A Comparison of Energy Output and Input among Elite Rowers

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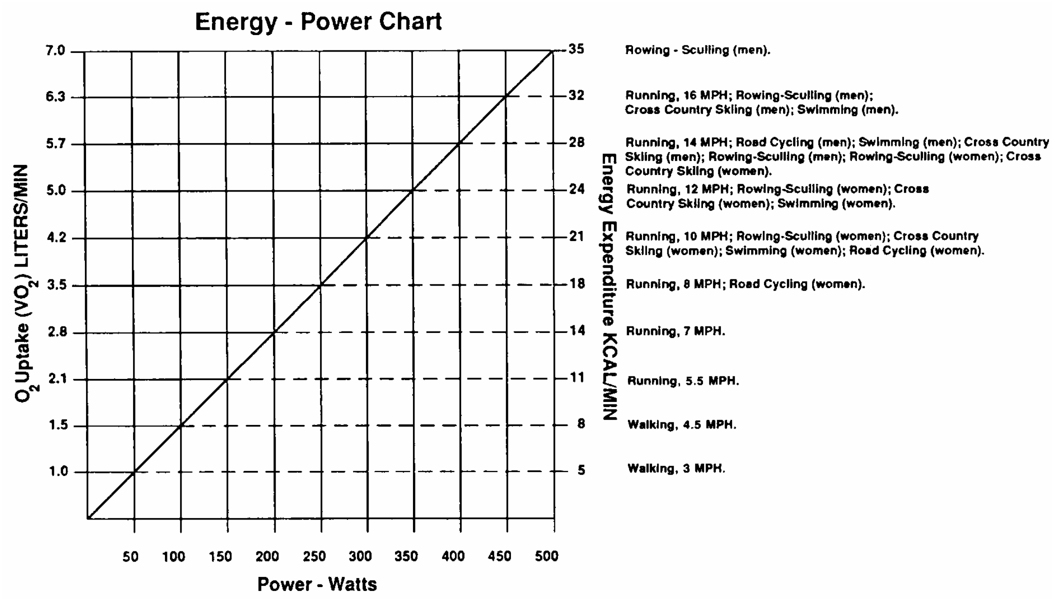
Competitive rowing, with the exception of single sculling, is one of the most unique of all endurance sports as it involves two or more athletes working together in a rhythmic, synchronous manner. Therefore, it appears from a purely physical basis that a multiple oared boat is only as strong as its weakest link. Furthermore, unlike other predominantly aerobic sports, rowing is characterized by exceedingly high muscular power production and energy expenditure in a very limited time frame.

Maximum power and metabolic responses are necessary to compete successfully over 2000 meters (m). Typical training sessions use exercise intensities that range from very low submaximal work to short term supramaximal efforts. Based on our research and that of others, rowing ranks at the top of the list as the most physiologically demanding of any aerobic sport. Some time ago, we determined that rowers performing 2000m competitive efforts generated average power outputs of between 250 and 550 watts depending on whether they were heavyweights or lightweights, male or female (4). The higher power outputs for men often surpass 0.7 horsepower and the best women approach half of a horsepower for average outputs for six minutes of work.

As might be expected, these excessive power outputs require extraordinary amounts of energy to sustain them (Figure 1). It has been estimated that a 2000m race is fueled by about 25-35 large calories produced every minute (4). These estimates have been obtained by measuring the amount of oxygen consumed during ergometer work and actual on-the-water testing. The body's ability to take in, deliver, and use oxygen is probably one of the best measures of aerobic fitness. Although it takes five to eight minutes to row 2000m, the relative proportion of aerobic to anaerobic metabolic contribution is roughly 75% to 25% respectively (6). If a rower expects to achieve success at the international level, it will be necessary to produce maximal oxygen consumptions that approach 4.5 liters/minute for women and 6.0 liters/minute for men (slightly less for lightweight rowers).

Maximal oxygen consumption (VO_2 max) is often used as the "yard stick" to determine aerobic capacity. However, a rower's ability to row at a high percentage of his/her maximum aerobic capacity without tiring and increasing mechanical efficiency (ME) are more important factors. We have found that being able to row 2000m at an oxygen consumption that is 98% or higher of VO_2 max and increasing mechanical efficiency are far more important than VO_2 max itself. We have recently reported that one of the most common reasons for individual successes by U.S. rowers in international competition over the last 10 years has been the significant improvement of mechanical efficiency (5), and it is doubtful that a rower can be successful at the international level without achieving a ME of greater than 20%. There is a wide variance in the energy and time it takes to row a highly competitive 2000m race compared to the amount of time and energy used for training. During the season most competitive rowers spend between one and two hours on the water every day. During a competitive effort a rower will expend a total of about 200 kcal. This is small compared to the range of 1000 to 2000 kcal that is often the cost of a single training session depending on the intensity and duration of exercise. Our higher value was measured for heavyweight men while lightweight women expend as much as 0.290 kcal/min/kg.

Figure 1: Energy - Power Chart



Because of the extremely high energy expenditures associated with rowing training and racing, one should be concerned about adequate energy intake to fuel the muscles of rowers. This is a problem because of the difficulty that rowers sometimes experience in maintaining body weight, especially lean body mass.

We recently conducted a study of 28 elite female and 16 elite male rowers, all candidates for the National Team. Their physical characteristics are listed in Table 1.

Table 1: Physical Characteristics of Subjects (X/=/-SE)

	Number of Athletes (n)	Age (yrs)	Height (cm)	Weight (kg)	Body Fat (%)
Women	28	24 (0.78)	178.6 (0.3)	73.6 (2.41)	14.8 (0.36)
Men	16	23 (0.87)	194.1 (0.49)	89.0 (2.36)	8.7 (0.29)

Daily energy expenditure, in kilocalories, was estimated for each athlete by measuring maximal oxygen consumption and heart rate during both rest and maximal ergometric rowing. Using biotelemetry procedures, average daily caloric expenditure was extrapolated by relative heart rate data. Noting the intensity of various training regimens permitted an estimation of average daily caloric cost. Average daily energy output for our subjects is displayed in Table 2.

Table 2: Summary of Results (X/+/-SE)

Power Output	**VO_2 max**	**HR max**	**Energy Output**	**Energy Input**	**%kcal**	**%kcal**	**%kcal**	**%kcal**
Watts	**ml^2/min**	**b/min**	**kcal/day**	**kcal/day**	**Cho**	**Fat**	**Pro**	**Alcoh**
Heavyweight Women								
285	4277	191	3177	3169	52.0	34.6	13.0	0.40
2.3	0.06	1.76	103.9	167.7	1.30	1.13	0.45	0.17
Heavyweight Men								
428	6200	188	4710	4688	49.6	49.6	15.1	1.00
2.6	0.08	2.85	98.7	321.7	3.57	3.57	0.93	0.54

Sports nutrition is a topic that is often misunderstood and woefully abused. The often-used "shot-gun" approach to meeting caloric needs by simply increasing caloric intake without regard to nutrient source is scientifically contrary to the need for a more careful study of the nutritional requirements of rowers.

A comprehensive protocol of nutritional assessment, followed by individual dietary counseling for the 28 heavyweight women and 16 heavyweight men trying out for the 1987 National Team provided a rare, in-depth look at the extent to which the nutritional needs of elite rowers were being met by their diets.

Two individual sessions, separated by approximately eight weeks, were conducted with each athlete by a registered dietitian. At the first session, the purpose, procedure, and projected benefits of nutritional counseling to the rower were outlined. A diet history, the rower's usual dietary patterns, health habits, and a detailed-as-possible recall by the athlete of food intake and workout intensity/schedule over a typical 24-hour period as well as anthropormetric measurements were taken.

This 24-hour record was then assessed and any recommendations for immediate changes in food consumption habits were made. Each rower was urged to take advantage of a more comprehensive computerized nutritional assessment and evaluation of their food intake. Those who elected to participate in the in-depth counseling were provided detailed verbal and written instructions on how to keep a record of all foods and beverages consumed over a three-day period. Each three-day food record was analyzed for the nutrient level and the caloric distribution of the three energy-providing nutrients.

At a second individual counseling session held with each rower who returned a three-day food record, results of the analysis were shared in detail. An evaluation form was developed by the consultant to include a summary of desirable changes in dietary practices and specific food recommendations. Counseling also included reinforcement of present dietary practices considered to be appropriate and the provision of an opportunity for questions. Each rower left the second conference knowing how well his/her normal food intake met his/her nutrition needs during training, and if recommendations for change were made, exactly how to implement those changes in terms of food choices. Summary information for each rower was shared with the appropriate coach.

The significant commonality in the rowers' diets was that many were too low in carbohydrate and too high in fat. Percent of total calories from carbohydrate, protein, and fat surprised many rowers who, by virtue of the fact that they ate bran muffins for breakfast and spaghetti at dinner, considered their diet to provide ample carbohydrate. In order to replenish glycogen to the working muscles during strenuous daily training, research (3) has established that an athlete's diet should provide either 60% of the calories as carbohydrate or 650 grams of carbohydrates per day. Table 2 shows, however, that the average three-day intake of calories from carbohydrate for women was 52% and for men only 49.6%. One male was getting only 34% of his calories as carbohydrate, while a woman recorded only 36% (neither was selected for the National Team). Conversely, fat levels (mean of 34.6% of calories for women and 34.3 % for men) were higher than the recommended desirable range of 28-30%.

Adequacy of protein intake is more appropriately reflected by individual need as dictated by kilograms of body weight than by percent of total calories as protein. Only the latter measurement is reflected in Table 2. The extent to which each athlete's diet met the need for protein varied with the individual's size, so a group mean is not appropriate. Protein need was, however, individually calculated for each rower at 1.4 grams protein/kg of body weight, as recommended by recent research findings. Nearly 40% of the women had diets below this level while all of the men had adequate protein intake using this standard.

One of the most frequently asked questions by the athletes was, "Should I be taking a vitamin/mineral tablet(s) each day?" Table 3 shows the percentage of men and women who were able to meet their need for selected vitamins and minerals through their diet alone. The standard for Vitamin C was set at three mg/kg of body weight, considerably higher than the Recommended Dietary Allowance (RDA) of 60 mg for Vitamin C.

Table 3: Percentage of Heavyweight Rowers Who Met Vitamin and Mineral Needs Through Food Intake

Gender	Vitamin C 3mg/kg wt	Vitamin B_1 0.5mg/1000kcal	Vitamin B_2 0.6mg/1000kcal	Niacin 6.6mg/1000kcal
Women n=28	43	96	89	86
Men n=16	40	90	90	90

Gender	Calcium 800mg	Iron 18mg, 10mg	Potassium 4000mg	Magnesium 5mg/kg wt
Women n=28	86	64	57	54
Men n=16	100	100	70	70

All of the women and all but one of the men received more than 60 mg of Vitamin C per day, however, only 43 and 40 percent of the women and men respectively were taking in enough Vitamin C to meet the higher level of three mg for each kg of body weight. This standard is based on Van Huss's review of the literature (7) that concluded that it would be prudent for athletes in training to consume three to five mg Vitamin C/kg body weight per day. Many of the rowers were advised to increase their intake of fruits and vegetables high in Vitamin C, such as citrus fruit and juices, cantaloupe, watermelon, strawberries, broccoli, spinach, brussel sprouts, cabbage and tomatoes. Increasing fruits and vegetables would also help to increase potassium and magnesium, which were low in many of the rowers' diets.

Intake of the B vitamins, important as co-enzymes in the metabolism of energy by the body, was adequate for most of the rowers. Since need for these vitamins is directly related to the intake of calories, each athlete's sufficiency was related to caloric intake over the three-day period. Calcium was figured at the RDA level of 800 mg per day, however women were urged to try to consume 1000 mg/day in view of the role of calcium in decreasing risk of osteoporosis. This is particularly important for any female athlete who is amenorrheic.

The RDA of 10 mg iron for men and 18 mg for women was used as the standard. Many of the women had a diet that was too low in iron, a finding consistent with data from the non-athletic population as well. The men had no difficulty meeting their lower need for iron.

Suggestions were made to each athlete regarding specific dietary changes to bring vitamin and mineral intake to an optimal level. Use of vitamin/mineral supplements was fairly common, and in many cases unwarranted, since the athlete either was obtaining, or with small changes could obtain, the recommended levels of nutrients from food. Natural supplementation is the preferred route.

These elite U.S. rowers were both interested in and concerned about their diet. It is an important factor which they totally control. Keeping track of their food intake and then seeing their nutritional profile was both a revelation and, for the conscientious, a road map to improved eating for competing.

Summary

Several important discoveries resulted from this comparative study. Although there is only a small difference between excessive energy output over intake, if this portion is allowed to accumulate then rowers would have difficulty in maintaining body weight (especially muscle mass). This phenomenon is sometimes evident during peak summer training.

Like all heavily trained athletes, rowers must be concerned with keeping caloric intake at high levels. However, athletes must be more aware of identifying specific food sources to insure that muscle glycogen levels and vitamin and mineral intakes remain optimal. A careful analysis of rowing training and competition demonstrates that maintaining high muscle glycogen levels during training is essential for achieving maximal performances (2). It appears that these optimal glycogen levels can be assured by the daily ingestion of at least 60% carbohydrates.

When considering the immediate pre-competition meal, it is important that the athlete's diet does not vary from the recommendations already made in this article. As competition nears, carbohydrates should be kept at 60-70% of the intake. A meal should be eaten three to four hours prior to the event and should consist of 800-1200 kcals consisting primarily of carbohydrates. At the same time, adequate fluid consumption should be ensured. Both training and competition benefit from good nutrition and therefore dietary planning for the athlete should be as important as planning training programs and race strategies.

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The Training Diet

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The competitive rowing event is a relatively short one, requiring an all-out effort for approximately six minutes. If a rower goes into the race having consumed a proper diet during the preparatory training period, glycogen stores in the muscle and liver should be more than adequate to support the demands of approximately six minutes of maximum anaerobic-aerobic effort. Thus it is not necessary for a rower to super load the muscles with glycogen, as a marathon runner or Tour de France cyclist might wish to do. A rower's goal on race day, with regard to diet, is to have available in the working muscles glycogen stores which are adequate to fuel less than ten minutes of intense exercise. During such an intense effort on the water, a rower will expend approximately 18 to 22 Kilocalories per minute, depending on individual body size and rate of metabolism. Should this figure increase to even as high as 30 Kilocalories per minute, six minutes of racing would require a maximum of 180 Kilocalories, or 45 grams of carbohydrate stored as glycogen. When the diet is optimal in carbohydrate, the body's working muscles can store up to 300 to 400 grams of glycogen (1200-1600 Kilocalories) to have available for use as fuel during exercise. In addition, the liver will contain stores of an additional 100 grams of glycogen (400 Kilocalories) which can be converted to glucose to fuel the exercising muscles. Fat can be stored by the body in larger amounts, and can also be used to fuel energy demands, however carrying excess body fat is usually detrimental to performance, and fat has been shown to be less efficient than carbohydrate at producing kilocalories from the limited amount of oxygen able to be taken in during all-out exercise.

Thus, the real issue when looking at a rower's diet is not so much what he or she eats the day of competition, but rather how the athlete keeps glycogen levels in the muscle at an optimum level to support daily training regimens for all the days *leading up to* the competition event. Research shows that to support the high energy requirements of one or two per day vigorous training sessions on a daily basis requires a diet which is high in carbohydrate, adequate in protein, vitamins, minerals and fluids, and minimal in fat. Without attention to diet composition, the rower runs the risk of gradually depleting glycogen stores during each training session, never allowing the muscle to fully regain its potential supply of glycogen. This situation not only makes it difficult to reap the greatest benefits from a training program, it also means the athlete enters the competition with glycogen stores which could be inadequate to sustain an all-out effort for even ten minutes. Witness the case of an oarswoman who during pre-selection testing for the 1987 national team, elected to participate in nutritional counseling made available for the first time that year. She admitted to having barely enough energy to just make it through each daily workout - in no way could she give her training an all-out effort. She theorized her lack of energy might be due to a diet which lacked iron. Analysis of her diet showed that though her iron intake was adequate, she was averaging only 36 percent of her kilocalories from carbohydrate each day - a far cry from the recommended 60 percent level. In reality, she was not eating enough carbohydrate foods to provide the necessary glycogen levels to support her vigorous training schedule. Her goal was to change her diet to launch a more competitive bid for a national team spot the following year.

Carbohydrate: 60% of Calories

Practically speaking, how does one eat to supply the recommended 60 percent of total caloric intake as carbohydrate? Since the usual American diet provides about 50-55 percent of kilocalories as carbohydrate at best, food selection for a rower has to change to facilitate a good training diet. *Foods supplying a high level of nutritious carbohydrate need to be increased. These include bread, cereals, pastas, fruits and vegetables, dried beans and peas and dairy products made from skim milk.* Instead of four daily servings each from the high carbohydrate-containing fruit, vegetable and bread/cereal groups, an athlete should have eight servings from each of these groups to continually replenish glycogen stores which are consumed during training efforts. Also, it's wise to have some of the fourteen weekly servings from the protein-rich meat/fish/poultry/and nut group be provided by what are called legumes - navy, kidney, pinto and garbanzo beans, peas and dried peas, and lentils. These inexpensive foods not only provide a source of almost fat-free protein, they are also high in carbohydrate.

Many rowers believe that eating an English muffin and cereal for breakfast and a plate of spaghetti for dinner translates into a high carbohydrate diet. Not necessarily so. Though grain products certainly are an important part of a high carbohydrate diet, one must also include generous amounts of fruits, fruit juices and vegetables, and at least two to three servings of skim milk products daily. Also of great importance to remember is this: in order to keep the carbos high, and the protein level adequate to provide for body needs (see section which follows), the only expendable item in the diet which can be decreased is fat.

In summary then, a rower would want to plan his/her diet around the following carbohydrate-rich foods:

Breakfast:

- cereal, bread, muffins, bagels, pancakes (occasionally only)
- fruit and fruit juices
- eggs (soft-cooked or poached are prepared without added fat and are therefore preferred) - limit to 3 to 5 per week
- lean ham or Canadian bacon - no oftener than twice per week (no bacon or sausage)
- yogurt made from low fat or skim milk
- skim or low-fat milk

Lunch & Dinner:

- soups made from fat-free broths or low-fat milk
- fresh vegetable salads (without cheese and bacon toppings)
- limited amounts of salads made with mayonnaise (ham, tuna, egg, pasta and cabbage)

- hot vegetables of all kinds (top with grated Parmesan cheese rather than cheese sauce or butter)
- lean meat, fish, poultry; skinless and broiled or roasted rather than deep-fried
- peanut butter (in limited amounts)
- breads/rolls/bagels/buns
- fresh or canned fruit
- angel food cake, low-fat frozen yogurt, ice milk, sherbet (other desserts limited to 2 to 3 times per week only)
- skim or low-fat milk

Snacks:

- bagels with jelly and thin layer of peanut butter
- fresh or dried fruits and fruit juices
- fig bars, oatmeal cookies, vanilla wafers, graham crackers
- popsicles, low-fat fruited yogurt

Athletes often wonder about the wisdom of including sweets as part of their high carbohydrate training diet. From a standpoint of glycogen replacement, research tells us that during the first 24 hours following an event, carbohydrate from simple sugars has a slight edge over starch carbohydrate in replenishing muscle glycogen. However, during the following 48 hours, starch carbohydrate is preferable for optimal glycogen stores. The practical suggestion is to include a mixture of carbohydrates, with concentrated sweets (cookies, candy, cake, sweet desserts) eaten only in limited amounts, since they are also frequently high in fat and don't come packaged with as many other valuable vitamins and minerals (folacin and iron, for example) as do carbohydrates from grains, fruits, vegetables and legumes.

What is the coach's role in helping the athlete to choose a high-carbohydrate diet? Making sound information available to the athlete is certainly an important first step, but probably even more important than your words (or the words of a sport nutritionist or registered dietitian) are your actions. Whenever a team meal is planned, arrange for it to be high in nutritious carbohydrate foods, so a model of appropriate choices is apparent to the rower. If the oarsmen/women know the rationale for a high carbo training diet, and then are ***taught through example*** what foods are good choices to include in their training meals, they can benefit from a perfect follow-up of educational theory put into practice.

Protein: 15 to 20% of Calories

Protein is the nutrient which is used by the body to build and maintain cell tissues of all kinds - from blood to bone. Since an athlete usually has a higher proportion of lean body mass to fat and bone than the non-athlete, protein needs are slightly greater than those of the average person. Protein need is based on one's size and stage of growth and is expressed as grams of protein required per kilogram of body weight. A standard Recommended Daily Allowance or RDA chart found in any nutrition textbook (a suggested volume to use as a reference for sport nutrition is *Nutrition for Fitness and Sport* by Melvin H. Williamns. Wm. Brown, Dubuque, Iowa, 1988) will list a recommended protein intake for various age groups, based on an average weight. However, an individual athlete's protein need can be figured more precisely by the following formula:

1.) Divide weight in pounds by 2.2 to obtain weight in kilograms.

2.) Multiply weight in kilograms by 1.4 to obtain grams of protein recommended per day.

Example:

An oarsman weighs 209 pounds. His protein need would be 133 grams per day.

209 ÷ 2.2 = 95 kilograms

95 kilograms X 1.4 grams protein/kg body weight = 133 grams protein/day

An athlete who is receiving 1.4 grams of protein per kilogram of body weight each day will have adequate protein to meet present body needs and also have enough additional protein to provide for any increase in lean muscle mass which may be realized through a weight training program. It is not difficult to obtain this amount of protein through a balanced diet. Protein is available from many different foods in varying amounts:

Type of Food	Grams Protein
*8 ounces (237 ml) of milk (any fat level)	8
*4 ounces (113 g) of meat, fish or poultry without bone	28
1 cup serving of dried beans or peas, cooked	9
2 Tablespoons of peanut butter	14
1 Cup serving of cereal, potatoes, or pasta	6
1 slice of bread or 1/2 bun or bagel	3
1/2 cup serving of vegetables	2

*High quality complete protein

To determine the adequacy of protein intake to meet his/her individual needs, an athlete may wish to keep track of foods eaten during one day and use the above values to calculate total protein available. Most athletes who consume a balanced diet, which includes foods from all four groups and has an adequate number of kilocalories to maintain weight, will have no difficulty in meeting protein needs. The one exception may be those rowers who follow a strict vegetarian (vegan) diet. Consuming only plant foods and including no meat, fish, poultry, eggs, or dairy products, strict vegetarian rowers should be concerned about obtaining adequate high quality protein from their daily meals. It would be well for these athletes to check their intake carefully, and if it is below the recommended amount for their body size, they may wish to consult a registered dietitian for help with menu planning to incorporate more protein into their normal plan of eating.

In research done with candidates for the 1987 national teams, all of the men, both heavy and light weight, obtained adequate protein from their diets to meet the recommended level of 1.4 grams protein per kilogram of body weight. In contrast, only 60 percent of the women, again including both light and heavier weights, met their protein needs, using the above standard. More of the women tended to be vegetarians or were at least limiting their intake of protein foods, both from the meat and dairy groups. It is important to caution these women that while carbohydrate is very important, so also is protein, and in order to meet the demands of the exercising body, protein intake must be adequate. It may be difficult to impossible for the heavyweight vegetarian rower to meet caloric and protein needs on a totally plant-based diet; the sheer bulk of such a diet may mean one is filled up before adequate kilocalories and protein are consumed. Care must be exercised to insure adequacy.

Occasionally athletes wonder about taking protein powders or amino acid supplements to boost their protein intake. As mentioned above, this is really not necessary if one eats a balanced diet adequate in kilocalories; in such a case protein intake from food will usually more than meet needs. Since it comes packaged with other nutrients like the B complex vitamins, iron, and zinc food is certainly the preferred source. Keep in mind there are inherent dangers in consuming excessively high amounts of protein, whether from food or a combination of food plus protein powder supplements. Protein foods often carry saturated fat with them, so excess fat intake - something we are all urged to avoid for good health, particularly of our hearts - can accompany excess protein from foods. Since water is required to break down protein to its component amino acids before the body can use it, dehydration can also accompany a high protein intake...a particular risk for the exercising athlete who requires body fluids be present at an optimum level to cool the working muscles. Further, any excess protein not required for either tissue maintenance or energy production is broken down by the body and stored as fat - again, an undesirable outcome for the competitive athlete.

Finally, taking individual amino acids is not recommended. There is no solid proof that such a practice is either effective or safe. When amino acids are taken separately, the balance is often skewed, and an excess of one may reduce absorption of others - thereby making it difficult for the body to form the complete protein tissues it is constantly producing. By obtaining protein from a wide variety of food sources, the balance of all 22 amino acids required for human body function is better assured.

Fat: 20 to 25 % of Calories

Fat is not quite the villain we sometimes make it out to be! The body requires some fat in the diet to have enough available to perform a host of functions - everything from production of healthy skin and sex hormones to protecting the internal organs and carrying certain vitamins throughout the body. Fat is also a valuable energy source, particularly during low-intensity exercise. When the intensity of the exercise increases, however, the body relies primarily on glycogen stores to fuel the working muscles.

Since the body normally has virtually unlimited stores of fat, ***it is not necessary to eat a high fat diet to have adequate fat available for any low-intensity workouts***. A regular mixed diet will provide all the fat required to resupply adipose tissue deposits in the body which in the average weight person store in excess of 11,000 grams of fat, or over 100,000 kilocalories! With all this fat stored in the body, we require only about 2 to 10 percent of our total daily kilocalories as fat, to supply adequate amounts of a fatty acid called linoleic acid, which the body cannot make, and therefore must obtain from food. Unfortunately the average American consumes much more than 10 percent of kilocalories as fat - the figure currently is about 37 percent.

Not only is it unnecessary to eat a high fat diet to provide fuel for low intensity training, it is undesirable. Total fat, and especially saturated fat from meat, poultry, whole milk dairy products, and several tropical plant oils - coconut, palm and palm kernel - has been implicated as a contributing factor in both heart disease and cancer. Also, a diet high in fat can lead to excess fat weight on the body, since gram for gram, fat will provide more than twice the kilocalories of carbohydrate and protein, and because fat from food is very efficiently turned into fat in the body. Finally, recall that kilocalories for energy production come from three sources: carbohydrate, protein and fat. For an athlete to keep carbohydrate intake at the recommended 60% of total kilocalories while also providing adequate protein for his/her body size, the only "adjustable" energy providing nutrient is fat. Whatever is left of caloric intake after planning for carbohydrate and protein needs can be assigned to fat, and usually for an athlete, this is between 20 to 25 percent of total kilocalories.

Is this amount of fat a change from the usual mixed American diet? Definitely. And to achieve this level of fat intake ,which is appropriate for athletic training as well as for overall good health, requires a careful look at the food choices one makes each day.

Suggestions to reduce fat from the present 37% of total kilocalories to the recommended 20 to 25% include:

- Limit cheese consumption. (This was one of the most commonly eaten high fat foods in rowers' diets analyzed in 1987.) Switch to the lower fat types of cheese such as mozzarella made from part-skim milk and 1 or 2% fat cottage cheese.

- Switch from the regular or premium type ice creams to low fat frozen yogurt, ice milk or sherbet.

- Choose margarines made from liquid vegetable (non-tropical) oils rather than butter as a table spread or topping.

- Limit amount of salad dressings used to no more than two to three Tablespoons per salad, and avoid those containing cheese or bacon.

- Limit amount of mayonnaise-containing salads such as tuna, ham, egg, pasta and chicken, and when preparing these yourself, use the lower fat types of mayonnaise and try substituting low fat yogurt for part of the mayo.

- Avoid fried foods, especially those which are deep fried. Food which is baked, broiled or steamed absorbs far less fat than that which is fried.

- Limit amount of rich sauces, such as Alfredo, made with cream and/or butter. Instead, eat pasta with tomato sauce and top vegetables with a dash of grated Parmesan or Romano cheese.

- Choose leaner cuts of red meats, eat fish which is poached or baked rather than fried, and remove the skin from poultry.

- Limit intake of concentrated sweets like cake, cookies and candy, all of which are frequently high in fat.

In addition to reducing the ***total amount of fat*** you eat, the type of fat you select is also important. Olive, peanut, safflower and canola oils are all relatively high in monounsaturated and polyunsaturated fatty acids, and low in saturated fatty acids, and are therefore considered more heart-healthy. Avoid foods containing lard, the tropical oils mentioned above, beef suet, and butter - these are all high in saturated fat. You can tell the kind of fat in a product by reading the ingredients listed on the label, which are required to be in descending order of predominance by weight.

Vitamins & Minerals

If a rower is obtaining adequate daily kilocalories from a wide variety of foods, it is not necessary to take a vitamin-mineral supplement to supply recommended amounts of these regulatory nutrients. The one exception to this might be the mineral, iron, which females may need to supplement. In a mixed diet of 1000 kilocalories, one can expect to receive about 6 mg of iron. Since the pre-menopause female requires about 15 mg of iron per day, she would have to ingest about 2500 kilocalories daily, to provide an adequate iron intake. Most oarswomen will eat at this level and probably even higher, but in the event a lightweight female rower may be consistently below this level of caloric intake, she may need to discuss an iron supplement with her physician.

Rowers may wish to consume Vitamin C at a level somewhat higher than the RDA for this vitamin. Some research suggests that athletes consume 3 mg Vitamin C per kg of body weight, rather than the RDA of 60 mg. A diet which includes 4 to 5 servings of the following fruits and vegetables which are rich in Vitamin C should easily meet the need:

-citrus fruit and juices
-cantaloupe and watermelon
-strawberries
-broccoli, spinach and brussel sprouts
-cabbage
-tomatoes

<u>Example:</u> A rower weighs 180 pounds or about 82 kilograms. His/her Vitamin C requirement would be 82 X 3 or 246 mg of Vitamin C per day. This could easily be obtained through:

Food Type	Mg of Vitamin C
8 ounces (237 ml) orange juice	120
1 medium tomato	22
1/2 cup cooked broccoli	49
1 cup cantaloupe	<u>68</u>
Total:	257 mg

Including enough fruits and vegetables to meet this higher Vitamin C level would have the added advantage of also increasing the minerals potassium and magnesium, which were low in the diets of many of the national team candidates studied in 1987. As noted previously, fruits and vegetables also provide a rich supply of carbohydrates.

Whenever possible, vitamins and minerals are best obtained from food rather than from pills. In foods, they come packaged with other nutrients important to good health - not just one or two isolated vitamins or minerals. Further, when these nutrients come in food there is little if any danger of ingesting such high levels as to be toxic to the body. The same cannot always be said for supplements, which are often taken in amounts great enough to be dangerous to normal body function.

If a rower for one reason or another is unable to eat an optimally balanced diet, he or she may wish to consider a vitamin/ mineral supplement. The best advice is to choose an all-purpose one/day supplement which provides between 50 and 100 percent of the USRDA for the given vitamin(s)/mineral(s). This combination with nutrients received from the diet should provide a safe level of supplementation. It is wise to check with a physician before supplementing iron to the diet, however.

Fluid Consumption

For optimal performance, it is essential to drink fluids to maintain adequate body hydration. During training, heat is generated as a byproduct of energy production to fuel the muscles, and this heat must be dissipated in order to prevent the body's core temperature from rising to a dangerously high level. The body can rid itself of heat by: 1.) dilating the blood vessels of the skin, which in turn increases the flow of blood to the skin and release of the heat to the environment by radiation and convection and 2.) secretion of sweat onto the surface of the skin requiring heat kilocalories to evaporate the moisture, causing a cooling reaction. In hot weather, especially, it is the cooling by evaporation process which allows exercise to continue, but only if these sweat losses are replaced through adequate fluid intake. When training in hot weather, sweat losses from the body can be in excess of 2 liters per hour, and these need to be replaced during and following training. Some practical guidelines to help keep fluids balanced during training:

- Cool fluids (40-50°F or 4.5-10°C) are more quickly absorbed from the stomach and small intestine.

- If a sweet drink is preferred, the carbohydrate content should be present in no greater than a 10% solution, so as not to delay fluid emptying.

- Only a small amount, if any, of electrolyte replacement is necessary. Less than 200 mg of sodium and less than 200 mg of potassium per quart is sometimes suggested. Water is the most important replacement under most conditions.

- Consume 16 ounces (473 ml) of cold fluid about 30 minutes before exercise.

- During exercise, rehydrate by drinking 4-6 ounces (118-178 ml) of cold fluid every 10 to 15 minutes of activity. It's important not to wait until you feel thirsty to replace fluids. Thirst usually doesn't develop until 1-2% of body weight is lost through dehydration, and performance can be adversely affected at a 2% loss.

- Following exercise, replace fluids based on weight lost during the activity: 1 pint (2 cups or 473 ml) of fluid should be consumed for every pound (0.45 kg) lost from pre-exercise weight.

In general, use of mineral supplements such as salt tablets to replace electrolytes lost in sweat is not necessary for rowers engaging in usual training regimens. Adding a little extra salt to daily meals, and including high-potassium foods such as citrus fruits and bananas should easily replace the small amount of electrolytes lost and maintain adequate balance.

The Pre-Race Meal

There is no single combination of foods which constitute the ideal pre-event meal. Choices will vary with the individual rower - what he or she has learned through experience is comfortable and effective. The following general guidelines may be of help as each athlete learns what foods are tolerated best during pre-race anxiety.

- Eat a small meal of no more than 500-800 kilocalories about 2-3 hours before the race, so the stomach has time to empty before competition begins.

- Emphasize starch or "complex" carbohydrate foods which are digested relatively quickly and can boost glycogen supplies in the working muscles. Avoid excessive intake of foods high in sugar, which may cause stomach upset and may trigger reactive low blood sugar levels.

- A small amount of protein should be eaten, but avoid fatty foods or those prepared in fat. Fat takes longer than any type of food to leave the stomach.

- Avoid those foods which tend to form gas, such as beans, onions, peppers, cabbage, cauliflower and apples. Gas-forming foods will vary with the individual.

- Avoid spicy foods and those foods which are new and untried. Just before a competition is no time to experiment with new cuisine; stay with the tried and true.

- Be wary of foods which are high in indigestible fiber. Though high fiber foods help promote good intestinal function, they can also lead to diarrhea, increasing risk of dehydration; general abdominal discomfort from flatulence can also be a problem with high fiber intake.

Examples of two pre-event meals follow. Liquid nourishment such as Nutrament, Carnation Instant Breakfast or Ensure can also provide an appropriate pre-event meal, and for those with particularly nervous stomachs before competition, are frequently better tolerated since liquids are more readily digested than solid foods.

Breakfast: ***Total Kilocalories: 419***
4 fluid ounces (118 ml) orange juice
1 poached egg
2 slices toast
2 Tablespoons jelly
8 fluid ounces (237 ml) skim milk

Lunch: ***Total Kilocalories: 550***
4 fluid ounces (118 ml) tomato juice
2 ounces (57 g) baked fish
1 cup rice
1 orange

2 cookies
8 fluid ounces (237 ml) skim milk

Don't neglect nutrition after the race is over. This is the time to replace glycogen used during the event. Research suggests that 1.5 grams of carbohydrate per kilogram of body weight should be consumed immediately and at 2 hour intervals during the first four hours after exercise. And don't forget to replace fluids after the event, as discussed earlier.

Weight Control

Lightweight rowers must constantly face weigh-ins, and are thus concerned with techniques to lose weight without losing strength.

Weight should be lost gradually through a combination of reduced kilocalories from food and increased caloric expenditure via more intense and frequent workouts. Try to limit weight loss to a maximum of two pounds per week, which translates into 1000 fewer Calories per day from one's usual pattern. This 1000 kilocalorie deficit can be accomplished through eating 500 fewer Calories worth of food, and increasing exercise to expend 500 calories more. By using this two-pronged approach to weight loss, the weight is more likely to be kept off rather than regained, and most of the weight lost is fat rather than lean muscle mass.

When losing weight, it is important for males to consume a minimum of 1500 to 1800 Calories per day and for females to not go below 1000 to 1200 Calories per day. Going below these minimum caloric levels risks a low intake of vitamins, minerals and protein, compromising nutritional health. When cutting Calories, start with alcohol and then look for foods high in fat and sugar - these are expendable. Fresh fruits and vegetables, whole grain breads and cereals, skim dairy products, fish, poultry, and lean red meats should provide the basis for a weight loss diet. It is neither necessary nor desirable to eliminate any food group from a reduced Calorie diet - simply choose those foods within each group which contain fewest Calories from fat, and eat smaller servings of all foods.

Don't neglect fluids. Even when trying to lose weight, the body should be kept adequately hydrated. Losing water weight is deceiving - the scale may register a lower number of pounds, but it is weight that must be replaced for safe and optimal training and performance. Weight loss should mean ***fat*** loss, not water loss. The practice of losing water weight by excessive sweating, use of diuretics, laxatives, even emetics prior to weigh-in, and then planning on the several hours between weigh-in and race time to rehydrate the body to normal levels is risky at best and dangerous at worst. Research at Ohio University's Human Performance Laboratory has shown a decrease in aerobic endurance occurs with as little as 2 percent of body weight lost through dehydration, and a decrease in strength has been documented when 5 percent of weight is lost through dehydration. Further, one should probably allow a minimum of 6 hours to completely rehydrate the fluid-depleted body. Although weight regain will occur in less time when rehydrating, it takes more than five hours for fluid to become evenly distributed to all the cells, where it is essential for proper metabolism.

In summary, both The American College of Sports Medicine and The American Dietetic Association embrace a sound program for weight loss which includes three main components: a diet which is well-balanced, but reduced in Calories, increased exercise, and behavior modification in the dieter's social, physical and personal environments.