THE RESPIRATORY EXCHANGE RATIO IN ATHLETES' NUTRITIONAL PRACTICE

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Abstract: *Purpose: Identify the main factors influencing energy consumption through respiratory exchange ratio (RMR) and macronutrients consumption at rest, reported to muscle/liver enzymes. Materials and methods: We conducted a cross-sectional study on a group of elite athletes consisting of 23 rowers, mean age 18.83±1.46 years, 91.65±7.67 kg weight, and 194.6±4.97 cm height. The resting metabolic rate has been determined among athletes using Cosmed Quark CPET equipment and the metabolic rate at rest protocol (RMR), associated with blood determinations of the main muscle, and liver enzymes (CK, LDH). Results: We achieved an average energy consumption at rest equivalent to 2732±249.3 kcal. R value reached an average of 0.89±0.93. Value associated with resting energy expenditure, both in the case of carbohydrates (%), and in the case of lipids (%) p =0.0001. Signifying that R≤0.86 represents a protective factor in order to obtain a lipid consumption value at rest ≥45% of total energy consumption. Conclusions: We established a definite relationship in the consumption of macronutrients at rest, and metabolic/ respirators indications of athletes. Also, adaptation of their daily activities will help increasing the effort capacity of the athlete by balancing the respiratory exchange rate.*

INTRODUCTION

Estimating energy requirements is one of the most important tools used to obtain metabolic balance, secondary to the effort performed.(1) Respiratory determinations based on the consumption of oxygen (O_2), and carbon dioxide (CO_2) production take into account sports physiology.(2) Moreover, connections regarding VO_2 and carbohydrate intake at rest have been highlighted in literature in terms of adenosine triphosphate (ATP) production at mitochondria level.(3) Improved exercise capacity aims at increasing the number of mitochondria, and at sustaining the body in the use of various energy sources during exercise.(4)

Rowing is an endurance sport whose energy consumption distribution is not linear. Both aerobic and anaerobic metabolism (anaerobic lactacid, anaerobic alactacid) will provide a continuous supply of energy to the athlete.(5) Energy consumption reported in training sessions ranges between 750- 1500 kcal, while a 2000 m race simulation indicates an energy consumption ranged between 250-450 kcal (6), reporting a significant difference between the two separate activities.

The daily effort performed in training aims to improve the use of energy sources during exercise and to adapt the athletes to the work performed. (7) Aerobic exercise should be an important part of the imposed training model in endurance sports.(8) The fact is that such an effort supports the use of lipids as an energy source during sports activity, requiring decreased O_2 value compared to anaerobic efforts.(8)

Anaerobic activity is the specific competition effort and contemplates the use of anaerobic/aerobic energy system in the mentioned order.(5) Increased consumption of carbohydrates is directly proportional to increased exercise intensity, information suggested by the fact that carbohydrate, containing O_2, becomes the primary energy source of the body during exercise with oxygen debt.(9) From this point, the change in energy metabolism, cardiac, and respiratory function will indicate the adaptation, or non-adaptation of the body during exercise.

PURPOSE

Identify the main factors influencing energy consumption through respiratory exchange rate (RMR) and macronutrients consumption at rest, reported to muscle/liver enzymes.

MATERIALS AND METHODS

We conducted a cross-sectional study within an elite group of rowers, after receiving the consent from the ethics committee, and informed consent of the athletes to participate in the study. Place of the research was Orşova, Romania, representing the athletes training center.

Data was retrieved through Cosmed Quark CPET equipment, using the research protocol associated with resting metabolic rate (RMR). Parameters monitored in the study were: FC (heart rate - bpm), VO_2 (ml/min), $PetO_2$ (partial pressure of oxygen - mmHg) $PetCO_2$ (partial pressure of carbon dioxide - mmHg), Rf (respiratory frequency - b/min), METS (metabolic equivalents), CO_2exp (amount of carbon dioxide expired - ml), R (respiratory exchange ratio), resting energy expenditure (kcal), CHO consumption at rest (carbohydrates%), L consumption at rest (lipids %), creatine kinase (CK-U/L), lactate dehydrogenase (LDH-U/L), urea (mg%). Respiratory values were associated with biochemical determinations through biochemical analyser type Eppendorf (CK, LDH, Urea), by

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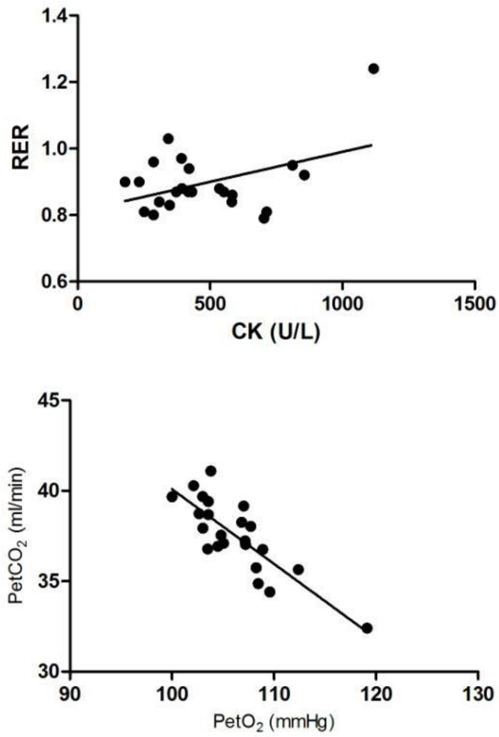
collection of the biological material, basal. To determine the metabolic rate at rest, the following protocol research was used: lack of effort (24 hours), food intake (5 hours), consumption of caffeine (12 hours), sports supplements (containing ephedrine, Ma Huang, presudoefedrin), nicotine (12 hours) pre testing. Following the activity protocol, and the equipment used we took as reference values: CK (38-174 U/L), LDH (207-414 U/L).

Statistical evaluation was performed using GraphPad Prism 5.0 software. Statistical indicators used were standard deviation (SD), standard error (SE), and coefficient of variation (CV). For data normalization, we used Pearson correlation index (r) and Student's t-test (pairs). Fisher's exact test was used to determine risk factors (Relative Risk). Level of significance, $p < 0.05$ was considered statistically significant.

RESULTS

The study included a group of elite athletes, rowers, with mean age of 18.83±1.46 years old, 194.6±4.97 cm height, and 91.65±7.67 kg weight. The main respiratory parameters were correlated to the energy metabolism activity through resting energy expenditure (kcal), divided into macronutrients consumption (%). As a result, the values obtained by monitoring respiratory gases established statistical significant differences with the parameters advanced for examination. VO_2 (ml/min), CV=8.38% was significantly correlated to energy consumption at rest (p=0.0001, r=0.96, CI=0.92-0.98) obtaining the importance of respiratory system in providing energy to the muscle. By raising VO_2 we obtained a decrease in total energy demand. Also, $PetO_2$ (106.2 ± 4.04 mmHg), CV = 3.81%, established a significant correlation with $PetCO_2$ value, equivalent to 37.54±2.03 mmHg (p=0.0001) along with R, 0.89±0.09 (p=0.0001), CV =10.67%, the consumption of L at rest (40.93±19.48%) (p=0.015), CV=18.32% and CHO consumption at rest (59.47±19.40%) (p=0.012), CV=32.63% (figure no. 1).

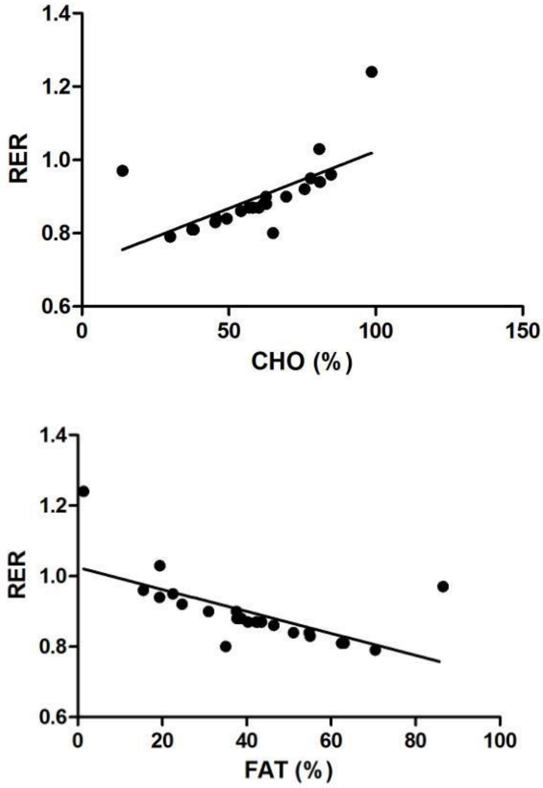
Figure no. 1. Relationships $PetO_2$ - $PetCO_2$; CK - RER (respiratory exchange rate) (p = 0.0001)



Respiratory frequency (12.88±2.68 bpm), CV = 20.84%, representing the number of respiratory cycles characterized by inspiration/expiration, during a minute, established a statistical significant correlation with R (p=0.0014), the consumption of lipids (p=0.018) and carbohydrate at rest (p=0.0190) (figure no. 2). Respiratory exchange ratio, representing the value which can indicate the predominance of consumption in energy resources, has been statistical correlated to CHO consumption (p=0.019), along with L consumption at rest (p=0.018) (figure no. 2), and the determined creatine kinase (CK) value (p=0.038) (figure no. 1), together with VT (0.90±0.28) (p=0.0001).

By applying Fisher test (Relative Risk), we obtained relevant data, according to which R≤0.86 value represents a protective factor towards obtaining carbohydrate consumption values at rest above 55% of the total energy consumption (p=0.0002, r=7.46, CI=1.18-46.96). Similar data were obtained for the consumption of fat. Thus, it is reported significant correlation (p=0.001, r=3.73, CI=1.15-12.50) signifying that R≤0.86 represents a protective factor in order to obtain a lipid consumption value at rest ≥45% of total energy consumption.

Figure no. 2. Relationship between significant RER and carbohydrates consumption (CHO%), lipids (L%) at rest



CO_2exp, associated with the total amount of carbon dioxide identified in respiration, reveals the basal metabolic values. RMR energy measurement is based on the amount of oxygen used and CO_2 produced. Thus, respiratory data such as Rf values (p=0.0001; r=-0.74; CI=-0.93/-0.67), are inversely associated with changes of CO2exp parameter. $PetO_2$ value (p=0.0013; r=0.63; CI=0.29-0.82) identifies a directly proportional increase in respiratory rate values. Respiratory exchange ratio (RER) (p=0.0001; r=0.86; CI=0.69-0.93), issues an increase in R, and CO_2exp simultaneously, meeting a directly proportional increases in the case of both parameters. VT (p=0.0001; r=0.97; CI=0.94-0.99) establishes positive changes, directly proportional to the amount of CO_2exp. This increase will represent the elevation of the determined parameters.

METS value (1.2±0.10), identified as metabolic equivalent, is directly proportional to resting metabolic rate (kcal), determined through Cosmed Quark CPET equipment in the studied group (2732±249.3 kcal; CV=9.13%). In the case of CK values (486.2±231.1 U/L; CV=47.82%) we determined a statistically significant correlation with LDH value (93.65±74.52 U/L; CV=20.84%). The affirmation of the interrelationship determined between the two enzymes is achieved through: p=0.0001, r=0.73, CI =0.45-0.87, representing a directly proportional increase of the values presented (Risk Ratio).

DISCUSSIONS

It is certified that both carbohydrates and lipids influence athletic performance. The contribution of these macronutrients to force production of the body is imminent, being influenced by factors such as pre-exercise food intake, exercise status, exercise intensity and hormonal response.(10) Endurance training can cause reversible dysfunction in cardiac function (11), while intensive efforts based on anaerobic metabolism, with passage from aerobic metabolism, can cause a growth in the level of lactic acid, $PetO_2$, and a decline in $PetCO_2$ value.(12)

Precise physiological activity in body supports the exchange of gases effectively, representing the main function of the lungs. Gas exchange is also carried out in cells, where O_2 and CO_2 diffuse from mitochondria. CO_2 levels will influence the body, and blood pH value, while the effort performed will determine the total volume of activity in the lungs.(13) Therefore, blood pH value will decrease with increased concentration of lactic acid, reported in an area of anaerobic lactacid effort. However, in different situations, it will encounter a decrease in pH value, without a significant increase in lactic acid value, dictated by the accumulation of hydrogen ions (H+).(14) As a result, with changes in respiratory parameters, pH, and accumulation of hydrogen ions, the respiratory function rate will changes. Therefore, with changes in pH, hydrogen ions accumulation, and respiratory parameters variation, we will find a modified respiratory exchange ratio.

An increase in R values ≥1.0 will be associated with accessing carbohydrates as determinant energy source. Therefore it is suggested that achieving a R≥1.10, equivalent to maximal exercise capacity, will be associated with 100% carbohydrates consumption (RER≥1.0) (15,16), and the possible increase in CK, from the lactic acid accumulation. Establishing an energy consumption at rest relied primarily on lipids, can be achieved by respecting the effort zones during training programs, through the respiratory, and metabolic recovery of the athlete, confirmed at RER≤0.86. Issue highlighted through scientific sources which highlights the impact that the effort has on mitochondrial enzymes, representing an improved fatty acid oxidation, during a decline in R value.(17,18)

At the same time, the respiratory exchange ratio value represents and illustrates metabolic evolution during the first few hours post-exercise, according to the activity previously performed (19,20), statement justified in the light of data which relates to respiratory development according to the exercise performed, obtaining a R value of 0.86 for an effort equivalent to 25% of maximum capacity, and a value of 0.97 in an effort that reaches 70% of the athlete's ability.(19,20)

As a result, changing $PetCO_2$, $PetO_2$ parameters during exercise is imminent within individual asset.(20) Increased resting respiratory ratio as a result of the performed effort, through respiratory recovery failure, will induce an increased metabolic rate at rest, associated with increased carbohydrate consumption at rest.(22,23) Achieving increased R values during effort will induce, in the case of athletes, the obligativity upon which during the immediate future, effort and intensity will decline significantly upon aerobic effort zone. Lack of proper periodization with an increased value of the mentioned parameters during exercise, inability of the athlete to recover respiratory, metabolic, and muscular, will impose respiratory/metabolic imbalance values during rest, associated with lack of recovery, increased CK, related to LDH value, and decreased activity level.(24)

CONCLUSIONS

Determining the metabolic value, through energy consumption at rest, and resting respiratory rate, will indicate the metabolic/respiratory status of the body, following the full recovery of athletes. Thus, an RER value ≥0.86 is associated mainly with carbohydrate consumption (during rest or effort period), while lowering the value ≤0.85 will provide equilibrium within a nutritional plan which will satisfy the athlete in quality/quantity terms.

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