3
Fueling the Human Weapon

Patricia A. Deuster, PhD, MPH, CNS
Teresa Kemmer, PhD, RD
Lori Tubbs, MS, RD
Stacey Zeno, MS
Christiane Minnick, M.Ac
In This Chapter

Fuels for Energy
Fueling the Tank
H₂O
Fluid Replacement
Beverages

Key Points

- Carbohydrates (CHO) are the vital fuel for endurance and resistance activities, competitive athletic events, mental agility, and healthy living.

- Fats, the primary form of stored energy, are essential, but should be eaten in moderation.

- Proteins are essential for building and repairing body tissues; however, excess protein is converted to fat.

- Restore fluid balance by taking in enough liquids to replenish weight (pounds) lost plus an additional 25%.

- Performance decrements begin when only 2% of body weight has been lost.

“Y"ou Are What You Eat.” Although this statement has not been proven, it is known that the foods eaten make a difference in performance, longevity, and quality of life. A car engine typically uses only one source of fuel, but the body can use carbohydrate, fat, protein, and alcohol. To a certain extent, the source of fuel is dictated by availability. In other words, the body tends to use whatever it has. The macronutrients, or energy-providing nutrients, are important in this respect. Without energy the body would starve, and performance would be greatly reduced. The three main sources of energy are:

- Carbohydrate.
- Fat.
- Protein.

These fuels are called “macronutrients” because they are eaten in large quantities unlike the micronutrients to be discussed later. This chapter will provide basic information about macronutrients and alcohol, which may be a dominant source of energy among Warfighters. In addition, information relating to portion size and hydration will be provided.
Fuels for Energy

Carbohydrates

Carbohydrates, or CHO, are the preferred foods for endurance and resistance training, competitive athletic events, mental agility, and healthy living. CHO foods are the preferred energy source for all athletes and for Warfighters. CHO should not be restricted. In the past, CHO have been considered “off-limits” and many Warfighters have blamed weight gain on CHO. In addition, many fad diets promote protein and fat at the expense of CHO, but as a vital energy source, and restriction can degrade performance. Chapters 5, 9 and 10 discuss the amount of CHO to eat with respect to nutrient timing and type of training.

Definition, Composition, and Classification

Carbohydrates exist in many forms, but the two major types of CHO are labelled simple and complex.

- Simple CHO include table sugar, honey, fruit sugars, milk sugar, brown sugar, corn syrup, maple syrup, corn sweeteners, high-fructose corn syrup, and molasses.
- Complex CHO include grains, fruits, seeds, potatoes, pasta, seaweed, algae, peas and beans, and all other vegetables.
- Complex CHO, starches and fibers, come from plant materials. The body digests starches, but it does not digest dietary fiber. Fiber is discussed in Chapter 18.

Functions of Carbohydrate in the Body

CHO are used in the body mainly as:

- Fuel for muscles, brain, heart, and other organs in the form of glucose; the brain requires 130 grams/day from glucose.
- Building blocks to make chemicals needed by the body.
- Chemical cement for joints and other structures in your body.
- Glycogen is the only CHO stored in humans.

Glycogen, stored in liver and skeletal muscle, is limited to about 500 grams and is depleted by three to four hours of heavy exercise; a 24-hour fast will use up liver glycogen stores.
Carbohydrate in the Diet

Some people are phobic about eating CHO and believe that foods high in CHO are unhealthy and lead to weight gain. Fear not. That notion comes from muscle-building myths and low CHO diet fads that lack scientific evidence. No one has ever been able to show that performance suffers from consuming potatoes, rice and bread. To the contrary, performance is enhanced by such foods. Rather, high-fat toppings (butter on bread, sour cream on potatoes, cream cheese on bagels, cream sauces on macaroni) may contribute to the notion that CHO are bad. Also, CHO that are highly processed with high fructose corn syrup and other highly processed sugars, are less healthy than whole food products, such as baked potatoes, brown rice, whole wheat pasta, and wheat bread. CHO-rich foods from around the world are shown below.

<table>
<thead>
<tr>
<th>Table 3–1. Carbohydrate Sources in Selected Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
</tr>
<tr>
<td>Mexico</td>
</tr>
<tr>
<td>Brazil</td>
</tr>
<tr>
<td>India</td>
</tr>
<tr>
<td>Japan</td>
</tr>
<tr>
<td>Middle East</td>
</tr>
<tr>
<td>United States</td>
</tr>
</tbody>
</table>

*When combined, these CHO are also a good source of protein.

Energy From Carbohydrate

One gram of Carbohydrate = 4 kcal.

Click here to calculate kcals from carbohydrates.

Fat

Fat is a vital part of the diet as it adds taste to foods and satisfies hunger. However, not all fats are created equal. By understanding the different types of dietary fat, how it works in the body, and using guidelines for daily
fat consumption, excess fat can be eliminated from your diet and you can eat for better health.

**Definition, Composition, and Classification**

Fat (technically fatty acids) is an essential nutrient and is usually classified according to its chemical form.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated Fats</td>
<td>Solid at room temperature.</td>
<td>Whole milk, cream, ice cream, whole-milk cheeses, butter, lard, meat, palm kernel, coconut oils, and cocoa butter.</td>
</tr>
<tr>
<td>Polyunsaturated Fats</td>
<td>Liquid at room temperature.</td>
<td>Safflower, sesame, soy, corn and sunflower-seed oils, nuts, seeds, and fish.</td>
</tr>
<tr>
<td>Monounsaturated Fats</td>
<td>Liquid at room temperature but may solidify in the refrigerator.</td>
<td>Olive oil, canola and peanut oil, peanut butter, cashews, almonds, and avocados.</td>
</tr>
<tr>
<td>Trans Fats or “Partially Hydrogenated” Fats</td>
<td>Man-made from saturated fats.</td>
<td>Cookies, crackers, and other commercial baked goods, French fries, donuts, fried onion rings and other commercial fried foods.</td>
</tr>
</tbody>
</table>

**Functions of Fat in the Body**

Fat serves a number of critical functions:

- Major form of stored energy: provides energy during exercise, in cold environments, and during starvation.
- Insulates the body.
- Helps transport other nutrients to places in the body.
- Protects organs.
- Serves a structural role in cells.
How Much Fat Should We Eat?

All the different types of fats are desirable, but too much fat is the primary dietary problem in our country. A high intake of fat is associated with many diseases, including:

- Heart disease.
- Obesity.
- Many forms of cancer.
- Diabetes.

The average American consumes 33% of daily calories as fat (52% carbohydrate and 15% protein). Total fat intake (saturated, trans, monounsaturated, polyunsaturated) should be adjusted to fit total caloric needs. It is recommended that no more than 35% of total calories come from fat. Saturated fat intake should not exceed 10% and the balance should come from mono- and poly-unsaturated fats. Trans fat intake should be less than 1% of total calories each day.

Energy From Fat

One gram of FAT = 9 kcal.

Fat provides more than twice the energy supplied by CHO and protein.

Determining Your Daily Fat Allowance

Everyone talks about grams of fat, but what does that mean on a practical level? How does one translate “grams” of fat to percent fat and how many grams of fat should be consumed each day? Again, no more than 35% of calories should come from fat, so with that in mind, the example below will show you how to determine your daily fat allowance.

Example: Determining Fat Allowance

If estimated energy need (EEN)= 3,222 calories

Step 1. Multiply EEN by 0.35 to get calories from fat

3,222 x 0.35 = 1,128 fat calories

Step 2. Divide fat calories by 9 to get grams of fat.

1,128/9 = 125 grams of Fat per day
Where Did The Numbers Come From?

Estimated Energy Need or EEN was given to you in the example. You should know your EEN from the preceding chapter.

- 0.35 in Step 1 is for calculating 35% of calories from fat.
- 9 in Step 2 represents the number of calories in one gram of fat.
- 125 is the maximum number of grams of fat that should be eaten to ensure the diet provides no more than 35% of calories from fat.

An excel worksheet is provided to determine the amount of calories from you should get from the fat in your food.

Click here to calculate kcals from fats.

Protein

Protein seems to be the preferred food among Warfighters to consume, based on the number of protein drinks and sports bars used in place of “real food.” Also, people like to eat high protein foods because they think protein makes them grow “big and strong.” Are they correct? Let’s take a look at protein and what it really does.

Definition and Composition

CHO and fat consist of carbon, oxygen, and hydrogen; protein consists of these atoms, plus nitrogen, which is essential for life. Proteins are made up of amino acids—small building blocks hooked together in various orders. Although over 20 different amino acids are part of our body, only 10 are “essential amino acids” (EAA) because our body cannot make them; they must be obtained from protein in the diet. Failure to obtain enough of the 10 EAA, in the right balance, may result in degradation of other proteins, such as muscle, to obtain the one EAA that is needed. Unlike fats and starch, the human body does not store excess amino acids for later use—the amino acids must be obtained from the food every day.

The 10 EAA, in alphabetical order, are arginine (required for the young, but not for adults), histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Functions of Protein in the Body

Proteins vary in size, depending on how many amino acids are linked together, and each one performs different functions in the body. Although they can provide energy, protein is **not** a main source of energy, like carbohydrates and fat. Some functions of protein are:

- Muscle contraction.
- Formation of muscle, hair, nails, skin, and other tissues.
- Direct energy production.

Table 3–2. How Many Grams of Protein Do I Need?

<table>
<thead>
<tr>
<th>Activity Level</th>
<th>Protein Range (grams/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low to Moderate</td>
<td>0.4–0.5</td>
</tr>
<tr>
<td>Endurance Training</td>
<td>0.6–0.8</td>
</tr>
<tr>
<td>Strength/Weight Training</td>
<td>0.6–0.8</td>
</tr>
</tbody>
</table>

Over 1.6 grams of protein/pound body weight may compromise muscle growth.

Example: Suppose a Warfighter weighs 175 pounds and is training for a mission that requires both endurance and strength.

Protein needs = 0.6 x 175 lb = 105 grams
Protein needs = 0.9 x 175 lb = 140 grams
Protein needs = 105–140 g/day.
• Repair of injuries.
• Transport fats, vitamins and minerals around the body.
• Structural roles for every part of the body.

How Much Protein Should I Eat?

Protein needs are determined by age, body weight, and activity level. Many athletes believe that if they eat more protein, their muscles will increase in size, but this is not true. Excess calories from protein can be converted to and stored as fat. Additionally, large quantities of protein strain the liver and the kidneys.

Click here to calculate protein needs.

Energy from Protein

One gram of protein supplies 4 kcal.

Alcohol

Alcoholic beverages (beer, wine, or liquor) are a potent source of energy, but they are not good sources of energy for physical activity or exercise. Obviously, alcohol is not essential, unlike CHO, protein and fat. Also, most people tend to eat junk food when they are drinking. If trying to keep in shape, it is a good idea to minimize the amount of alcohol consumed; it contains little in the way of other nutrients, so replacing a meal with alcohol is not a good idea.

One 12 oz beer is about 150 kcal and one 12 oz “lite” beer is approximately 110 kcal. Wine provides about 90 kcal for every 5 oz, and liquor contains 90 kcal for every 1.5 oz. If the liquor is prepared with a carbonated drink, the energy intake will increase by at least 75 more kcal.

Click to see how many calories are in alcoholic drinks.

Energy from Alcohol

One gram of alcohol supplies 7 kcal.

Click to calculate the percent of daily calories from alcohol.
The term “serving” describes the recommended amount of food that should be eaten from each food group. Packaged foods list the number of servings on the Nutrition Facts panel and a serving describes the amount of food recommended in the Food Guide Pyramid and the Dietary Guidelines for Americans. A “portion” is the amount of a specific food chosen to be eaten or served for breakfast, lunch, dinner, or snack. Portions can be bigger or smaller than the recommended food servings. Over the past 20 years, portions have increased substantially, and this has resulted in many people eating more than they should. Larger portions have also contributed to the high incidence of obesity. The next page provides a summary of standard serving sizes, but a Serving Size Card can be downloaded, cut out, and laminated for long time use to help you recall what standard food servings look like. To test your knowledge of portion sizes click here.

### Table 3–4. Body Weight Losses and Dehydration

<table>
<thead>
<tr>
<th>Starting Weight (lbs)</th>
<th>2.5% Weight Change (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>146</td>
</tr>
<tr>
<td>170</td>
<td>166</td>
</tr>
<tr>
<td>190</td>
<td>185</td>
</tr>
</tbody>
</table>

Click here for more information on hydration.

### H₂O

Water is an essential nutrient and the most abundant component of the human body. Approximately 50–70% of your total body weight is water. Since lean body/muscle mass requires more water than fat, the leaner one is, the more body water there is. Water must be consumed regularly to ensure normal functioning of the body.

## Distribution and Functions of Water

Water is found inside and outside cells, but most water is inside cells, especially muscle cells. Water in the body serves many important roles, including:

- Participates in digestion and absorption of nutrients.
- Participates in excretion of wastes.
- Maintains blood circulation in the body.
- Maintains body temperature.
A loss of 2.5% of your body weight will result in performance decrements: decision-making and concentration will be impaired and 35% of physical performance potential can be lost.

Being well hydrated during operations is absolutely critical, since adequate fluids will help compensate for blood losses if wounded. For these reasons, fluid balance is essential to a Warfighter’s performance. Below are signs and symptoms that might be experienced when weight is lost from dehydration.

- Thirsty.
- Dry mouth.
- Urine output reduced.
- Reduced physical performance.
- Headache and feeling ill.
- Difficulty concentrating.
- Sleepiness.

**Maintaining Water Balance**

Water balance is determined by water/fluid output and input. In order to maintain performance, it is critical that a fluid deficit or dehydration does not occur. With dehydration, water output exceeds input and balance becomes negative. A sedentary man typically will expel body water at a rate of 1–3.2 quarts (1–3 liters or 32–102 oz) a day from the following:

<table>
<thead>
<tr>
<th>Weight Lost (lbs)</th>
<th>Fluid to be Replaced (oz/cups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–24 (2.5–3 cups)</td>
</tr>
<tr>
<td>2</td>
<td>40 to 48 (5–6 cups)</td>
</tr>
<tr>
<td>4</td>
<td>80–96 (10–12 cups)</td>
</tr>
<tr>
<td>8</td>
<td>160–192 (20–24 cups)</td>
</tr>
</tbody>
</table>
Urine and stools.

• Breathing.

• Sweating.

When activity levels are low, most fluids are lost through the urine. However, when activity levels and/or the outdoor temperature are high, most fluid is lost by sweating. Up to 2.1 quarts (2 liters or 66 oz) per hour can be lost through sweating, depending on the outside temperatures and intensity of the activity.

All fluids lost must be added back each day by drinking 125–150% of the weight lost to restore fluid balance. This can be measured by weighing yourself as often as possible. If no scale is available, monitor the color of your urine. Sources of fluid for rehydrating include:

• Water in food.

• Sports drinks that contain sodium and potassium.

Sweat output increases markedly in both hot weather and during prolonged exercise—the amounts will be even greater if exercise is performed in the heat.

Eating foods high in water and drinking fluids will help restore water balance. The fresh foods listed in Table 3–6 are over 90% water. Beware of drinking too much plain water (hyper hydrating). It is also important to consume some sodium, which helps restore hydration status better than water taken alone. Taking in salt will also help prevent levels of sodium in the blood from getting too low (hyponatremia), which can be dangerous. Hyponatremia is a huge operational problem. It is caused by excessive intake of plain water during prolonged exercise. Salty foods can be ingested before or with other fluids (including sports drinks) to provide sodium, promote fluid retention, and stimulate fluid intake.

| Table 3–6. Fresh Foods Containing Mainly Water |
|---|---|---|---|
| Bean Sprouts | Broccoli | Cabbage | Carrots |
| Cauliflower | Celery | Cucumbers | Eggplant |
| Lettuce | Peaches | Spinach | Squash |
| Strawberries | Tomatoes | Watercress | Watermelon |

What Conditions Will Increase Water Losses?

The primary ways in which you may become dehydrated, or in need of additional body fluids, are by:

• Exercising for over 60 minutes.
• Working in a hot environment—wet or dry.
• Working in a cold environment—wet or dry.
• Going to high altitudes.
• Drinking too much alcohol or caffeine. Click for the caffeine content of various products.
• Exercising in the heat, cold, or at altitude.
• Exercising with a hangover.

Several points about fluids should be considered:
• Do not rely on thirst as a good indicator of fluid needs; body weight losses are better.
• Before any exercise or simulated-mission, fluids should be ingested in anticipation of losing fluid (12–20 oz of cool water before exercise).
• Before starting, urine should be clear or between 1–3 on the chart (unless taking B vitamin supplements)—this is a sign of adequate hydration. The more dehydrated, the darker (and smellier) urine will be (will look like cola).
• Drink regularly or whenever possible during workouts and operations. Drink 12–18 oz of fluid every 20 minutes to maintain hydration;
• Weigh yourself before and after an event to determine how much fluid is lost.
• Every one pound of weight lost requires 125–150% more fluid or 20–24 oz. It will take about 6 hours to recover from dehydration post exercise/military operation.
• Performance decrements begin when only 2% of body weight has been lost.

What Should You Drink?

Although the type of activity will determine what to drink, the beverage selected should:
• Empty from your stomach and intestines rapidly.
• Taste good.
• Provide CHO when exercise lasts > 1 hr.
• Contain a small amount of sodium (salt).
• Provide no more than 19 grams of CHO per 8 oz.
• Be cool (10 to 15°C).
• Be diluted to ≤ 9 grams CHO/8 oz or a 4–5% CHO solution if fluid needs are > 4L.
**Fluid Replacement Beverages**

If the exercise is longer than one hour, a beverage that provides CHO should be ingested. Beverages with “glucose polymers” (maltodextrin), or a mixture of glucose and fructose are usually preferable to glucose or sucrose alone. The important message is “drink.” A list of beverages, some of which are used as “fluid replacement beverages” by athletes, and a set of criteria for selecting commercial off-the-shelf fluids replacement beverages are presented in Table 3–7.

Fluid replacement beverages that contain more than 19 grams of CHO per 8 oz may cause stomach distress and not be absorbed well if consumed before or during physical activity. For example, orange juice should be mixed with an equal amount of water because it is so concentrated.

**Criteria for Commercial Off-The-Shelf Fluid Replacement Beverages**

- < 95 kcal/8oz.
- CHO Content: 9–19 g/8oz.
- CHO to Protein Ratio: > 4:1 ratio, if any protein/amino acids.
- Sodium: 0.2–1.15 g/L (40-240 mg/8 oz).
- No carbonation.
- No substances other than CHO, electrolytes, and protein.

<table>
<thead>
<tr>
<th>Products</th>
<th>Energy kcal/8 oz</th>
<th>CHO g/8 oz</th>
<th>CHO:Pro ≥ 4:1</th>
<th>Sodium mg/8oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>CarboPack Beverage</td>
<td>94</td>
<td>19</td>
<td>-</td>
<td>55–160</td>
</tr>
<tr>
<td>Cerasport</td>
<td>76</td>
<td>13</td>
<td>-</td>
<td>102</td>
</tr>
<tr>
<td>Gatorade Original</td>
<td>50</td>
<td>14</td>
<td>-</td>
<td>110</td>
</tr>
<tr>
<td>Gookinade</td>
<td>86</td>
<td>10</td>
<td>-</td>
<td>64</td>
</tr>
<tr>
<td>GU2O</td>
<td>50</td>
<td>13</td>
<td>-</td>
<td>120</td>
</tr>
<tr>
<td>MetRx ORS</td>
<td>75</td>
<td>19</td>
<td>-</td>
<td>125</td>
</tr>
</tbody>
</table>
Table 3–7. Commercial Off-The-Shelf Fluid Replacement Beverages Meeting Criteria

<table>
<thead>
<tr>
<th>Products</th>
<th>Energy kcal/8 oz</th>
<th>CHO g/8 oz</th>
<th>CHO:Pro ≥ 4:1</th>
<th>Sodium mg/8oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powerade</td>
<td>72</td>
<td>19</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td>Power Bar Endurance Sports Drink</td>
<td>70</td>
<td>17</td>
<td>-</td>
<td>160</td>
</tr>
<tr>
<td>Gatorade Endurance</td>
<td>50</td>
<td>14</td>
<td>-</td>
<td>200</td>
</tr>
</tbody>
</table>

When and How Much to Drink?

Remember: although the following recommendations are generally sound for most people, everyone is different. Each person must learn to look for signs alerting to his fluid needs. Make adjustments to how warm/hot it is outside. If very hot, make sure to drink fluids with sodium to replace lost electrolytes from sweating. The more physical activity, the more fluid needed! Be careful not to drink too much plain water, especially during prolonged exercise in the heat. The figure to the right shows daily water requirements as a function of activity and environmental temperature.

“A Warfighter needs the right nutrition and quantity of food in the same way a high performance car needs the right mixture of high octane fuel and air to achieve peak performance.”

CDR Todd L. Tinsley, NSWSBT22