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Energy balance and dietary habits of America's Cup sailors

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Abstract
This research, which was conducted with crew members of an America's Cup team, had the following objectives: (a) to assess energy expenditure and intake during training; (b) to evaluate the sailors' diet, and (c) to identify any dietary flaws to determine the appropriate intake of nutrients, correct possible dietary mistakes, and improve their food habits. Energy expenditure was estimated on 15 sailors using direct measurements (oxygen consumption) and a 3-day activity questionnaire. Oxygen consumption was measured on sailors during both on-water America's Cup sailing training and dry-land fitness training. Composition of the diet was estimated using a 3-day food record. Average daily energy expenditure of the sailors ranged from 14.95 to 24.4 MJ, depending on body mass and boat role, with the highest values found in grinders and mastmen. Daily energy intake ranged from 15.7 to 23.3 MJ (from +6% to −18% of energy expenditure). The contributions of carbohydrate, protein, and fat to total energy intake were 43%, 18%, and 39% respectively, values that are not in accord with the recommended guidelines for athletes. Our results show the importance of assessing energy balance and food habits for America's Cup sailors performing different roles. The practical outcome of this study was that the sailors were given dietary advice and prescribed a Mediterranean diet, explained in specific nutrition lectures.

Keywords: *Sailing, energy expenditure, oxygen consumption, sports nutrition, dietary survey*

Introduction

Sailing is a very peculiar physical activity in comparison with other sports, because it relies not only on the physical fitness of the athletes, but also on the characteristics of the boat and on meteorological conditions. The relationship among these variables can affect performance. During mild wind sea conditions, physical fitness is less important than other tasks such us dexterity with rudder and sail trimming, and tactic competence. During rough meteorological conditions, physical fitness acquires a different significance when different variables, such as class of boats, roles within the boats, and types of regatta, are taken into consideration. Therefore, sailing demands are highly specific and vary widely (Marchetti, Delussu, & Rodio, 2001). The present study addresses the energy balance and dietary habits of sailors who competed in the specific match-race regatta called the America's Cup. The sailors competed in the 2002–2003 America's Cup regatta in Auckland, New Zealand. America's Cup boats consist of 16 sailors performing different roles under specific physical and technical demands (see Glossary in this special issue for a brief description of role functions), to which energy requirements must be matched.

In elite athletes, nutritional interventions can support training in promoting physiological and biochemical adaptations and therefore improving performance (Maughan, 2002). Proper nutrition must be considered as a key element to success within a wide variety of competitive sports (Knuttgen, 2000). Since literature dealing with athletes' nutritional knowledge often complains about myths and the mistakes thus induced, inquiries into athletes' dietary habits are advisable (Heredeen & Fellers, 1999; Rosenbloom, Jonnalagadda, & Skinner, 2002; Wiita & Stombaugh, 1996). Recommendations on appropriate diet are particularly important and should be proposed in an integrative nutritional education programme to ensure optimal efficacy.

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To estimate the nutritional requirements of athletes, assessment of energy expenditure during physical activity is fundamental. The physical training practised by athletes includes numerous activities together with their specifically chosen sport. While most of the physical activities are classified in terms of energy expenditure (Ainsworth, Haskell, & Whitt, 2000), no specific data are available, to our knowledge, regarding energy expenditure of America's Cup crew members during sailing.

The present study was designed with the following aims: (a) to assess energy expenditure and intake during training; (b) to evaluate crew members' diet, and (c) to identify any dietary flaws to determine the appropriate intake of nutrients, correct possible dietary mistakes, and improve their food habits. To accomplish these three aims we assessed crew members of an America's Cup challenger (*Mascalzone Latino*). During a typical training period, daily energy expenditure and energy intake, together with the composition of their diet, were assessed, after which specific nutrition advice was given. We formulated the following research hypotheses: (a) during America's Cup sailing, energy expenditure will differ greatly among different crew members depending on their roles; (b) these energy expenditures could also differ from the general range of data presented in literature about sailing, which is principally concerned with much smaller boats (Ainsworth *et al.*, 2000); and (c) composition of the sailors' diet could result in dietary flaws.

Methods

Participants

The research was carried out with 15 crew members of the *Mascalzone Latino* America's Cup challenger. All crew members, after being fully informed about the purpose of the research, signed an informed consent form to participate in the study. All sailors were elite male athletes, most of whom were very experienced in international regattas. The research was carried out during the training period at Isola D'Elba (Italy) from November 2001 to June 2002.

Anthropometric characteristics

The anthropometric characteristics of the athletes were measured monthly during the survey period. Body fat was assessed by measuring four skinfolds (biceps, triceps, subscapular, and supra-iliac), using the formula of Durnin and Womersley (1974). Since the sailors varied in body mass, height, and energy expenditure depending on their boat roles (see Glossary for details), they were grouped as follows: grinders and mastmen, trimmers, bowmen and midbowmen, and others. In this boat, the midbowmen served also as sewermen. The "others" group included navigator, helmsman, and tactician. Participants' anthropometric characteristics at the beginning of the research are shown in Table I.

Aerobic fitness evaluations

Evaluation of aerobic fitness was conducted with a continuous multi-stage incremental maximal exercise test on a cycle ergometer (Ciclo V500, Cosmed, Italy). The exercise test, consisting of increments of 6 W every 12 s and performed to volitional exhaustion, began after a 3-min warm-up at a mechanical power of 50 W. Pulmonary ventilation ($\dot{V}_E$), oxygen uptake ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$), and heart rate were recorded breath by breath using a stationary pulmonary gas analyser (Quark b^2, Cosmed, Italy) to assess peak aerobic power ($\dot{V}O_{2peak}$) and ventilatory threshold. The ventilatory threshold was deduced by the "V-slope" method, confirmed by ventilatory equivalents (Wasserman, Hansen, Sue, Whipp, & Casaburi, 1994). The test was terminated either when the participant was not able to maintain the workload required or when there was no increase in $\dot{V}O_2$ for a further increase in workload. The respiratory exchange ratio (RER), expected to be higher than 1.1, and peak heart rate compared with age-predicted maximum heart rate, were used at the end of the exercise test to confirm that the athlete had achieved valid maximal aerobic power for exercises performed with the legs. Electrocardiogram was monitored and recorded at rest, during exercise and during recovery (Quark C12, 12-Lean ECG; Cosmed, Italia).

The same stationary pulmonary gas analyser and electrocardiograph, and the same methods used for

Table I. Anthropometric characteristics of the participants (means and standard deviations).

Role on boat	*n*	Age (years)	Body mass (kg)	Stature (m)	Body mass index	Body fat (% body mass)
Grinders and mastmen	5	27, $s=5$	102.4, $s=4.2$	1.91, $s=0.05$	28.0, $s=1.4$	12.6, $s=2.4$
Trimmers	5	28, $s=7$	80.7, $s=6.9$	1.77, $s=0.05$	25.7, $s=2$	13.4, $s=2.5$
Bowmen and midbowmen	2	28, $s=1$	77.2, $s=0.2$	1.80, $s=0.00$	23.8, $s=0.07$	9.9, $s=1.3$
Others	3	33, $s=6$	75.7, $s=4.1$	1.78, $s=0.09$	24.0, $s=1.3$	14.4, $s=0.3$
Mean		28, $s=6$	86.4, $s=12.7$	1.82, $s=0.08$	25.8, $s=2.2$	12.8, $s=2.3$

the lower limbs, were used to assess upper-body maximal aerobic power. The protocol consisted of a continuous multi-stage maximal exercise test performed to volitional exhaustion on an arm-cranking ergometer (Ergometrics 800, Ergoline, Germany; assisted by Cosmed, Italy). The same handles used in the coffee grinder winches of America's Cup boats were mounted on the ergometer and were positioned in such a way as to allow the sailors the typical grinder's posture during sailing. The exercise test consisted of a warm-up at a mechanical power of 50 W and an exercise phase with a ramp increment of 6 W every 12 s.

Energy expenditure

Energy expenditure was assessed through a detailed diary, listing and describing all the activities performed during the day. All sailors completed an activity questionnaire for 3 days. Apart from sailors' specific gym training and sailing, energy expenditure during the other activities was assessed by converting data from the 3-day activity questionnaire into their energy equivalent by adopting Ainsworth and colleagues' (2000) tables. A typical daily schedule is shown in Table II.

$\dot{V}O_2$ measurements

Energy expenditure during sailing and gym training was assessed by measuring $\dot{V}O_2$ using a portable pulmonary gas analyser (K4b^2, Cosmed, Italy). During sailing, the sequence of the activities was video-recorded and accurate notes were taken. Three grinders, two mastmen, a midbowman, and a tactician were tested on different days under different wind conditions (range 8 – 12 knots), while performing typical manoeuvres (i.e. tacking, gybing, and hauling gennaker and genoa). All these physical activities will be referred to from now on as "active sailing". Active sailing data were collected during a period of about 40 min (20 min upwind and 20 min downwind) during which the team was requested to perform sequences of tacking and gybing with rest intervals of a few minutes between the manoeuvres. Time during physical activities not included in the quoted manoeuvres (i.e. towing the boat to and from the sailing area) will be referred to from now on as "light sailing". Based on the video analysis, time spent in light sailing and active sailing in a typical training day was assessed.

The gym training $\dot{V}O_2$ demand was assessed taking into account the time spent in the following three daily activities: resistance training, upper-limb controlled aerobic training, and lower-limb controlled aerobic training. Each of the three activities was performed at a similar time every training day and lasted on average about 20 min. Energy expenditure during resistance training, assessed using standard values of energy cost during human physical activities (Ainsworth, Haskell, & Leon, 1993), corresponded to 6 METs. Energy expenditure during specific (upper- and lower-limb) aerobic training was prescribed on the basis of the laboratory results and subsequently monitored. Each sailor was requested to train using the cycle and arm-crank ergometers at a mechanical power corresponding to his ventilatory threshold. Because the sailors wore a chest belt to monitor heart rate, further continuous feedback of the appropriate workload was obtained.

Table II. Typical daily activities.

Time	Activity
07.00 – 08.00 h	Gym training
08.00 – 10.00 h	Breakfast and self-care activities
10.00 – 10.30 h	Briefing and daily planning
10.30 – 11.30 h	Boat preparation
11.30 – 17.00 h	Sailing activity (20 min interruption for lunch)
17.00 – 17.30 h	Boat care activity
17.30 – 18.00 h	Snack
18.00 – 20.00 h	Various personal activities (including indoor and outdoor physical training)
20.00 h	Dinner
21.00 h	Leisure time

Dietary assessment

Together with the 3-day activity questionnaire, a 3-day food record was kept to determine food intake. Each participant was instructed in detail on how to complete the food record. Examples of completed food records, measuring utensils, and portion-guide with colour photographs were supplied. Food records were analysed using nutrition analysis software (Nutritrac for Windows^{TM}, Version 3.0, Mosby, St. Louis, MO, USA). The macronutrients intake of the sailors was compared with the recent recommendations of the Joint Position Statement of the American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada for athletes (ACSM, 2000). The recommended distribution of macronutrients in athletes is 55 – 58% of the total energy intake for carbohydrates, 12 – 15% for proteins, and 25 – 30% for fat (ACSM, 2000).

Statistical analysis

Descriptive statistics (means and standard deviations) were calculated for laboratory and sailing data, based on sailors' roles. Data from active sailing were calculated during the whole 40-min period (including rest intervals between manoeuvres), subtracting the basal values. A one-way analysis of variance (ANOVA) was used to evaluate possible differences among both energy expenditure and intake of the different role groups. Statistical significance was set at $P < 0.05$.

Results

Means and standard deviations (s) for $\dot{V}O_2$ and heart rate measurements, collected during the two maximal exercise tests, are reported for each role group in Table III. During the study, none of the sailors showed variations in body mass or percentage fat.

Based on the prescriptions given to the sailors for their aerobic training and to the resistance training energy equivalents taken from the literature, the overall mean energy expenditure during gym training was equivalent to a $\dot{V}O_2$ of 30 ml · min^{-1} · kg^{-1} ($s = 5$).

During active sailing, the sailors showed bursts of high responses corresponding to gybing and tacking manoeuvres, which were paralleled by increases and decreases in $\dot{V}O_2$. A tacking manoeuvre lasted about 15 s and a gybing manoeuvre about 20 s. Grinders and mastmen typically carried out these physical activities using anaerobic metabolism, with most of the increase in $\dot{V}O_2$ occurring during the first part of the recovery phase. Approximately 10 tacking and five gybing manoeuvres were performed in 40 min. Mean $\dot{V}O_2$ for the grinders was 20 ml · min^{-1} · kg^{-1} ($s = 5$), and mean $\dot{V}O_{2peak}$ 39.5 ml · min^{-1} · kg^{-1} ($s = 5.1$). Mastmen showed their greatest $\dot{V}O_2$ increase when hoisting and lowering the sails. Mean $\dot{V}O_2$ for the mastmen was 15 ml · min^{-1} · kg^{-1} ($s = 1$), and mean $\dot{V}O_{2peak}$ 31.4 ml · min^{-1} · kg^{-1} ($s = 3.8$). The midbowman displayed a more stable and higher $\dot{V}O_2$ trend than the grinders and mastmen, reaching the highest mean energy expenditure of all groups. Peak oxygen uptake during the most strenuous activities ranged from 39 to 45 ml · min^{-1} · kg^{-1}. The lowest $\dot{V}O_2$ values (range 4–11 ml · min^{-1} · kg^{-1}) were measured in the tactician. His mean value (7 ml · min^{-1} · kg^{-1}) was taken to be representative of the role group "others" and of light sailing for each crew member. Trimmers were assigned a notional $\dot{V}O_2$, which was a mean of the values for grinders and mastmen and others, namely 10.2 ml · min^{-1} · kg^{-1}. On the basis of the video analyses, we assessed that, on average, 3 h of training were spent in active sailing and 2 h in light sailing. For each role group, mean $\dot{V}O_2$ measured during active sailing, mean $\dot{V}O_2$ determined for light sailing, and mean $\dot{V}O_2$ calculated for the whole sailing period are shown in Table IV.

Table V shows the detailed energy expenditure results for each of the activities performed by the sailors during the day. The table shows for all sailors the time dedicated to each activity, energy expenditure expressed per minute (absolute) and per kilogram of body mass (relative). In terms of relative intensity, gym training was found to be the most strenuous activity. However, sailing was the most relevant contribution in terms of total amount of daily energy expenditure.

The comparison between daily energy expenditure and daily energy intake, and the percentage imbalance between them, is shown for each role group in Table VI. Each role's energy expenditure differed from all others ($P = 0.038$). The grinders and mastmen showed the highest values, mainly because of their high body mass. Statistical comparison among role groups for daily energy intake showed that grinders and mastmen displayed values different from trimmers ($P = 0.02$) and "others" ($P < 0.01$). No statistical differences were observed among the other role groups.

Table III. Metabolic and heart rate data of America's Cup sailors during a maximal exercise test on (a) a cycle ergometer and (b) an arm-cranking ergometer (means and standard deviations).

Role on boat	$\dot{V}O_{2peak}$ (ml · min^{-1} · kg^{-1})	$\dot{V}O_2$ @$\dot{V}_{Thresh}$ (ml · min^{-1} · kg^{-1})	Peak heart rate (beats · min^{-1})	Heart rate @ $\dot{V}_{Thresh}$ (beats · min^{-1})
(a) Cycle ergometer				
Grinders and mastmen	48, $s = 4$	30, $s = 2$	179, $s = 10$	152, $s = 7$
Trimmers	49, $s = 3$	38, $s = 6$	180, $s = 8$	151, $s = 18$
Bowmen/midbowmen	56, $s = 1$	41, $s = 4$	181, $s = 5$	144, $s = 6$
Others	47, $s = 4$	28, $s = 3$	173, $s = 17$	127, $s = 13$
Mean	49, $s = 4$	33, $s = 6$	179, $s = 9$	147, $s = 15$
(b) Arm-crank ergometer				
Grinders and mastmen	41, $s = 4$	29, $s = 3$	185, $s = 6$	166, $s = 12$
Trimmers	47, $s = 1$	33, $s = 3$	189, $s = 5$	167, $s = 7$
Bowmen/midbowmen	53, $s = 6$	40, $s = 7$	176, $s = 18$	157, s = 9
Others	44, $s = 1$	28, $s = 1$	187, $s = 4$	164, $s = 3$
Mean	45, $s = 5$	32, $s = 5$	185, $s = 8$	165, $s = 9$

$\dot{V}_{Thresh}$ = ventilatory threshold.

Table IV. Sailors' energy expenditure during sailing.

	$\dot{V}O_2$ (ml · min^{-1} · kg^{-1})			
Roles	Measured during active sailing	Determined value	Determined for light sailing	Determined for the sailing training
Grinders and mastmen	17.9, $s = 4.2$*		7	13.5
Trimmers	–	10.2	7	8.92
Bowmen and midbowmen	31+		7	21.4
Others	7#		7	7

*Measured on three grinders and two mastmen.
+Measured on a midbowman.
#Measured on the tactician.

Table V. Sailors' energy expenditure.

Daily activities	Min · day^{-1}	$\dot{V}O_2$ (ml · min^{-1} · kg^{-1})	Energy expenditure (J · kg^{-1} · min^{-1})	Energy expenditure (kJ · kg^{-1} · day^{-1})
Sailing	300	12, $s = 5$	254, $s = 106$	76.0, $s = 32.0$
Gym training	60	30, $s = 5$	637, $s = 106$	38.2, $s = 6.4$
Sitting quietly	240	3.5*	74	18
Self-care	90	7*	149	13
Sleeping	480	3.15*	67	32
Eating	120	5.25*	111	13
Various activities**	150	12.25*	260	39
Total	1440		1553	230

*Ainsworth *et al.* (2000); **Walking and fitting out the boat. The "various activities" energy expenditure was determined by adopting data indicated as code number 11620 in Ainsworth and colleagues' (2000) tables.

Table VI. Energy balance (means and standard deviations).

Roles	Daily energy expenditure (MJ)	Daily energy intake (MJ)	Imbalance (%)
Grinders and mastmen	24.4, $s = 0.9$	23.3, $s = 3.9$	−5%
Trimmers	16.9, $s = 1.5$	17.6, $s = 2.8$	+4%
Bowmen and midbowmen	22.2, $s = 0$	18.4, $s = 0.2$	−18%
Others	14.9, $s = 0.8$	15.7, $s = 3.8$	+6%
Mean	19.7, $s = 4.1$	19.2, $s = 4.2$	−1%

The food record analysis showed that macronutrient intake, represented by percentage of daily energy intake, ranged from 34% to 49% for carbohydrate, from 13% to 22% for protein, and from 33% to 45% for fat (the remaining energy intake, 0–1%, was from alcohol). A detailed comparison of these data, expressed as absolute values, with the distribution of macronutrient intakes recommended for athletes (ACSM, 2000), shows that all America's Cup sailors had inappropriate food habits (Figure 1). In particular, excesses of fat and protein and a deficiency in carbohydrate are evident for all roles.

Table VII shows daily carbohydrate, protein, and fat intake expressed per unit body mass.

Discussion

The present research compared energy expenditure and intake in American's Cup sailors during their training period. The main findings demonstrate that: (1) the energy turnover in these athletes is remarkably high, similar to that observed in other elite athletes, such as rowers (Hagerman, Connors, Gault, Hagerman, & Polinski, 1978); (2) the energy expenditure of the sailors was dependent on their boat role; (3) dietary flaws were identified.

In sailing, energy demand can vary widely depending on meteorological and tactical conditions, sailing classes, and crew roles (Marchetti *et al.*, 2001; Spurway, 1999). Because the mean $\dot{V}O_2$ measurements interfered with the sailing training plans, we were only able to assess a limited number of athletes during sailing. Therefore, in trimmers the energy expenditure is largely approximate. Ainsworth *et al.* (2000) reported energy expenditure of 5 METs (equal to a mean $\dot{V}O_2$ of 17.5 ml · min^{-1} · kg^{-1}) during sailing competition. Detailed analysis of the literature (Marchetti *et al.*, 2001) appears to show that the wide range of values depends on the sailing classes and sailors' roles. For example, in Star class sailors, Gallozzi, Fanton, De Angelis, and Dal Monte (1993) reported $\dot{V}O_2$ values of about

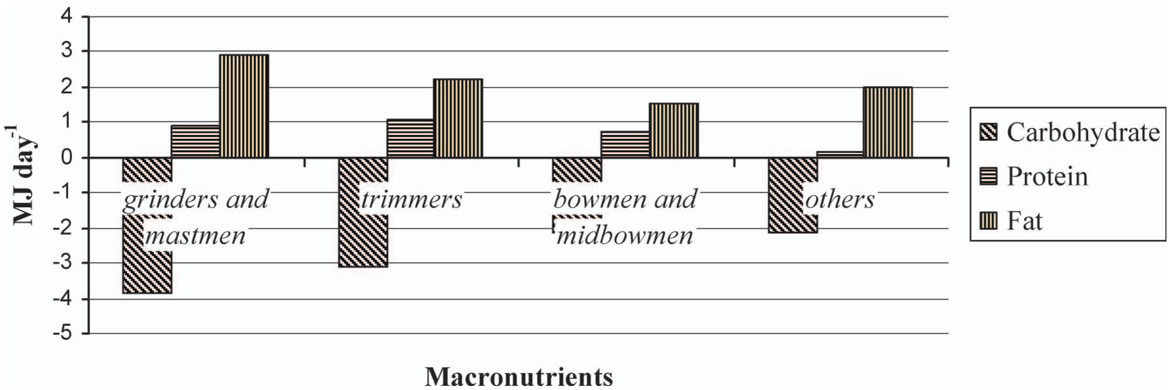

Figure 1. Differences in macronutrients, expressed in absolute terms for each role group category, between actual and recommended intakes (ACSM, 2000). The recommended intake values correspond to the "0" line.

Table VII. Daily carbohydrate, protein, and fat intakes (means and standard deviations).

Roles	Carbohydrate ($g \cdot kg^{-1}$ body mass)	Protein ($g \cdot kg^{-1}$ body mass)	Fat ($g \cdot kg^{-1}$ body mass)
Grinders and mastmen	5.7, $s = 1.4$	2.5, $s = 0.4$	1.3, $s = 0.1$
Trimmers	5.3, $s = 1.0$	2.6, $s = 0.4$	1.6, $s = 0.3$
Bowmen and midbowmen	6.8, $s = 0.3$	2.5, $s = 0.1$	1.5, $s = 0.0$
Others	5.6, $s = 1.5$	1.9, $s = 0.5$	1.8, $s = 0.3$
Mean	5.7, $s = 1.2$	2.4, $s = 0.5$	1.6, $s = 0.3$

10 $ml \cdot min^{-1} \cdot kg^{-1}$ in helmsman and about 11 $ml \cdot min^{-1} \cdot kg^{-1}$ in bowmen. The same authors reported a mean $\dot{V}O_2$ of 20.5 $ml \cdot min^{-1} \cdot kg^{-1}$ in Finn sailors. Similar values were reported by De Vito *et al.* (1996) for Laser class sailors (22 $ml \cdot min^{-1} \cdot kg^{-1}$) and by Vogziatis, Spurway, Wilson, and Boreham (1995) for Laser and Finn sailors (20.3 $ml \cdot min^{-1} \cdot kg^{-1}$). In the present study, during active sailing the energy expenditure was comparable with the values quoted above. Only the midbowmen tested in the present study presented mass-specific mean $\dot{V}O_2$ values greater than those observed in sailors of the quoted Olympic classes.

In the literature, the 3-day food record method is considered accurate, above all for the assessment of dietary intake in small groups of participant (Basiotis, Welsh, Cronin, Kelsay, & Mertz, 1987). Energy intake is generally under-reported when compared with expenditure. Hill and Davies (2001), while reviewing data on self-reported energy intake, observed that this imbalance varied from +19% to −46% in sedentary adults, and from 0 to −43% in athletes. In our study, the imbalance (Table IV) was less marked than that reported in the literature. Only bowmen and midbowmen presented an imbalance similar (−18%) to that reported for athletes participating in other sports. Since body mass did not vary in any of the role groups during the survey, we had evidence that the energy turnover was actually in balance among all sailors. In addition, the consistent relationship of intake to output can be considered as confirmation that the apparent differences between intake and expenditure can be disregarded.

Athletes are often prone to dietary flaws and susceptible to myths about miraculous food components (Heredeen & Fellers, 1999; Rosenbloom *et al.*, 2002; Wiita & Stombaugh, 1996). Rosembloom *et al.* (2002) reported that 47% of men and 43% of women believe that protein is the main energy source for muscles; 35% of men and 34% of women believe that protein supplements are necessary; and 63% of men and 71% of women believe that sugars eaten before a sport event will adversely affect performance. Sailors are not free from similar confusions (Burke, 2003). Our survey also revealed some erroneous dietary habits, such as a high protein intake to the detriment of carbohydrate intake, whereas a high carbohydrate intake in athletes' diet is part of official dietary guidelines (ACSM, 2000; Maughan & Horton, 1995). Costill and Hargreaves (1992) showed that a high carbohydrate diet can increase glycogen resynthesis after prolonged exercise, and Sherman, Doyle, Lamb, and Strauss (1993) demonstrated that carbohydrate supplementation after prolonged training can improve the quality of the following training sessions. The relative percentage intake of carbohydrate of sailors within the present study (mean = 42.7%) was lower than the minimum intake (50%) recommended to maximize glycogen storage (Guilland *et al.*, 2001). Expressed per unit body mass, as suggested by Burke, Cox, Cummings, and Desbrow (2001) and Maughan (2002), the sailors' mean intake of carbohydrate was about 30% lower than that suggested for endurance athletes and athletes who perform moderate- to high-intensity physical activity (7–10 $g \cdot kg^{-1}$ body mass) by Costill *et al.* (1981) and

Burke *et al.* (1995). According to data reviewed by Burke *et al.* (2001), male athletes generally achieve a carbohydrate intake within the recommended range. The sailors in the present study are an exception to this rule.

The present study revealed that the sailors' daily intake of protein per unit body mass was about 70% higher than recommended for athletes by ACSM (2000). Similar values were observed in a dietary survey carried out on a male World champion lightweight rower (Xia, Chin, Girandola, & Liu, 2001).

The mean percentage of energy from fat for all sailors in this study was 39.3% ($s = 4$), which is above the recommendations for athletes (ACSM, 2000) and even above the typical Western diet [approximately 35% of energy from fat (Hawley, Jeukendrup, & Brouns, 2000)]. A fat-rich diet does not lead to an improvement of endurance performance (Kiens & Helge, 2000), and the long-term negative effects on health of a high-fat diet are well known (ACSM, 2000).

Conclusions

The results demonstrate that energy turnover in America's Cup sailors is similar to that observed in other elite athletes, their energy expenditure is dependent on their boat role, and there are flaws in their diets in terms of the balance of macronutients.

Based on the energy expenditure analysis and the food records in the present study, the following procedures were adopted by the *Mascalzone Latino* America's Cup challenger:

1. Carbohydrate intake was increased to meet the macronutrients needs of very active athletes (ACSM, 2000).
2. The sailors' diet was changed to typical Mediterranean food, rich in complex carbohydrates. This new diet also had the aim of guaranteeing the right amount of dietary fibre and micronutrients.

To encourage the sailors to follow the proposed recommendations and the new diet, a nutritional education programme was introduced, in accordance with Burke and colleagues' (2001) recommendations, with the aim of helping the sailors to fine-tune their dietary habits to meet specific macro- and micronutrient intake goals.

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