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The Efficiency of Energy Recovery in an Elite Rowing Group
Eficiența procesului de recuperare energetică în cadrul unui grup elită din canotaj

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Abstract

Background. Optimizing recovery, in terms of energy, is an important step towards improving the practice of sports.

Aims. Identifying and connecting specific sports actions with practical nutrition activities, used to rehabilitate the athlete.

Methods. We initiated an observational cross-sectional study among a group of elite rowing athletes by monitoring RMR (resting metabolic rate), carbohydrate and daily fat consumption (in g/%). 64 subjects took part in this study, being monitored through the Cosmed Quark CPET device.

Results. Significant differences in carbohydrate consumption and preponderance of this source of energy throughout the day were identified between the studied groups (p=0.014). Also, the metabolic rate and alveolar oxygen tension level influence the whole energy consumption (p=0.005).

Conclusions. The results of this study show a lack of energy metabolism efficiency, directly related to the effort, indicating a level of fatigue among athletes.

Keywords: exercise intensity, energy consumption, athletes, recovery.

Rezumat

Premize. Optimizarea procesului de refacere, din punct de vedere energetic, reprezintă un obiectiv important de studiu pentru îmbunătățirea activității sportive.

Obiective. Acest studiu a urmărit analiza relației dintre activitățile sportive si metabolismul energetic, în procesul de recuperare al sportivului.

Metode. S-a desfășurat un studiu transversal, observațional, în cadrul unui grup sportiv de elită din canotaj, prin monitorizarea ratei metabolice în repaus, a consumului de carbohidrați şi de lipide. 64 subiecți au luat parte la acest studiu. Testarea s-a realizat prin intermediul aparaturii Cosmed Quark CPET.

Rezultate. S-au identificat diferențe semnificative privind consumul de carbohidrați între loturile expuse (p=0.014). Totodată, rata metabolică și tensiunea alveolară a oxigenului influențează consumul energetic în repaus (p=0.005), indicând un stadiu de oboseală, pe baza unor valori relevante.

Concluzii. Rezultatele acestui studiu subliniază o lipsă a eficienței metabolismului energetic, în relație directă cu efortul, indicând un stadiu de oboseală între sportivi, pe baza efortului prestat.

Cuvinte cheie: intensitate, consum energetic, sportiv, recuperare.

Introduction

Diet is an important factor influencing the athletes' activity through the energy substrate provided to the body (Beck et al., 2015). Sports activities performed daily in an organized setting entirely influence the specificity and efficiency of the effort performed. However, considering this form of influence, a systematic training program will ensure the athletes' recovery from their daily activity (Seiler et al., 2007). This is possible by respecting the proposed training intensities and the total recovery time between activities (Howatson et al., 2015).

The methods for the recovery of athletes exposed in the literature are widely used in all sports branches (Barnett, 2006). It is certain that nutrition provides through macronutrients, micronutrients and liquids the basis of metabolic body function. The elements referred to are transformed in total energy consumption (energy expenditure of the body) and could be quantified in the total energy consumption of the athlete at rest, adaptable to different periods during a general sports training program.

Through indices represented by O2, CO2, FeO2, PaCO2, PetCO2, PaO2, R (respiratory exchange ratio), used to determine the metabolic rate, different studies have evidenced significant differences during sports activity

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(***, 2001) based on respiratory indices.

The use of a similar system to monitor the data presented is based on the estimation of energy requirements in different periods of the training program. This may indicate the body's energy recovery stage and the action of adaptation to different types of exercise. The data reported are directly proportional to the effort that the athlete most frequently performs (aerobic, alactacid anaerobic, lactacid anaerobic). All data are revised based on the resting metabolic rate and standard values, which under normal circumstances should not be exceeded (e.g. carbohydrate metabolism in female athletes should not exceed 30-40% of energy throughout the day, at rest). However, the combination of these metabolic values (energy consumption, carbohydrate consumption, fat consumption) with blood pH levels may indicate an advanced state of fatigue, based on prolonged periods of the body in specific anaerobic effort (Dolezal et al., 2000). Unlike theoretical information, in practical terms, metabolism is an indicator that cannot indicate a trend for energy metabolism usable in the shortest time. Such data may be processed by biochemical tests, which may indicate the parameters of the body in the most appropriate form.

Hypothesis

The initiation of this study took into account the efficiency of the recovery process of elite athletes after activity. Significant differences in respiratory parameters and energy needs are most often seen in athletes. Furthermore, we believe that correct cyclization of daily sports activity can enhance recovery. Improving daily activity starts properly with the examination of the athletes' physiology, biochemistry, and nutrition. Based on such data, the training program will be implemented.

Materials and methods

Research protocol

The study was conducted after obtaining the approval of the University Ethics Committee and the subjects' informed consent to participate in the study.

a) Period and place of the research

The study was performed on 64 subjects, between 1 June 2015 - 1 July 2015, in Orsova and Bucharest, representing national training centers of elite rowing athletes.

b) Subjects and groups

64 elite rowing athletes representing Romania were included in the study; of these, 30 were male (mean age 19.6 years) and 34 were female (mean age 19.5 years). Male subjects were represented by junior athletes (7 subjects), youth athletes (15 subjects), and senior athletes (7 subjects). Female subjects were represented by junior athletes (15 subjects), youth athletes (8 subjects), and senior athletes (11 subjects).

c) Test applied

Data on resting energy expenditure (kcal), carbohydrate consumption (g%), lipid consumption (g%) were obtained by using the Cosmed Quark CPET device. The tests were conducted in June-July 2015, according to the following protocol: no food ingestion within 5 hours before the test; no sports activity within 24 hours before the test; no caffeine intake for at least 12 hours prior to testing; no consumption of sports supplements containing ephedrine, Ma Huang, pseudoephedrine for the last 12 hours before testing; no nicotine within 12 hours before testing.

d) Statistical processing

Descriptive statistics through the EpiInfo 6.0 test was used in a representative sample. The Chi-square test was chosen to interpret the reported differences in energy metabolism.

Results

We monitored the factors influencing energy requirements and their action on the balance of primary energy sources used during specific activity. The groups of subjects (female-male) were distributed by age and by the category in which they performed (Table I).

Table I

The mean age of the studied subjects.

Group	Senior		Youth		Junior	
	Athletes	Mean age	Athletes	Mean age	Athletes	Mean age
Male	7	22.14	16	19.43	7	17.42
Female	11	22.81	8	20.25	15	16.8

In the case of female athletes (34 subjects), the determined mean value of carbohydrate consumption at rest was 61.09%, equivalent to 298.24 grams, 1222.8 kcal. The mean consumption of lipids was 39.36%, indicating a value of 85.35 grams, equivalent to 776.7 kcal. In the case of the male group (30 subjects), the determined mean value of carbohydrate consumption was 60.56%, equivalent to 395.34 grams, and 1621 kcal. Lipid consumption represented 39.5% of energy consumption, equivalent to 111.37 grams and 1013 kcal.

Among the general groups, we identified no significant differences of total energy consumption at rest (Table II).

Table II

Mean energy consumption at rest male/female.

Group	Senior (kcal)	Youth (kcal)	Junior (kcal)
Male	2570	2707.25	2788.71
Female	2058.54	2046.62	2032.06

No significant results of carbohydrate/lipid consumption at rest (%) between the senior, youth and junior groups (females) were found. However, statistical significance for carbohydrate consumption at rest (p=0.0140) and fat consumption at rest (p=0.0142) was obtained between the youth and the junior group.

In the senior group (22.81 years), we identified statistically significant data between PetO2 representing a reflection of alveolar oxygen tension and total energy expenditure at rest (p = 0.005). Additionally, PetO2 (p = 0.008) and resting energy expenditure (p = 0.0001) were influenced by VO2 (mean value 292.54), which established statistical significance with the body mass index (BMI) (p=0.011). Between lipid and carbohydrate consumption, a direct connection was found (p = 0.0001), while BMI was statistically significant with resting energy expenditure (p = 0.006).

In the male group (seniors), statistical significance was observed between the value of alveolar oxygen tension (mean PetO2 value 105.04) and the amount of carbon dioxide present in the exhaled air (p = 0.0001). VO2 (mean value 365.80 mL/ min) was related with energy consumption at rest (p = 0.0001), carbohydrate intake at rest, % (p = 0.032) and fat consumption at rest, % (p = 0.031). Additionally, resting energy expenditure was linked with carbohydrate consumption at rest (p = 0.043) and lipid consumption at rest, % (p = 0.0001).

The respiratory exchange ratio (R) was monitored in all the existing groups. As a result, the mean value for the male groups was 0.89 (minimum 0.79; maximum 1.24). The mean value for the female groups was 0.88 (minimum 0.77, maximum 1.07).

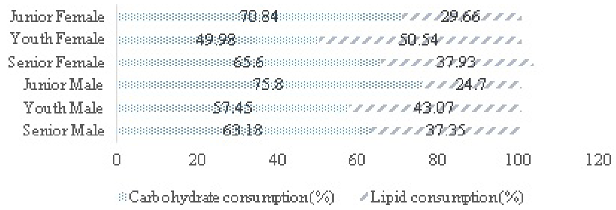

Fig. 1 – Mean monitored value of macronutrient consumption in the studied groups (%).

Regarding the amounts of macronutrients used throughout the day, in direct relation to exercise performance, the percentages of macronutrients monitored, as necessary, after a total rest period of 24 hours, were reported (Fig. 1).

The female youth group established different connections dictated by the work performed and the objectives. $PetO_2$ (p = 0.024) and the amount of carbon dioxide present in the exhaled air (p = 0.033) were related to the respiratory exchange ratio. Resting energy expenditure was significantly correlated with the VO_2 value (p = 0.0001), while the body mass index seemed to influence carbohydrate consumption at rest (p = 0.001), which was in turn related with the consumption of fat at rest, showing a statistically significant difference (p = 0.0001). The data obtained for the male youth group established a clear relationship between the body mass index and resting energy expenditure (p = 0.0460), which was also related with the VO_2 value (p = 0.0001).

In both the female and male junior groups, there were important correlations of alveolar oxygen tension with the amounts of carbon dioxide present in the exhaled air (p = 0.0001; p = 0.004), and in terms of metabolic energy, with carbohydrate consumption at rest (p=0.0001; p=0.004) and lipid consumption at rest (p=0.007; p=0.001).

In terms of total energy consumption at rest, the VO_2 value influenced the final amount of energy required for the junior group (women) through a direct relation (p = 0.0001).

We also mention as potential indicators of the body's reaction after effort: the heart rate value, respiratory rate index (Rf) - mean value for the male group - 12.72; mean value for the female group - 15.36; and alveolar oxygen tension - mean value for the male group - 105.91; mean value for the female group - 109.31.

Discussion

The results were considered over a pre-competitive period of one week of training for the 3 groups (senior, youth, and junior), at five different training intensities (Table III).

Table III
Areas of effort presented in an optimal framework during a week of training.

Effort zone	VO_2 (max%)	HR (max%)	Lactic acid (mmol/L)	Hours per week
R5: zone 1	45-65	55-75	0.8-1.5	1-6
R4: zone 2	66-80	75-85	1.5-2.5	1-3
R3: zone 3	81-87	85-90	2.5-4	50-90 min.
R2: zone 4	88-93	90-95	4-6	30-60 min.
R1: zone 5	94-100	95-100	6-10	15-30 min.

(Beneke et al., 1996; Beneke et al., 2001)

The parameters studied in this paper may represent direct indicators of the adaptation level reported among athletes during specific training periods.

The VO_2 values discussed validate the importance in the production of ATP at mitochondrial level (Bishop et al., 2002). During dynamic effort, heart rate variability decreases even if the respiratory rate and tidal volume increase (Cottin et al., 1999). Moreover, respiratory frequency may impose an increased lactic acid concentration (Kapus et al., 2005), decreased ventilator response during exercise (Kapus et al., 2013), and at the same time it can increase the level of fatigue for the specific efforts with severe oxygen liability by decreasing frequency (Jakovljevic et al., 2009). The metabolic rate is a direct indicator of the effort performed and body recovery, in direct relation with respiratory values. An increased metabolic rate, an increased ventilation can modify the respiratory frequency (Steinacker et al., 1993), a result mentioned in the paper. However, respiratory muscle activity is decreased post-exercise, regardless of the intensity of work, because of the effort performed, suggesting that its subsequent performance can be compromised (Driller et al., 2012). The respiratory exchange ratio (R), as a result of the tests performed, can identify an exclusive consumption of carbohydrates (R≥1 value); exclusive consumption of lipids (value R = 0.7); protein consumption (value R = 0.8) (Ramos-Jiménez et al., 2008). Consequently, the importance of proper periodization of the daily training schedule can be identified, in order to enhance the athletes' recovery period after exercise.

Considering the state of overtraining, indicated by a series of metabolic values, the main description of this state consists of an increased heart rate value, increased energy consumption at rest, mainly an increased metabolic consumption of carbohydrates at rest, loss of appetite and a lack of sports performance. This state is known to reduce the athlete's adaptability during daily training (Kenttä et al., 1998). Thus, in the present study, the percentage of carbohydrate consumption at rest was highlighted, especially in the group of seniors (women). Perceivable differences should be observed in the proportion of lipids to carbohydrates consumed at rest between the two studied groups (male and female) (Wismann et al., 2006) under normal conditions, with a mixed diet. This aspect is negatively influenced and changed either by a high intake of simple carbohydrates into daily meals, based on the principle according to which macronutrients consumed in excess become the main source of energy at rest (Wim et al., 2003), or through a prolonged period in specific anaerobic effort.

Following exercise performance, it can be seen how the body responds during the recovery process. Using forms of training such as running, frequently found in the case of juniors, is associated with an increased respiratory rate and consequently, with an increased consumption of carbohydrates at rest and a low consumption of fat at rest, indicating an energy imbalance. The individuals of the youth group had a stabilization of the respiratory frequency index, alveolar oxygen tension, and carbon dioxide. Senior athletes experienced significant changes in the main value of the heart rate, resting energy needs and macronutrient consumption preponderance, with a possible association of nutritional imbalances, based on increased energy consumption during prolonged periods in specific anaerobic efforts. The presence of a higher value of the PetO2 index in athletes relying on a high amount of carbohydrates at rest (women's groups) may indicate additional work in the muscle, energy production (Ozcelik et al., 2004) and a decrease in the efficiency of the recovery process.

Conclusions

1. The three groups of athletes included in the study have different forms of training that do not comply with the correct intensity order of the effort during a specific training week (repeating a high intensity effort in less than 24 hours).
2. Additionally, a non-specific activity such as running, without a prior exercise test showing the effort zone in which the athlete should be, is a form of exercise that will induce fatigue and lack of energy substrate, without significant improvements.
3. In this case, the respiratory rate was directly proportional to cellular energy metabolism and alveolar oxygen tension, indicating a prolonged period in which the athlete had an increased heart rate, associated with a mixed anaerobic exercise zone.
4. Restructuring of training, along with individualization of the training process, based on physiological/ biochemical determinations, represent an important point in the process of improving the recovery activity among athletes.
5. The daily nutrition structure must be established based on the period of training.

Conflicts of interest

There are no conflicts of interest regarding the methods, the results and the conclusions drawn.

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