (T) and cortisol (C) concentrations were measured by radioimmunoassay kits obtained from Diagnostic System Laboratories (Webster, Texas) using venous blood samples. The relationships between training workload in the pre-season, VO$_2$max, and hormones concentration was estimated in each test.

During the exercise, heart rate was continuously recorded using the PE-3000 Sport-Tester (Polar Inc. Finland). Blood lactate concentration (LA) was measured by enzymatic method using commercial kits (Bochrinker, Manheim, Germany). The lactate threshold (LT) was calculated according to Beaver et al. (2). Significant differences for metabolic variables (LA, VO$_2$, ExCO$_2$, VE) and HR between the each training period at relative work loads were determined using the Students-t test. The relation-

ships between training workload in the pre-season, VO$_2$max, and hormones concentrations was estimated in each test.

**The results of the study**

There were significant differences in VO$_2$max during the incremental cycling exercise in CS in relation to PS (p<0.05). The mean values of VO$_2$, HR and LA at the maximum power output determined during each training period in the cyclists are presented in Table 1. The work load and VO$_2$max were significantly lower during PS in relation to CS (p<0.05). Lactate threshold occurred at a lower exercise load (276±35, 9 W) in PS than during CS (333±30,1 W). Mean training volume and intensity increased during PC and CS period (Tab.2). The cyclists VO2max increased with the initiation of training (654,3±53,15 km . month -1), and continued to improve when they increased their training volume to 1652,5±99,14 km . month-1. Mean training volume significantly correlated with the increase of VO2max between the start of PS and CS season (r=0.75; p<0.01); furthermore, a mean exertion count calculated via the heart rate response to AT was associated with improvements in VO2max (r=0.54 ; p<0.02). There were differences in hormones concentrations during maximal

***Table 1***

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>PS</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2max [ml.min-1]</td>
<td>61,3±3,78</td>
<td>64,35±5,35*</td>
</tr>
<tr>
<td>W max [W]</td>
<td>400±32,6</td>
<td>420±21**</td>
</tr>
<tr>
<td>HRmax [b.min-1]</td>
<td>192±7,6</td>
<td>183±6,34**</td>
</tr>
<tr>
<td>LA peak [mmol.L-1]</td>
<td>9.63±1,9</td>
<td>9.94±1,88</td>
</tr>
<tr>
<td>Hct max [%]</td>
<td>49,2 ±2,18</td>
<td>49,0±2,18</td>
</tr>
<tr>
<td>WLT [W]</td>
<td>276±35,9</td>
<td>333±30,1**</td>
</tr>
</tbody>
</table>

* significant differences between pre-season and competitive period

VO$_2$max = maximal oxygen uptake; W max = maximal power output; HRmax = maximal heart rate; LA peak = peak blood lactate concentration; Hct-hematocrit; LT= lactate threshold

***Table 2***

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>PS</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T volume [km]</td>
<td>654,3±53,15</td>
<td>1652,5±99,14</td>
</tr>
<tr>
<td>T volume [hours]</td>
<td>51,1±10,89</td>
<td>98,2±6,05</td>
</tr>
<tr>
<td>T intensity [hours LT]</td>
<td>28,0±4,98</td>
<td>68,1±4,17</td>
</tr>
</tbody>
</table>
The results of the presented study indicate that incremental physical exercise causes a significant increase in circulating testosterone and cortisol concentrations. There were no changes in resting testosterone and cortisol concentration during different season of training cycle but endurance training significantly alters the exercise concentrations of both hormones. In the present study, the mean values of VO\(_2\) were significantly higher during CS in relation to PS. It is generally agreed that the interaction between training intensity and training volume influence of significant improvements in aerobic capacity (5, 9, 10). Our study confirms that physiological markers associated with endurance exercise capacity differ in the annual training cycle. For this reason we investigated the relationships between oxygen uptake during cycling exercise in relation to LA concentration. A progressive increase in VO\(_2\) kinetics was observed during competitive season in relation to pre-season. Possible causes of this magnitude include reduction in training intensity and increase in volume of each training period. Variables measured during our investigation point to higher physical efficiency of the cyclists at the pre-competitive and competitive season in relation to pre-season. In this period subjects have achieved highest work load at the anaerobic threshold and lowest value of oxygen uptake at LT. Deterioration of physiological variables, nutrition state indices (% fat) and largest changes in acid-base homeostasis were observed at the pre-season in relation to competitive season. In the annual training cycle differences in testosterone and cortisol concentration were registered only during maximal intensity of exercise. In the present study training did not significantly alter the ratio between T/C. The ratio is thought to regulate anabolic process and is considered to be an important indicator of protein metabolism in the cells, and perhaps a cause of overtraining syndrome (3, 4, 12, 14). These results suggest that long-term training enhances both testicular adrenal responses. In the investigated athletes the lowest testosterone and cortisol increase has been noticed during the competition season, during which subjects have achieved the best aerobic capacities. The hormonal and physiological variables expended during physical exercise are related to intensity and total energy expenditure during the competitive period of training cycle what could suggests the possible role of hormonal changes in the mobilization of energy substrates during exercise.

In conclusion the results of this study confirm earlier observations that male road cyclists have very high aerobic capacities, shown by the maximal power output and maximal oxygen uptake. However, the hormonal concentration and physiological variables expended during physical exercise differ during the successive training cycles.
REFERENCES

IŠTVERMĖS TRENIRUOTĖS POVEIKIS ANABOLINIŲ IR KATABOLINIŲ HORMONŲ KONCENTRACIJAI

Dr. Aleksandra Žebrowska, dr. Stanisław Poprzęcki

SANTRAUKA

Šio tyrinio tikslas buvo palyginti vyrų dviratininkų (plentas) kraujo serumo katabolinių ir anabolinių hormonų koncentraciją priklausomai nuo treniravimosi apimties ir intensyvumo priešvaržybiniu ir varžybu laikotarpiu. 10 tiriamujų (amžius 23,4±3,56 m., treniruojasi 7,2± 1,2 m.) priešvaržybiniu (PS) ir varžybø laikotarpiu (CS) laikotarpiai veloergometru atliko didinamo krūvio testus. Kraujo mėginiai hormonų koncentracijai tirti buvo imami prieš testavimà ir testuojant. Kiekvieno testo metu buvo įvertinti ryšiai tarp treniruotës krūvio priešvaržybiniu laikotarpiu, VO₂ max ir hormonų. Palyginus abiem rengimosi laikotarpius atliktu didinamo krūvio testu praturėti ryšiai tarp treniruotës krūvio priešvaržybiniu laikotarpiu, VO₂ max ir hormonų. Palyginus abiem rengimosi laikotarpius atliktu didinamo krūvio testu praturėti ryšiai tarp treniruotës krūvio priešvaržybiniu laikotarpiu, VO₂ max ir hormonų. Palyginus abiem rengimosi laikotarpius atliktu didinamo krūvio testu praturėti ryšiai tarp treniruotës krūvio priešvaržybiniu. T reniruotës krūvis reikšmingai nepakeitë serumo testosterono ir kortizolio koncentracijos poilsio metu. Ir priešingai, krūvio metu testosterono ir kortizolio koncentracijai buvo reikšmingai mažesnë (p<0,05) varžybu laikotarpiu negu priešvaržybiniu.

Tyrimo rezultatai leidžia teigti, kad dviejuose paeiliui einaus treniruotës cikluose (priešvaržybiniame ir varžybø) sportininkø organizme hormonų koncentracija ir fiziologiniai rodikliai fiziiniø pratimø metu yra skirtingi.

Raktaþodþiai: testosteronas, kortizolis, ištvermës treniruotë.