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CHAPTER 13

Strength/Power Athletes

Key Questions Addressed

- What is different about strength/power athletes?
- What energy systems are utilized during strength/power exercise?
- Are the calorie needs of strength/power athletes different from those of other types of athletes?
- Are carbohydrate needs different for strength/power athletes?
- Are protein needs different for strength/power athletes?
- Are fat needs different for strength/power athletes?
- Are vitamin and mineral needs different for strength/power athletes?
- Are fluid needs different for strength/power athletes?
- What meal-planning/event logistics need to be considered during strength/power events?

You Are the Nutrition Coach

Robert is a 45-year-old competitive master's power lifter who competes in the 181-pound weight class. He has been having trouble keeping his body weight low enough to compete in the 181-pound class and is concerned that his body fat level is actually increasing despite his heavy weight-training regimen. He has a rather sedentary office job and tries to walk about a mile every weekday evening with his wife. He states that he eats well (approximately 3500 calories per day). To help build muscle and enhance recovery, he consumes about 250 grams of protein per day from natural food sources and supplementation. His carbohydrate intake is low because he has been experimenting with an Atkins-type diet to control his weight.

Questions

- Why is Robert having trouble controlling his body weight?
- What are the most glaring concerns about his diet?

What is different about strength/power athletes?

The terms *strength* and *power* are often used interchangeably when describing athletes. Although strength and power are important aspects of physical fitness, and strength is a component of power, they are not synonymous. Strength is the ability of a muscle or group of muscles to generate force. Strength is purely a measure of how much weight can be moved or lifted by an athlete. It is highly dependent on the amount of muscle tissue an athlete possesses. In other words, the bigger the muscle, the greater the strength. Power, in contrast, is dependent not only on how much force is capable of being developed by the muscles (i.e., strength), but also on how fast the force can be generated. Because velocity of movement is an integral part of power, power is often referred to as speed-strength. The ability to run, jump, throw, and quickly change direction are all very dependent on the ability of muscle to rapidly generate force (i.e., power). For the purposes of this chapter, strength/power athletes are those involved in the explosive track and field events (i.e., javelin, shot put, discus, high jump, long jump, hammer, sprints), weight lifting, gymnastics, and wrestling, just to name a few. In short, strength/power athletes are athletes who participate in sports in which success is dependent primarily on demonstration of brute strength or relatively short bursts (i.e., ≤ 1.5 minutes) of near maximal muscle force production.

strength The ability of a muscle or group of muscles to generate force. Strength is purely a measure of how much weight can be successfully lifted by an athlete. It is highly dependent on the amount of muscle tissue an athlete possesses.

power The ability of a muscle or group of muscles to generate force at high movement speeds. In other words, the more work performed per unit of time, the greater the power output of the muscle. Power is also known as speed-strength.

speed-strength This term is synonymous with power.

The pure strength/power athletes are different from many other athletes in that success in their sport relies on activities of short duration; for example, any of the throws in track and field take only a few seconds to perform. As a result, the energy needs and goals of training differ vastly from those of the endurance athlete. This chapter discusses the macro- and micronutrient needs of strength/power athletes along with issues regarding hydration and meal planning.

What energy systems are utilized during strength/power exercise?

The body's three energy systems (the phosphagen, anaerobic, and aerobic systems) are constantly working together to meet the body's immediate energy demands. The short, high-intensity muscle contractions required to perform strength and power sports rely heavily on the phosphagen system, with increasing contribution from the anaerobic system as the length of the activity increases (see Figure 13.1). In the case of a strength athlete performing a one-repetition maximum bench press, the actual time the athlete spends performing the lift may be only 4 seconds. The time interval is even shorter for a javelin thrower or a person performing the shot put (i.e., the left-most region of area 1 in Figure 13.1).

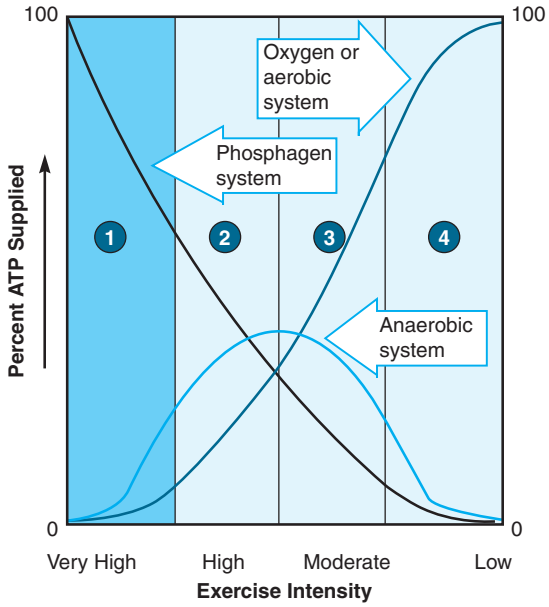


Figure 13.1 Strength/power athletes rely primarily on the phosphagen and anaerobic energy systems to provide ATP. The shaded area 1 in the graph represents all-out activities that progress in length from 1 second (i.e., left margin) to 30 seconds (right margin). Area 2 involves all-out efforts that progress from 30 seconds to about 1.5 minutes. Strength/power athletes tend to perform activities that fall in areas 1 and 2. Although the aerobic energy system is not a major provider of energy for these athletes, it is important for recovery afterward.
Source: Reproduced with permission of the McGraw-Hill Companies from Bowers RW, Fox EL. *Sport Physiology*. 3rd ed. Dubuque, IA: William C. Brown; 1992.

Muscle stores of adenosine triphosphate (ATP) and creatine phosphate (CP) enable the muscles of these athletes to meet the immediate demands for energy and thus complete a successful lift or throw. On the other end of the strength/power spectrum is an athlete such as an 800-meter sprinter. These athletes derive the majority of their energy from the combined efforts of the phosphagen and anaerobic energy systems (i.e., right-most region of area 2 in Figure 13.1).

Depending on the nature of the sport, it may be necessary to repeat the strength/power movement numerous times. Even though the phosphagen and the anaerobic systems supply the immediate energy need, the aerobic system should not be neglected or shrugged off as unimportant. In the case of a shot putter, aerobic metabolism is relatively unimportant because there is usually plenty of rest time between puts to recover; however, other strength/power sports require the athlete to repeatedly perform strength/power movements over a period of time with relatively short intervals of rest in between. In these cases, the aerobic system is important for supplying the energy for recovery, which, in turn, indirectly affects performance by delaying the onset of fatigue. An example of a sport requiring repeated powerful bursts of muscle activity can be seen during gymnastics competitions. In competition and during training, skills requiring muscle strength and power are separated by short rest periods that occur during the event (e.g., between tumbling runs during floor exercise) or between apparatus as the athletes rotate from one to another. Muscle recovery and the associated recharging of the creatine and ATP stores are dependent on the aerobic system. Therefore, if strength/power athletes neglect the development of their aerobic system, their ability to recover will be impaired, and fatigue will ensue more quickly.

In summary, strength/power athletes rely primarily on the phosphagen energy system to provide ATP during strength/power events, with increasing contributions of ATP coming from the anaerobic energy system as the duration of the activity increases. Although the aerobic energy system contributes little ATP during the actual strength/power activity, it is important for recovery after the activity. During the recovery period, the aerobic energy system replenishes ATP and CP levels, thus recharging the phosphagen system and delaying the onset of fatigue.

Are the calorie needs of strength/power athletes different from those of other types of athletes?

As with most athletes, the main dietary concern with individuals involved in strength/power sports is the consumption of adequate amounts of total daily calories. Energy needs are based on several factors, including age, gender, body mass, and sport-specific demands, which can vary tremendously between athletes. No single macronutrient is more important than the others; thus the dietary composition for strength/power athletes is not much different from the recommended healthy diet of nonathletes. This section will review calculating total calorie needs for strength/power athletes, and subsequent sections will focus on the roles of each of the macronutrients, micronutrients, and fluids.

How are daily calorie needs calculated for strength/power athletes?

For strength/power athletes, similar to other athletes, there are three main considerations when determining energy needs and developing an individualized meal plan: Does the athlete want to maintain, lose, or gain weight? In the category of strength/power athletes, weight goals span an enormous continuum. On one end of the spectrum are weight lifters who, in general, are trying to gain muscle tissue and build mass. At the other end are gymnasts who, in general, are attempting to minimize body mass while simultaneously aiming for increased strength and power. Therefore, nutrition plans need to meet the athlete's basic nutrient requirements while also reflecting the athlete's desires and goals.

The energy needs for strength/power athletes can be calculated using the equations and activity factors presented in **Table 13.1**. The following examples provide real-life scenarios of strength/power athletes who want to lose, maintain, or gain weight. Each scenario reviews how to calculate energy needs and provides recommendations based on the athlete's goals and objectives.

How can calorie needs be calculated for athletes aiming to lose/minimize body weight while increasing strength/power?

Female gymnasts are a category of strength/power athletes who are generally aiming to lose weight or maintain an already low weight. To obtain their goal,

TABLE 13.1 Resting Energy Expenditure (REE) Calculations and Activity Factors

Gender and Age	Equation (BW in kilograms)	Activity Factor
Males, 10 to 18 years	REE = (17.5 × BW) + 651	1.6–2.4
Males, 18 to 30 years	REE = (15.3 × BW) + 679	1.6–2.4
Males, 30 to 60 years	REE = (11.6 × BW) + 879	1.6–2.4
Females, 10 to 18 years	REE = (12.2 × BW) + 749	1.6–2.4
Females, 18 to 30 years	REE = (14.7 × BW) + 496	1.6–2.4
Females, 30 to 60 years	REE = (8.7 × BW) + 829	1.6–2.4

Source: Data from World Health Organization. Energy and Protein Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report 724. Geneva, Switzerland: World Health Organization; 1985:206.

many gymnasts are eating suboptimal levels of not only total calories, but also a variety of nutrients. Several studies have examined the differential between recommended and actual calorie intake. The results are staggering—gymnasts are consuming only 47–84% of their daily calorie requirements![1–4] When working with female gymnasts or any other strength/power athlete whose goal is to lose weight, calculate energy needs and then compare the calculations to actual current intake before developing a meal plan and making recommendations.

Lyndsi's Case Study Kari, the mother of an 11-year-old gymnast named Lyndsi, calls to make an appointment with a sports nutritionist. Kari has grown increasingly concerned about her daughter's eating habits and weight loss over the past several months. Lyndsi has been part of a local club team for several years that practices 2 to 3 hours a day, 5 to 6 days a week. While on summer break, the club team hosted a 2-week gymnastic camp. Lyndsi was very excited about the opportunity to train and learn from the older girls on the team, commenting to her mother several times about how she envied their performance and abilities. At the end of camp, Kari noticed gradual changes in her daughter's eating habits—Lyndsi began to turn down her favorite foods, and she had developed a strong aversion to any food containing fat. Lyndsi's eating habits subsequently became very routine, consisting of a plain bagel for breakfast, an iceberg lettuce and green pepper salad with nonfat dressing for lunch, and a chicken breast, baked potato, and broccoli every night for dinner (see **Training Table 13.1**). Lyndsi would usually have a small bowl of nonfat frozen yogurt or dry cereal for a snack in the evening. Kari has noticed a "drawn" look to Lyndsi's face and that her clothes seemed to just hang loosely on her body. The point at which she knew it was time to seek professional assistance was when Lyndsi went to the doctor for a routine checkup, and her 5′3″ frame weighed only 95 pounds. She is certain Lyndsi is not eating enough but is unsure of how much she should be consuming and how she can get Lyndsi back on track to "normal" eating.

Making recommendations. In this situation, Lyndsi has made some drastic changes to her diet and, as a result, noticeable weight loss has occurred.

1. The first step is to estimate her total calorie needs:
   REE = (12.2 × BW in kg) + 749 = (12.2 × 43.2) + 749 = 1276
   Total calorie needs = REE × Activity factor = 1276 × (1.6 – 2.4) = 2041–3062 calories/day
   Lyndsi needs at least 2041 calories per day on rest or easy days, and up to 3062 calories a day for heavy training days (3+ hours per day).
2. The second step is to estimate her calorie intake. Refer to Training Table 13.1 for Lyndsi's initial meal plan. After making changes to her diet, she was only consuming ~900 calories a day. It is obvious that she is not meeting her energy requirements—in fact, she is only consuming 45% of her bottom-level energy needs ([916 calories/2041 calories] × 100 = 45%). One of the roles of a sports nutrition professional is to understand the client's perspective by determining why a client eats in a certain way. In this scenario, it is critical to determine why Lyndsi made changes to her diet in order to have a better feel for her potential risk of developing an eating disorder. For this example, assume that Lyndsi is merely ignorant of how the changes she has implemented can potentially negatively affect her health and performance.
3. Because her calorie intake is low, she should increase her daily calories, but gradually. The sports nutrition professional should ensure that Lyndsi's questions, concerns, and fears are addressed prior to suggesting the revised meal plan. The revised meal plan (refer to Training Table 13.1) provides adequate nutrients for growth, development, health, and performance. Even though the revised plan is at the lower end of the recommended range, it may take a couple of weeks to gradually progress her intake to the new level. The more gradual the process, the easier it will be for

Training Table 13.1: Lyndsi's Initial and Revised Meal Plans

	Lyndsi's Initial Meal Plan		Lyndsi's Revised Meal Plan	
Meal/Snack	Food/Beverage	Calorie Content (kcal)	Food/Beverage	Calorie Content (kcal)
Breakfast	Bagel	195	Bagel	195
			with 2 tbsp peanut butter	190
			8 oz orange juice	112
Lunch	2 cups iceberg lettuce	13	2 cups iceberg lettuce	13
	with ½ green pepper	10	with ½ green pepper	10
	3 tbsp fat-free French dressing	68	½ tomato	13
			½ cup mushrooms	13
			3 tbsp fat-free French dressing	68
			3 oz turkey sandwich	388
			8 oz skim milk	85
Dinner	4 oz chicken	187	4 oz chicken	187
	1 baked potato	220	1 baked potato	220
	1½ cups broccoli	66	1½ cups broccoli	66
			cooked in 1 tbsp olive oil	119
			12 oz skim milk	128
Snack	1 cup fat-free frozen yogurt	157	1 cup Total raisin bran	180
			8 oz skim milk	85
	Total calories = 916		**Total calories = 2072**	
	Total carbohydrates = 153 g		**Total carbohydrates = 290 g**	

Lyndsi to adapt physically and mentally to the increased number of calories. Once she reaches the minimum requirement for calories, the revised meal plan can be reevaluated and adjusted accordingly.

How can calorie needs be calculated for athletes aiming to maintain body weight while increasing strength/power?

Nutrition becomes a focus for some athletes who are trying to bring their performance "to the next level" by optimizing their intake of macro- and micronutrients. Often, these athletes are satisfied with their current weight but feel something is missing in their daily dietary regimen. For these athletes, energy needs should be calculated to confirm an appropriate calorie level is being consumed, and then the focus should shift to establishing balance, variety, and moderation within the diet.

Jake's Case Study Jake is a 25-year-old 50-meter butterfly swimmer. He swam competitively in high school and college and now trains and competes periodically with the master's swim team at the YMCA. During high school and college, he ate "whatever he wanted" and never gained an ounce because he was so active. He has been at the same weight (165 pounds) since graduation, and he wants to maintain that weight. He works full time, lives alone, swims 5 to 6 days a week, and volunteers as an assistant coach for a high school team. Since he has become so busy, he has been relying more on fast food (see **Training Table 13.2**), which he recognizes has affected his swimming performance and energy levels (unlike the "glory days" of his high school and collegiate career). He wants to stay fit, eat healthy, increase his energy levels, and compete at several upcoming swim meets.

Making recommendations. In this scenario, Jake has realized he needs to make some changes to his diet to keep his energy levels up, to meet his nutritional needs, to avoid weight gain, and to swim at his best.

1. The first step is to calculate his energy needs:
   REE = (15.3 × BW in kg) + 679 = (15.3 × 75) + 679 = 1827
   Total energy needs = REE × Activity factor = 1827 × (1.6–2.0) = 2922–3654 calories/day
   Because Jake is not as active as he was in high school and college, a moderate activity factor can be used (1.6–2.0 versus 1.6–2.4).
2. The next step is to evaluate the adequacy of his current intake by analyzing a food record. An

Training Table 13.2: Jake's Initial and Revised Meal Plans

	Jake's Initial Meal Plan		Jake's Revised Meal Plan	
Meal/Snack	Food/Beverage	Calorie Content (kcal)	Food/Beverage	Calorie Content (kcal)
Breakfast	2 pieces wheat toast with butter	245	2 pieces wheat toast	160
	8 oz cranberry juice cocktail	144	with 2 tbsp peanut butter	190
			16 oz 100% cranberry juice blend	265
			½ cup Egg Beaters, scrambled	60
			with 2 tbsp shredded cheddar cheese	57
Snack	Granola bar	180	2 Granola bar	360
Lunch	2 McDonald's cheeseburgers	640	1 McDonald's cheeseburger	320
	Small french fries	210	McDonald's garden salad	35
	12 oz Diet Coke	2	with 1 pkt of fat-free dressing	50
			16 oz skim milk	170
			Banana	108
Snack	Banana	108	Orange	62
Dinner	12″ Tombstone pizza	1550	2 cups instant brown rice	433
	16 oz 2% milk	242	6 oz stir-fry chicken	281
			2–3 cups stir-fry vegetables	98
			cooked in 2 tbsp olive oil	239
			16 oz skim milk	171
Snack			1 cup low-fat yogurt	258
			Apple	60
	Total calories = 3321		**Total calories = 3377**	
	37% of calories from fat		**25% of calories from fat**	
	Total carbohydrates = 381 g		**Total carbohydrates = 468 g**	

excerpt from Jake's food record is listed in Training Table 13.2. As noted by the nutrition analysis, Jake is consuming an appropriate number of total calories; however, he is eating 37% of his calories from fat. Therefore, dietary recommendations for Jake should focus on substituting some of the high-fat foods with lower-fat, more nutrient-dense options.

3. Jake maintains a busy schedule, so meal planning needs to be simple and easy to follow. By making a few adjustments to his food choices, keeping meal preparation to a minimum, and taking time to plan ahead, Jake's revised meal plan will help him maintain his weight while also rebalancing his daily macronutrient intake. See Training Table 13.2 for Jake's revised meal plan.

How can calorie needs be calculated for athletes aiming to gain muscle mass to increase strength/power?

Strength/power athletes who are aiming to gain weight need to consume extra calories each day to support basic energy needs, the energy demands of daily training, and the nutrient support for tissue growth and development. The success of a plan for weight gain depends on both the quality and quantity of the diet as well as an appropriate strength training and conditioning program. It is essential that these two components go hand in hand; if increases in training are not accompanied by extra calories, muscle mass can potentially be used as an energy source, resulting in weight loss, and if extra calories are consumed without the physical challenge of training, extra calories will most likely contribute to larger fat stores.

Tissue growth of approximately 1 pound requires approximately 5–8 calories per gram.[5,6] Because 1 pound of muscle weighs 454 grams, a reasonable estimate of total calories needed to produce 1 pound of muscle is a range of 2300–3600 calories. In general, no more than 1–2 pounds of weight gain is recommended per week. Therefore, an athlete would need to consume approximately 300–500 additional calories per day for a 1-pound lean weight

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Strength/power athletes must be provided with a sufficient amount of calories per day to meet energy needs or performance will suffer. Total energy requirements should be calculated on an individual basis and modified according to the athlete's goals and objectives. Take into consideration an athlete's current intake before making final recommendations to avoid drastic and unrealistic changes.

gain per week, or 600–1000 additional calories for a 2-pound lean weight gain per week, assuming all calories are used for muscle construction. However, this assumption cannot always be made. Although increasing daily calories is an effective way to gain weight, researchers have found that only 30–40% of the weight gain is in the form of lean mass when study participants are consuming an extra 500–2000 calories per day.[7] It seems reasonable to assume that the more dramatic the increase in daily calorie consumption, the greater the percentage of gained weight will be in the form of fat. The body can construct only a finite amount of muscle tissue daily; above that level, extra calories are stored as adipose tissue. Therefore, strength/power athletes should aim for a modest increase in daily calorie consumption (300–500 calories/day) and be patient with gradual weight gain.

The extra calories needed for a 1-pound weight gain can be easily obtained by consuming a snack such as:

- 2 tablespoons of peanut butter on one slice of thick bread with 1 cup of milk = 370 calories
- A 6-ounce yogurt with ¼ cup of dry oatmeal and ¼ cup of mixed nuts = 310 calories
- A can of tuna with 4–6 crackers and a banana = 395 calories

For individuals needing 600–1000 calories, portion sizes should be increased at each meal and at least one or two snacks included throughout the day, such as:

- Any of the preceding snacks
- A smoothie made with 12 ounces of milk, 1 cup of frozen fruit, and a scoop of protein powder = 470 calories
- 4–6 ounces of turkey in a whole wheat pita with lettuce and tomato = 410 calories
- A canned nutrition drink or a large energy bar (no more than one supplement item per day—focus heavily on whole foods) = 255–360 calories

Leo's Case Study Leo is a 45-year-old recreational cyclist and weight lifter. He commutes to work on his bike daily and goes to the gym 4 to 5 days per week for weight-lifting sessions. His goal is to gain 5–10 pounds of muscle mass (current weight, 170 pounds), but he is having a hard time gaining any weight. He follows a well-balanced strength-training program and changes his routine every 6 to 8 weeks. He is currently eating three meals a day and sometimes a snack. He wants to gain weight in a healthy way and not rely on candy bars and chocolate shakes to add calories to his diet. However, when he increases his intake through fruits and vegetables, he experiences some gastrointestinal bloating and discomfort. He is frustrated about his inability to gain weight and is looking for advice from a professional.

Making recommendations. Leo's complaints are common among strength/power athletes—he has attempted to gain weight with little to no success. Fortunately, he is dedicated to a healthy diet by focusing not only on weight gain, but also on long-term health. However, in his attempts to add more food to his normal regimen, he has chosen the two food groups with the lowest calorie density—fruits and vegetables. Although whole fruits and vegetables are certainly an important part of his overall diet, they may be contributing to his sense of fullness and discomfort, ultimately discouraging him from eating enough food to increase his total calorie intake.

1. The first step is to determine how much he is currently consuming. **Training Table 13.3** shows a typical day for Leo. An analysis of his current intake reveals a total calorie consumption of 3527 calories. Therefore, it is obvious that he needs to eat more than 3527 calories a day to make any progress in gaining weight.
2. The next step is to calculate total energy needs based on his age and activity level. Using the formulas stated in Table 13.1, his total daily energy needs are:
   REE = (11.6 × BW in kg) + 879 = (11.6 × 77.3) + 879 = 1775
   Total calorie needs = REE × Activity factor = 1775 × (1.6 – 2.4) = 2840–4260 calories/day
   Because he is currently consuming ~3500 calories and he is not gaining weight, the lower end of the spectrum can be eliminated. For him to gain weight gradually, he will need to consume approximately 3800–4200 calories per day. This range would provide additional calories above his current intake, while staying within the calculated estimate.
3. Leo should be congratulated on adding fruits and vegetables to his diet. However, consuming more nutritious and calorie-dense foods should be the focus of his weight gain efforts. Foods that provide excellent nutrition and extra calories include

Training Table 13.3: Leo's Initial and Revised Meal Plans

	Leo's Initial Meal Plan		Leo's Revised Meal Plan	
Meal/Snack	Food/Beverage	Calorie Content (kcal)	Food/Beverage	Calorie Content (kcal)
Breakfast	Smoothie:		Smoothie:	
	16 oz skim milk	171	16 oz skim milk	171
	½ cup nonfat yogurt	78	½ cup nonfat yogurt	78
	Banana	108	Banana	108
	½ cup protein powder	180	1 packet instant breakfast mix	130
	2-egg cheese omelet	284	2 small blueberry muffins	316
Snack			8 pretzel twists	183
Lunch	Two 4–5 oz ham sandwiches	691	Two 4–5 oz ham sandwiches	691
	Apple	81	16 oz apple juice	233
	1½ cups melon balls	86	1½ cups melon balls	86
	16 oz skim milk	171	16 oz skim milk	171
Snack	2 cups carrots	104	2 cups carrots	104
	with 2 tbsp fat-free dressing	50	with 2 tbsp fat-free dressing	50
	Pear	98	5 oz tuna	181
	5 oz tuna	181		
Dinner	6 oz pork chops	408	6 oz pork chops	408
	1½ cups mashed potatoes	332	1½ cups mashed potatoes	332
	3–4 cups salad with veggies	93	3–4 cups salad with veggies	93
	3 tbsp oil/vinegar dressing	240	2 tbsp oil/vinegar dressing	121
	16 oz skim milk	171	2 dinner rolls	205
			16 oz skim milk	171
Snack			3 oatmeal cookies	240
			8 oz skim milk	85
	Total calories = 3527		**Total calories = 4157**	
	Total carbohydrates = 399 g		**Total carbohydrates = 612 g**	

Food for Thought 13.1

Considerations for Gaining Weight

In this exercise, you will identify the components necessary for eliciting weight gain.

items such as fruit juices, dried fruits, avocados, olives, thick breads, nuts, seeds, yogurt, instant breakfast mixes, granola bars, and fruit/milk smoothies. See **Table 13.2** for more ideas on how athletes can gain weight in a healthy way by eating nutrient- and calorie-dense foods. Leo should maintain balance in his diet by eating items from every food group of the MyPlate food guidance system. Discourage Leo from focusing on one type of macronutrient or food group as the sole source of added calories. Balance, variety, and moderation are still his keys to success. Refer to Training Table 13.3 for Leo's revised meal plan, which provides 4157 calories per day.

How are calorie needs calculated during strength/power training and competition?

Energy needs for strength/power athletes can vary greatly between a training session and a competitive event. Training sessions can last several hours, whereas performance at a competition may last only seconds or minutes. Therefore, these two scenarios should be addressed differently.

Similar to endurance athletes, consuming appropriate amounts of energy, mainly in the form of carbohydrates, during training sessions will

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A majority of required calories for strength/power activities should be consumed before or after exercise sessions to avoid gastrointestinal upset and the subsequent interference with training. Consuming sports beverages throughout a practice or eating a light snack during a break will provide the energy needed to fuel high-intensity performance.

TABLE 13.2 Gaining Weight the Healthy Way Through Nutrient- and Calorie-Dense Foods

Foods	Nutrient- and Calorie-Dense Options
Grains	Oatmeal, Cream of Wheat
	Thick, dense breads
	Bagels
	Wheat germ
	Muffins
	Cornbread
	Quick breads (e.g., banana bread)
Fruits	100% fruit juice
	Dried fruit
	Pineapple
	Bananas
Vegetables	Potatoes
	Corn
	Peas
	Squash
	Beets
	Avocados
	Olives
Dairy (milk alternatives)	Nonfat powdered milk
	Malt powder
	Instant breakfast mixes
	Fruited yogurts
	Canned shakes (e.g., Ensure)
Protein foods (meat alternatives)	Beans (e.g., pinto, black, kidney)
	Lentils
	Split peas
	Nuts and nut butters
	Seeds
Desserts	Puddings
	Hot cocoa made with milk
	Oatmeal raisin cookies
	Fig bars
	Milk shakes made with low-fat dairy products

help to delay fatigue. Carbohydrate intake of up to 1.0–1.1 grams of carbohydrates per minute is appropriate, providing approximately 240–270 calories per hour. Strength/power athletes add the element of repeated high-intensity bursts of effort throughout a typical training session. This factor mandates the need for energy sources that are easily digestible to avoid gastrointestinal discomfort. Sports beverages are an ideal source of calories and are generally well tolerated even during high-intensity exercise. The consumption of solid food should be reserved for during breaks or at the end of a training session.

For some strength/power athletes, competition day consists of only one event that lasts less than a few minutes. In these situations, it is neither practical nor necessary to consume calories during the event. The body will not deplete its energy reserves in such a short burst of effort, and therefore immediate replenishment is not critical to performance. The exception to this rule is when an athlete is competing in multiple events at the same meet within one day. In this situation, the length of the meet can last several hours, with a small, but progressive, depletion of energy stores with each event. Therefore, to sustain a high level of performance throughout the day, an athlete should plan on consuming easy-to-digest snacks, beverages, and possibly small meals in between events to keep energy levels elevated. The quantity of food consumed will depend on several factors including time between events, length of each event, time elapsed since the last full meal, and personal preferences.

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To meet calorie needs, strength/power athletes should focus on consuming calorie-containing beverages and easily digestible snacks during training sessions and half- or full-day competitive meets. However, during single-bout events it is neither practical nor necessary to consume any food or beverage.

Are carbohydrate needs different for strength/power athletes?

Consuming enough carbohydrates on a daily basis is critical for optimal strength/power performance. Because many strength/power sports rely on anaerobic metabolism, carbohydrates are the main fuel for these short, high-intensity bursts of energy. Anaerobic metabolism taps into glycogen stores for energy during an activity; therefore, if glycogen stores are depleted, performance will suffer.

Similar to endurance exercise, strength/power exercise can deplete muscle glycogen, although not to the same degree. Several studies have examined the glycogen-depleting effects of strength training. Tesch and colleagues[8] found a 25% decline in muscle glycogen stores after subjects performed 5 sets of 4 different leg exercises for 6 to 12 repetitions each. Other protocols involving 5 to 6 sets of 6 to 12 repetitions at 35–70% of maximal strength produced a similar reduction in glycogen stores.[9,10] Therefore, it

has been suggested that the ingestion of higher carbohydrate diets will improve performance through higher initial glycogen levels. Several studies have supported this recommendation after examining the effects of a high- versus low-carbohydrate diet prior to performing a single bout, as well as intermittent, high-intensity activities.[11–14] Strength/power athletes should strive for a moderate to high intake of carbohydrates daily to have fully loaded glycogen stores before training sessions and competitive events.

A possible exception to the rule of glycogen stores making an impact on strength/power performance is during a single sprint effort. During one sprint of about 400 meters or less, the quantity of muscle glycogen stored in the muscle is not necessarily the limiting factor in performance.[15] Carbohydrates are still the main source of fuel; however, because of the short duration of the effort, glycogen stores will not be depleted by one burst of sprinting. Therefore, carbohydrate loading for one sprint is not as critical as it would be before a training session or other repeated high-intensity exercise bout. Sprinters may train intensely several times per week, including repeated sprints per workout, so moderate carbohydrate consumption on a daily basis is a sound dietary practice.

In addition to fueling activity, carbohydrate intake can play an indirect role in building muscle mass. Carbohydrate ingestion stimulates the secretion of insulin. Insulin is considered an **anabolic** hormone, driving nutrients into the cells for the growth and development of tissues as well as preventing normal postexercise muscle protein breakdown.[16,17] Consuming adequate amounts of carbohydrates, as well as ensuring that total energy and protein needs are met, will support muscle growth in response to the demands of an appropriate strength training and conditioning program.

anabolic A metabolic process or activity that results in tissue repair or growth. An anabolic hormone or substance is one that stimulates anabolism.

How are daily carbohydrate needs calculated for strength/power athletes?

Many strength/power athletes will train intensely three to five times per week; without sufficient dietary carbohydrate intake, this could lead to glycogen depletion and decreased performance. An intake of 6–10 grams of carbohydrates per kilogram of body weight per day has been shown to replenish glycogen stores after daily training sessions.[18] This quantity of carbohydrates should contribute approximately 55–65% of total calorie intake. This percentage can also be used to estimate carbohydrate needs based on total calorie requirements.

Estimated carbohydrate needs should be compared to total estimated energy requirements to verify that carbohydrate recommendations fall near the range of 55–65% of total calories. Building on the scenarios described in the last section regarding Lyndsi, Jake, and Leo, the following examples demonstrate the importance of fine-tuning carbohydrate recommendations for every athlete:

- Lyndsi, the gymnast, requires 259–432 grams of carbohydrates daily based on the 6–10 grams of carbohydrates per kilogram of body weight recommendation (95 lbs ÷ 2.2 = 43.2 kg; 43.2 kg × 6–10 g/kg = 259–432 g). Lyndsi's initial meal plan analysis revealed that she was consuming 66% of her total calories from carbohydrates. Although this percentage sounds appropriate, the absolute value of her carbohydrate intake was only 153 grams, which is only 59% of the low end of her recommended carbohydrate intake range. In addition, Lyndsi's absolute carbohydrate intake is only slightly higher than the RDA for carbohydrates (130 grams) for adults and children based on the average minimum amount of glucose utilized by the brain daily.[19] In Lyndsi's revised meal plan, the percentage of calories from carbohydrates decreased to 56%; however, the absolute value of her intake increased to 290 grams. This number is within the 259–432 recommended range and represents an 89% increase from her previous carbohydrate consumption.
- Jake, the swimmer, requires 450–750 grams of carbohydrates daily based on the 6–10 grams of carbohydrates per kilogram of body weight recommendation (165 lbs ÷ 2.2 = 75 kg; 75 kg × 6–10 g/kg = 450–750 g). In this case, 450 grams of carbohydrates contribute 1800 calories (450 g carbohydrates × 4 calories/g carbohydrates = 1800 calories). This quantity of carbohydrates represents 62% of 2922 calories (the low end of his recommended calorie range) and 49% of 3654 calories (the high end of his recommended calorie range). Clearly, 450 grams of carbohydrates would be appropriate for a calorie intake at the

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Carbohydrates are the master fuel for strength/power sports. Consuming adequate amounts of carbohydrates on a daily basis ensures glycogen stores will be sufficient to support high-intensity training and competition. Carbohydrates also act as a support crew for the construction of muscle mass in response to resistance training.

low but not the high end of his recommended range; therefore, it is more appropriate to estimate his carbohydrate needs through a percentage of total calories. For example, 55–65% of Jake's high-end calorie range (i.e., 3654 calories) equals:

([0.55–0.65] × 3654 calories)/
4 calories per gram of carbohydrates =
502–594 grams of carbohydrates daily

For Jake, estimating an appropriate amount of carbohydrates varies greatly depending on his total calorie intake. Therefore, a final carbohydrate recommendation for Jake is 450–594 grams of carbohydrates per day. Jake's revised meal plan provides 468 grams of carbohydrates, thus meeting his daily needs.

- Leo, the weight lifter, requires 464–773 grams of carbohydrates daily based on the 6–10 grams of carbohydrates per kilogram of body weight recommendation (170 lbs ÷ 2.2 = 77.3 kg; 77.3 kg × 6–10 g/kg = 464–773 g). Because Leo is attempting to gain weight and thus has higher calorie needs, the estimated carbohydrate intake based on body weight should be checked using the percent total calories method.

By comparing the body weight recommendation range of 464–773 grams of carbohydrate to that of the percentage of total calories range (i.e., 522–682 grams), it is apparent an adjustment is needed for his minimum intake recommendation. In this case, the minimum value of the body weight recommendation range (i.e., 6 grams per kilogram of body weight, or 464 grams) is too low because it accounts for less than 55% of total calories. As a result, adjusting the minimum recommendation to 522 grams is warranted. If you convert the 522 grams of carbohydrate into a gram per kilogram body weight recommendation, it would be 6.8 grams per kilogram of body weight (i.e., 522 g/77.3 kg = 6.8 g/kg).

Leo's initial meal plan was providing only 399 grams of carbohydrates per day. The revised meal plan increased his intake 53% to a total of 612 grams of carbohydrates per day.

Keep in mind that these scenarios provide only three examples of individual athlete needs. Most of these cases suggest 55–65% of total calories from carbohydrates; however, this recommendation can be raised or lowered based on the volume of training a strength/power athlete engages in daily. None of these cases recommended carbohydrate intakes at the high end of the range—10 grams of carbohydrates per kilogram of body weight. This does not mean that 10 grams of carbohydrates per kilogram of body weight is not appropriate in some situations. Evaluate each athlete individually, compare estimations to current intake, and then make recommendations based on the athlete's goals and training schedule. Figure 13.2 compares the individual


© Photos.com

Energy needs:
2072
Carbohydrate needs:
290 grams


© Photos.com

Energy needs:
3377
Carbohydrate needs:
468 grams


© Photodisc

Energy needs:
4157
Carbohydrate needs:
612 grams

Figure 13.2 Lyndsi, Jake, and Leo have different energy and carbohydrate needs based on their size, sport, and training level.

carbohydrate and energy needs of the three athletes discussed here. Each of these athletes has different energy and carbohydrate needs based on his or her body weight, gender, and strength-training program.

Are carbohydrates needed before and during training and competition?

The performance effects of carbohydrate ingestion immediately prior to and during strength/power sports are unclear. The limited research available presents evidence to support a variety of benefits and potential drawbacks. Thus, trade-offs exist, requiring recommendations and nutrition plans to be individualized based on the goals and objectives of the athlete and a consideration of the specific activity to be performed.

Although engaging in strength/power sports generally does not cause a reduction in blood glucose levels during a workout, a considerable glycogenolytic effect has been observed during either intermittent, high-intensity exercise or strength-training-type activities.[8,10,20,21] If depletion of glycogen occurs, then performance suffers as a result of fatigue, and over the long term the athlete can experience muscle loss. Therefore, it appears prudent to consume carbohydrates before and also during strength/power exercise.

A general recommendation for preactivity eating is to consume a carbohydrate-rich meal approximately 2 to 4 hours prior to the initiation of exercise. The provision of carbohydrates helps to top off the body's glycogen stores prior to training or competition. Many athletes find that the consumption of carbohydrates before a hard training session allows them to complete a tough workout without feeling fatigued prematurely. Therefore, athletes push themselves harder and gain more benefit from the workout. Furthermore, recent research has suggested that the provision of carbohydrates, as well as amino acids, prevents muscle breakdown during intense exercise, potentially leading to a maintenance or enhancement of muscle mass.[17]

Additional benefit has been observed when athletes supplement the preactivity meal with a supply of carbohydrates during the workout or competition, typically in the form of a beverage or liquid supplement. Especially for long training sessions, consuming carbohydrates periodically during exercise sustains energy levels and work output for longer periods of time.[22,23] In a well-designed study, Haff et al.[22] aimed to determine the performance effects of carbohydrate supplementation on the ability to perform resistance exercise during a second training session on the same day. Subjects performed a glycogen-depleting session of resistance training in the morning (15 sets of various lower body exercises) and then returned to the gym 4 hours later to squat to exhaustion. The carbohydrate-supplemented group outperformed the placebo group by successfully completing a greater number of sets and repetitions. Although higher energy levels and greater strength/power outputs during a training session because of carbohydrate intake sounds like a "no-brainer," not all research findings have yielded similar results.[24,25] In fact, some athletes, coaches, and researchers are suggesting the exact opposite nutrition practice—avoiding carbohydrates before and during training.

This school of thought exists mainly in the world of weight lifting and body building. It is based on the premise that a steady stream of carbohydrates into the bloodstream will prevent the body from tapping into other energy sources, specifically fat stores. Therefore, the recommendation is to avoid eating carbohydrate-rich foods 2 to 4 hours prior to exercise. In fact, most recommend not consuming any food before a workout. The second half of the recommendation includes the avoidance of carbohydrate beverages, supplements, and food during a workout. Although this practice will cause the body to turn to fats (adipose tissue and intramuscular fats) for energy, it is well known that when glycogen and blood glucose levels begin to run low, the athlete will begin to tire, perception of effort increases, and performance levels can plunge. However, not all athletes experience extreme fatigue, particularly if their diet is adequate at other times of the day when following this practice; therefore, the final recommendation will be based on individual preference and tolerance. If an athlete chooses to avoid consuming food before and during a strength/power workout, a strong emphasis should be placed on consuming the required number of daily calories throughout the rest of the day. Obviously, this carbohydrate avoidance scenario is best implemented



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Trade-offs exists in the "to eat" or "not to eat" schools of thought regarding consuming carbohydrates before and during strength/power sports. Currently, most research suggests that supplying the body with carbohydrates before and during exercise will lead to greater gains in strength/power performance. Athletes should try both methods and determine which recommendation is ideal in helping the athlete reach his or her goals and performance potential.

with early morning workout sessions to prevent the disruption of regular meal times throughout the day.

The final recommendation should be based on an athlete's preference for carbohydrate consumption, the effects on performance, and the safety of the athlete. Some athletes feel they perform better on an empty stomach, whereas others become hungry, distracting them from performing well. In terms of safety, if blood glucose levels run too low, athletes can pass out and injure themselves, especially during an activity such as weight lifting. Athletes should test both methods during practice sessions and determine which recommendation leads to improved performance, increased strength/power, overall safety of the athlete, and a feeling of well-being that they are meeting their goals. At the same time, researchers will continue to examine the effects of macronutrients on strength/power performance and eventually determine specific nutritional guidelines.

Are carbohydrates needed for recovery from strength/power activities?

Similar to endurance sports, strength/power activities can deplete glycogen stores, requiring carbohydrate consumption after exercise. Complete replenishment of glycogen stores can take as little as 4 to 6 hours and up to 24 to 48 hours depending on exogenous carbohydrate availability. It is in the athlete's best interest to consume carbohydrates immediately following exercise as well as throughout the day at regular meals and snacks.

Athletes should focus on the timing and quantity of carbohydrates consumed after exercise. A source of carbohydrates should be eaten as soon as possible—ideally within 15 to 30 minutes—after the cessation of exercise. This will ensure that the carbohydrates are digested and delivered to muscles in the window of time in which the muscles are most receptive to absorbing and storing carbohydrates as glycogen for the next training session. Ideally, athletes should ingest 1.0–1.5 grams per kilogram of body weight every 2 hours for 6 hours postexercise. Consuming enough carbohydrates is more important than the exact type of carbohydrates. Fruits, vegetables, juices, whole grains, low-fat milk, and dairy products are some of the best choices to supply carbohydrates.

Although the provision of carbohydrates after high-intensity exercise is critical for glycogen replenishment, it has also been suggested that it plays a role in muscle adaptation after intense training. However, carbohydrates cannot act alone in this role; muscle protein synthesis will be much greater when a combination of carbohydrates and protein is consumed immediately after exercise.[26] The quantity and timing of this macronutrient combination for muscle growth and development will be addressed in the upcoming sections on protein needs for strength/power athletes.

Carbohydrates may be important not only for the replenishment of glycogen stores and muscle construction but also for the attenuation of immunosuppression observed after exercise. Many studies have reported that high-intensity exercise suppresses immune function temporarily after exercise.[27–30] It has been suggested that ingestion of carbohydrates before, during, and/or after exercise may minimize the immune function changes in athletes, leading to less risk of illness.[31–34] Many of the studies related to immunosuppression have been conducted with endurance athletes. However, Chan et al.[31] researched the effects on immune function of carbohydrate consumption before and after resistive exercises. Subjects consumed a low-carbohydrate meal 2 hours prior to the strength-training session. Ten minutes prior to exercise and 10 minutes after exercise subjects drank either a carbohydrate supplement beverage (one trial) or placebo (second trial). The researchers reported that carbohydrate ingestion minimized the decrease in interleukin-2 and interleukin-5 (an indication of greater immune function as compared to controls) after exercise. More research is needed in this area to verify these results. However, carbohydrate consumption after strength/power exercise is important for glycogen resynthesis and muscle construction regardless of its effect on the immune system. If research does reveal that carbohydrate consumption surrounding high-intensity, short-duration exercise has a positive effect on immune function, it will be a bonus benefit to an already solid nutrition practice.



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Carbohydrates are the master fuel for strength/power athletes. Each athlete should experiment with different quantities of foods and beverages to determine his or her individual "ideal" plan for before, during, and after exercise.

Are protein needs different for strength/power athletes?

The high intensities that strength/power athletes train at on a daily basis challenge the body and skeletal muscle. This "challenge" creates microscopic tears in muscle tissue, which are the stimuli for

subsequent tissue repair and rebuilding. Amino acids, either synthesized by the body or obtained from the digestion and breakdown of dietary protein, are the building blocks for muscle repair and rebuilding. Because of this function, protein has long been a major dietary focus for strength/power athletes. The mantra has typically been "the more protein, the better." Although strength/power athletes do have higher protein needs than their sedentary counterparts, an overdose of protein intake on a daily basis is not ergogenically beneficial.

How are daily protein needs calculated for strength/power athletes?

Strength/power athletes have an increased requirement for dietary protein. Muscle tissue goes through a process of self-repair on a daily basis and, therefore, sufficient amounts of high-quality protein sources need to be consumed at every meal. Dietary proteins are digested and broken down into amino acids, which the body then uses for building blocks for all bodily tissues. Insufficient protein intakes will lead to suboptimal improvements in muscle development, low energy levels, and poor performance. However, excessive protein intakes can also lead to adverse effects on performance, body composition, and overall health. Strength/power athletes need to find the right balance between these two extremes. In addition to the total protein intake, the variety of protein sources ingested is also of importance.

How do you determine the "optimal" daily dose of protein for strength/power athletes?

The true "optimal" quantity of daily protein intake for strength/power athletes has been debated over the years. A few articles have reported that active individuals become more efficient at using protein on a daily basis, and therefore protein needs actually decline versus increase in athletes.[26,35] However, a majority of the current research points to protein needs in the other direction, at the higher end of the scale. Some researchers suggest a range of 1.4–1.7 grams of protein daily per kilogram of body weight is appropriate,[36] whereas others recommend a higher upper limit of 2.0 grams of protein per kilogram of body weight.[37] Magazines, coaches, practitioners, and athletes often push the upper limit even higher, to levels greater than 2.5–3.0 grams per kilogram of body weight. The bottom line is that strength/power athletes do have increased protein needs; however, there is a limit to the amount of protein that can be used effectively and ingested without adverse effects.

Since the early 1980s, studies have revealed that dietary protein plays an integral role in muscle growth and development. Although all the parameters affecting muscle protein synthesis have not been identified, a few factors such as increased insulin levels and availability of amino acids are obvious. A decline in intracellular amino acid concentration will inhibit protein synthesis. Strength/power exercise has been shown to elicit a decrease in amino acid concentrations.[38,39] Therefore, it seems to follow that the ingestion of protein or amino acids would prevent this decline and, in turn, stimulate protein synthesis. In fact, studies have shown that the consumption of dietary proteins, which increases endogenous amino acid availability, can stimulate an increase in muscle protein synthesis by 30–100%.[26,40] Muscle growth and development are largely caused by an enhanced protein synthesis, versus a decreased muscle breakdown.[41] Therefore, daily and particularly pre- and postworkout provision of amino acids is of utmost importance in maximizing muscle building.

Because of the essential role of protein and amino acids in the growth and development of muscle tissue, a common misconception is that by increasing protein intake an athlete can increase muscle mass. As stated in the previous paragraphs, there is no doubt that protein is critical for muscle growth. However, once an athlete has reached the peak of protein assimilation, additional protein will not be used to create even more muscle tissue. Physical training is the strongest stimulus for signaling the muscles to grow and develop. Proper nutrition acts as a support network to the training stimulus; however, it does not necessarily initiate a further stimulus when consumed in quantities that significantly surpass physical requirements. To increase muscle mass, the equation is simple: Train hard and eat well, but do neither in excess.

Similar to carbohydrates and fat, athletic performance and overall health can suffer if too much protein is ingested and macronutrient balance goes astray. Excessive daily protein intake is generally considered to be greater than 2.0 grams of protein per kilogram of body weight. At intakes above this level, protein is either used for fuel or converted and stored as fat. Second, increased protein digestion and breakdown result in greater urea production, thus causing more fluid to be excreted from the body to flush out the toxic urea, potentially leading to dehydration. Third, if calories remain stable and protein intake increases, carbohydrate intake and glycogen replenishment generally suffer, ultimately affecting workouts. Finally,

high-protein foods, especially animal products, tend to be high in fat, saturated fat, and cholesterol, all of which can negatively affect cardiovascular health. As with most nutrients, more is not always better.

How do you determine the "optimal" food sources of protein?

In the world of strength/power athletes, "high-quality" and "complete" proteins receive the most attention. Although the quality of a protein is certainly important, true success is achieved with variety. It should be noted that the term *incomplete protein* often is misinterpreted as meaning "inadequate" or "useless" for strength/power athletes. This interpretation is erroneous and misleading. The bottom line is that all sources of protein are valuable for the strength/power athlete. To maximize the benefits of dietary protein, consider putting into practice the tips outlined in **Training Table 13.4**.

Do individual amino acids have an ergogenic effect on muscle growth and development?

The ingestion of specific amino acids or groups of amino acids has been purported to enhance muscle strength and development. It has been suggested that amino acids can influence muscle strength and development through the initiation of protein synthesis and/or increase the secretion of various anabolic hormones. The current research provides some insight into the action of various amino acids, but more research is needed to make firm conclusions and subsequent dietary recommendations.

Glutamine is one of the most popular amino acid supplement products on the market because of its touted "anticatabolic" effects in regard to skeletal muscle. It is the most abundant amino acid found in blood plasma and skeletal muscle[42] and accounts for more than 60% of the total intramuscular free amino acid pool.[43] However, glutamine is in high demand by other tissues of the body. For example, glutamine is needed by the cells of the gastrointestinal system to support their continual high protein synthesis rates. Glutamine is also used as a fuel source for cells of the immune system and hair follicles.[43,44] As a result, if glutamine levels are not sufficient to meet the body's total needs, particularly during periods of high stress such as intense training, then glutamine is taken and/or synthesized from amino acids present in skeletal muscle. It appears that glutamine not only prevents muscle catabolism, but several studies have reported that glutamine also is critical for protein synthesis within skeletal muscle.[45,46] Although the current research appears promising, the long-term effects of glutamine supplementation on protein synthesis and body composition have yet to be confirmed. As a result, more research is needed before conclusions can be drawn and recommendations made for glutamine supplementation.

catabolism A metabolic process or activity that results in tissue breakdown or destruction.

The branched chain amino acids (BCAAs), particularly leucine, have been suggested to be positive regulators of muscle protein synthesis.[47] However, the research on the effects of the BCAAs on exercise performance is still in its infancy. The exact actions of

Training Table 13.4: Tips for Maximizing the Benefits of Dietary Protein for Strength/Power Athletes

- *Consume enough total calories to meet energy needs.* If calorie intake declines, a higher percentage of ingested protein will be used for energy versus for muscle building and repair.
- *Consume a level of protein that falls within 1.4–2.0 grams of protein per kilogram of body weight.* This level of protein generally contributes 15–20% of total calories. Athletes should ensure that plenty of carbohydrates and at least minimum amounts of fat are also ingested daily.
- *Include a protein source in every meal and snack.* By focusing on including a protein source at every meal and snack, protein is digested gradually and continuously throughout the day. This recommendation is especially important for athletes engaging in multiple training sessions daily.
- *Choose a variety of different protein sources.* Lean meats, poultry, fish, and dairy products are excellent choices because of their amino acid profile and high overall protein content. Vegetarians should consume plenty of soy products, which also contain an ideal amino acid profile and high protein content. Beans, lentils, nuts, seeds, and grains supply protein in smaller amounts and with low levels of one or two amino acids. By consuming a variety of these sources on a daily basis and in larger quantities, strength/power athletes can achieve optimal intakes of protein.
- *Consume protein supplements in moderation, if necessary.* In general, protein needs can be met through "real" foods consumed throughout the day. Studies have shown that supplemental protein provides no added benefit over whole food sources.[38] However, if an athlete is already eating a well-balanced diet but is still having a hard time obtaining optimal quantities of protein, a supplement can be used in moderation. Protein powders are an appropriate supplement to use because a powder can be added to "real" foods such as milk, yogurt, cereal, and smoothies.

these amino acids before, during, and after exercise and the subsequent requirements and recommendations for intake are yet to be elucidated.

growth hormone A hormone produced by the pituitary gland that results in the growth of many different tissues in the body, including skeletal muscle.

The increased secretion of growth hormone is at the center of many amino acid supplement claims; however, study results have shown mixed conclusions. For example, Suminski et al.[48] reported that 1500 milligrams of arginine and 1500 milligrams of lysine consumed at rest increased growth hormone levels 60 minutes after ingestion. However, the same quantity of amino acids provided immediately prior to weight lifting did not alter circulating growth hormone levels in males while exercising. Amino acids and their respective influence on insulin, testosterone, and cortisol have also been highlighted as potential factors in protein metabolism and synthesis. Once again, more research is needed to ascertain the connections and interactions of amino acid ingestion and hormonal responses and the subsequent effects on protein metabolism and muscle protein synthesis.

Is protein needed before and during training sessions and competitions?

The benefits of consuming protein before strength/power sports have recently received more attention in the research. Most of the studies have explored not only the effects of protein, but also the combination effect of carbohydrates and protein on muscle synthesis, catabolism, and performance. The influence of ingesting protein during training or competition on strength/power performance has received minimal attention, and therefore the relationship between these two factors is still under investigation.

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Until further research is conducted to elucidate the benefits and drawbacks of consuming individual or groups of amino acids, the best way for athletes to obtain amino acids is from protein-rich, whole foods eaten daily in appropriate amounts.

Until recently, many of the recommendations related to nutrition and muscle building have focused on the recovery period. Although the 1 to 4 hours after exercise are still considered a critical time for replenishment, it may not be the only time when the athlete can affect muscle and strength gains. The potential positive impact of consuming a protein–carbohydrate supplement before exercise is a relatively novel concept. The argument for consuming both protein and carbohydrates before strength/power training is based on the anabolic effects of increasing the secretion of insulin and circulating amino acids. By consuming carbohydrates before strength/power exercise, insulin levels will rise and thus decrease the normal exercise-induced catabolism of muscle tissue.[49,50] A supply of exogenous protein results in a greater delivery and increased concentration of intracellular amino acids in the muscle during exercise, enhancing protein synthesis.[39] Although the action of carbohydrates and protein is the same after exercise, the reason that preactivity consumption is preferable to postactivity is related to blood flow. The theory is that when the concentration of nutrients (through the digestion of a preactivity carbohydrate–protein source) and blood flow (caused by exercise) are both increased, the rate of nutrient uptake and utilization as well as protein synthesis is maximized.[39] The positive effects of consuming carbohydrates and protein prior to exercise have been reported with as little as 6 grams of essential amino acids and 35 grams of carbohydrates.[17] Therefore, large volumes of food do not need to be consumed to gain the anabolic benefits.

Strength/power athletes should strongly consider consuming a source of both carbohydrates and protein before a training session to maximize the ability of the body to synthesize new proteins. The benefit of consuming additional protein during strength/power sports still needs to be determined.

Is protein needed for recovery from strength/power activities?

High-intensity exercise and strength training stimulate protein synthesis in muscle tissue. In response to this physical stress, amino acids are released from the free amino acid pools within plasma and cellular spaces of the body.[51,52] To meet the basic metabolic needs of muscle tissue, to repair damage from high-intensity exercise, and to build new muscle tissue, exogenous amino acids are required. Therefore, protein is a critical component of any strength/power athlete's postexercise meal or snack.

Several studies have examined the effects of consuming macronutrients at various intervals after exercise to determine an ideal environment for muscle synthesis and recovery from training. It appears that the provision of amino acids after resistance exercise stimulates greater protein synthesis, producing a net positive effect (more synthesis versus breakdown as compared to fasting after exercise).[53] When a combination of essential amino acids (6 grams) and carbohydrates (35 grams) is provided, an even greater increase

in protein synthesis is observed.[41] This suggested ratio of 6 grams of essential amino acids to 35 grams of carbohydrates is the same as mentioned previously regarding preactivity protein and carbohydrate ingestion. Therefore, the combination of carbohydrates and protein both before and after high-intensity training is beneficial to protein synthesis.

A study conducted by Chandler[54] and colleagues reported that the combination of carbohydrates and protein was more advantageous than either carbohydrates or protein alone in stimulating anabolic hormone secretion after resistance exercise. Subjects performed a standardized resistance training workout and then consumed an isocaloric amount of one of three supplements (carbohydrates only, 1.5 g/kg; protein only, 1.38 g/kg; or carbohydrates and protein, 1.06 g/kg and 0.41 g/kg, respectively) immediately and 2 hours after the session. Both the carbohydrates and carbohydrate–protein supplements caused an increase in circulating insulin levels. However, only the carbohydrate–protein supplement additionally caused a modest but significant increase in growth hormone levels. The results of this study reveal that the combination of carbohydrate and protein ingestion after strength training can produce a hormonal environment during recovery that may be favorable to muscle growth.

A recent study performed by Borsheim et al.[55] provided more evidence that a combination of protein and carbohydrates after resistance training stimulates muscle protein synthesis to a greater extent than carbohydrates alone. Eight subjects engaged in resistance training on two separate occasions, and consumed either a combination supplement (77.4 grams carbohydrates, 17.5 grams whey protein, 4.9 grams amino acids) or a carbohydrates-only supplement (100 grams carbohydrates) 1 hour after the exercise session while net protein balance response was measured. The results revealed the combination beverage not only stimulated protein synthesis at 20 to 30 minutes after ingestion (as shown in previous studies), but also caused synthesis to peak again at 90 minutes postconsumption. The authors speculate that this second round of enhanced synthesis was caused by the delayed digestion of intact proteins versus rapidly digested amino acids.

Although the optimal balance and ideal quantity of carbohydrates and protein to consume after strength/power activities are yet to be determined, athletes can gain an edge on competitors by consuming a snack or full meal containing both carbohydrates and protein to help recover after training sessions or competitions. So the next question is: When should these macronutrients be ingested?

Similar to consuming carbohydrates immediately after endurance exercise to optimize glycogen replenishment, a combination of protein and carbohydrates should be consumed as soon as possible after strength/power activities. A protein–carbohydrate food or beverage should be consumed immediately following a training session or competition, with benefits diminishing 1 to 3 hours postexercise.[55] This nutrition protocol will stimulate the release of insulin to prevent muscle breakdown while also supplying amino acids needed as building blocks for muscle tissue.



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Strength/power athletes should aim for consuming at least 6 grams of essential amino acids (obtained by consuming approximately 15 grams of high-quality protein) and 35 grams of carbohydrates as soon as possible after training sessions and competitions. The combination of carbohydrates and protein will aid not only muscle protein synthesis, but also glycogen replenishment.

Are fat needs different for strength/power athletes?

Strength/power athletes burn very little fat during the performance of their sport. The bioenergetic demands of the forceful muscle actions performed by strength/power athletes are met by the phosphagen and anaerobic energy systems, neither of which relies on the metabolizing of fats for production of ATP. Does that mean that strength/power athletes do not need to consume fat? No. Essential fatty acids are needed for the general health of all bodily tissues. Fats are also attractive to the strength/power athlete because of their caloric density. A moderate amount of fat should be consumed on a daily basis, with an emphasis placed on unsaturated fats. The timing of fat consumption is also of importance to avoid any potential performance disturbance during training or competition.

How are daily fat needs calculated for strength/power athletes?

For strength/power athletes, the goal is to find the right balance of carbohydrate, protein, and fat intake to supply all essential nutrients and allow athletes to perform at their best. Fat is a controversial topic requiring the consideration of several factors, including caloric needs; the athlete's desire to lose, maintain, or gain weight; health history; and ideal sources of fat. All strength/power athletes need fat; however, fat intake recommendations can vary greatly.

A general recommendation cited by Rogozkin[18] suggests a daily fat intake of approximately 2 grams of fat per kilogram of body weight. This quantity of fat may be appropriate for most athletes; however, as always, the calculated estimate should be compared to total calorie needs before a final recommendation is made to the athlete. For general health, a fat intake of 30–35% of total calories is considered an upper limit. A range of 20–25% is more appropriate for strength/power athletes who are trying to lose weight because fat is more calorically dense and it takes less energy to digest, absorb, and assimilate fats than carbohydrates and proteins. What this means is that if excess calories from fatty foods are ingested, then more of the excess will be stored as fat than if the excess calories had come from proteins or carbohydrates. An athlete who is aiming to gain weight will generally find the 25–30% range sufficient in supplying extra calories as well as decreasing the total volume of food needed to meet total energy needs. General health and specific athletic goals/objectives should be considered when estimating fat needs.

For example, consider two athletes who both weigh 150 pounds: one is a wrestler aiming to lose weight who consumes about 2500 calories per day, whereas the other is a shot putter with the goal of increasing muscle mass who requires 4500 calories per day. Basing their fat needs on 2 grams per kilogram of current body weight, both athletes would require 136 grams of fat per day. Comparing this recommendation to estimated calorie needs, the percentage of total calories from fat would be 49% and 27% for the wrestler and shot putter, respectively. Knowing that the wrestler wants to lose weight, that the fat intake recommendation for overall health is no more than 30–35% of total calories, that fat is calorically dense making it easier to err on the side of overconsumption, and that fats do not increase the metabolic demands for digestion and absorption like proteins and carbohydrates, the 136-gram recommendation is not to the wrestler's advantage. Using the range of 20–25% of total calories from fat to estimate his needs:

$$(2500 \text{ calories} \times [0.20\text{–}0.25])/9 \text{ calories per gram of fat} = 55\text{–}69 \text{ grams of fat per day}$$

Thus, 55–69 grams of fat per day will supply the wrestler with a small amount of fat to provide satiety and essential fatty acids, while minimizing the impact on total calorie intake. In contrast, the 136 grams of fat calculated for the shot putter is appropriate, providing a moderate amount of fat to allow the athlete to meet his increased energy needs while maintaining a healthy diet (see Figure 13.3).



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Figure 13.3 Dietary fat consumed in moderation allows the strength/power athlete to meet increased energy needs while maintaining a healthy diet.

Strength/power athletes should also consider their health history when consuming fats. Saturated and trans fats are the most detrimental to health, whereas monounsaturated and polyunsaturated fats are beneficial to overall health. For those who are at risk for heart disease, high cholesterol, or cancer, special attention should be placed on unsaturated fats. An intake of mainly unsaturated fats is also considered protective for future health problems for all athletes. Strength/power athletes should be guided toward healthy types of fats, especially those who are consuming large quantities of protein, which are often rich sources of saturated fats. Protein sources that are lower in total fat and saturated fat include lean cuts of beef, chicken, turkey, fish, legumes, and soy products.

Are fats needed before and during training sessions and competitions?

Although fats are important to consume on a daily basis, fat intake should be minimized in the hours leading up to, as well as during, an intense training session or

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Fats are an important component to an overall healthy diet for strength/power athletes. Fat consumption should be kept within the range of 20–35% of total calories, based on total calorie needs and the athlete's goals and objectives. Fats should be obtained from mainly unsaturated sources, while minimizing saturated and trans fat intake. The ingestion of fats before, during, and immediately postexercise should be kept to a minimum. Fats should be ingested in other meals and snacks spread throughout the day.

competition. Fats take longer to digest, leading to a sense of fullness and potentially gastrointestinal discomfort during exercise. Very small amounts of fat can be included in a preexercise meal consumed several hours prior to the initiation of exercise to provide a feeling of satiety. However, a majority of fat intake should be reserved for after training sessions and competitions, spread evenly throughout the day.

Is fat needed for recovery from strength/power activities?

It is not essential to replace any fat used during strength/power exercise by consuming fat-rich foods immediately following training or a competition. Strength/power sports rely minimally on fat for energy during training sessions and competitions, and therefore fat "depletion" is not an issue. Even if fat was used during strength/power sports, the body's stores of fat are so great that they will not be depleted in one workout. For athletes aiming to lose weight and become lean, training sessions help to burn calories, leading to a long-term loss of fat mass, and therefore a replacement of fat postworkout would be counterproductive. Instead, the postexercise meal should consist of mainly carbohydrate- and protein-rich foods. However, fats add flavor to foods and create a sense of satiety, and therefore can be included in small amounts in the postexercise meal or snack.

Food for Thought 13.2

Nutrition Specifics for Gaining Weight

In this exercise, you are asked to provide and justify macronutrient intakes you recommend for an athlete wishing to gain weight.

Are vitamin and mineral needs different for strength/power athletes?

The vitamin and mineral needs of strength/power athletes have not been studied extensively. As with all active individuals, nutrient needs may be slightly higher than for sedentary counterparts, but an increased intake of specific vitamins and minerals may or may not be critical for optimal strength/power performance. This section reviews several of the micronutrients that have been suggested to be of importance, including antioxidants, boron, calcium, chromium, iron, magnesium, and zinc. As more research develops, clearer recommendations can be made.

Do strength/power athletes need to supplement with antioxidant vitamins?

The main antioxidants receiving attention in the exercise arena are beta-carotene, vitamin C, vitamin E, and selenium. Antioxidants are touted to combat free radical damage occurring during and after exercise, including strenuous and high-intensity exercise. Most of the current research conducted on the effects of antioxidants and exercise-related free radical damage has focused on endurance athletes. Although strength/power athletes may need more of these nutrients, a specific recommendation cannot be made at this time. The best option is to consume a variety of antioxidant-rich foods such as citrus fruits, dark green and orange vegetables, nuts, seeds, and Brazil nuts.

Should strength/power athletes supplement boron intake?

Boron is a nonessential trace mineral found in foods such as fruits, vegetables, nuts, seeds, and wine. It is readily absorbed by the body, and the average dietary intake is estimated to be 1–2 milligrams a day. Boron received considerable attention in the world of strength/power sports after a study in 1987 reported that people taking boron supplements had elevated testosterone levels.[56] Boron supplements quickly appeared in the market, claiming the product could be used as an "anabolic steroid alternative." However, a review of the study reveals that the researchers' conclusions were sorely misinterpreted and taken out of context. Nielsen and colleagues[56] fed a group of postmenopausal women a *boron-deficient* diet, and then once hormone levels had dropped, a boron supplement was provided. After taking a 3-milligram daily dose of boron, serum testosterone and estrogen levels returned to normal levels. This study focused on older women who were not athletes, and the supplement was intended to correct a deficiency in the diet. When a study was conducted on young individuals engaged in the sport of body building, a boron supplement of 2.5 milligrams per day had no effect on testosterone levels, lean mass, or strength as compared to the control group.[57] An RDA has not been established for boron; however, the estimated daily requirement is thought to be 1 milligram per day. A UL has been established at 20 milligrams per day for adults 19 years or older and 17 milligrams per day for adolescents.[58] Low intake of boron, as with all nutrients, can potentially cause adverse effects; however, supplemental boron at levels higher than the 20-milligram UL have not been shown to be beneficial and can have negative effects.

Should strength/power athletes be concerned about calcium intake?

Calcium is critical for optimal bone health, muscle development, and nerve transmission in both men and women. Unfortunately, many strength/power athletes are not consuming adequate amounts of daily calcium. This deficiency is often caused by an avoidance of dairy products in the quest for a leaner body. Ironically, recent studies have shown that higher intakes of calcium can actually aid in weight loss and body fat loss.[59] Much of this research has focused on overweight individuals placed on calorie-restricted diets with varied dairy calcium or supplemental calcium intakes. Of potential interest to strength athletes is the growing evidence that high dairy calcium intake aids not only increased weight loss, but also higher body fat losses compared to low dairy or supplemental calcium intakes.[60] In addition, dairy products contain many other essential nutrients for strength/power athletes, including protein, carbohydrates, vitamin D, and riboflavin. To promote overall health and a strong body, a minimum of three to four servings of calcium-rich foods such as milk, yogurt, calcium-fortified orange juice, green leafy vegetables, soy milk, and other soy-based dairy alternatives should be consumed on a daily basis to meet, but not necessarily to exceed, current recommendations (1000 milligrams for 19- to 50-year-old men and women).

Is chromium supplementation important for strength/power athletes?

Chromium is an essential mineral involved in the regulation of insulin-mediated metabolism of carbohydrates, fats, and proteins. Some early chromium studies reported positive changes in body composition,[61,62] which have led to a variety of ergogenic claims, such as increased muscle mass, decreased fat mass, and enhanced muscular strength. However, most studies reveal no effect on body composition or muscular strength after chromium supplementation.[63–66] Chromium can be easily obtained through the diet in foods such as mushrooms, prunes, nuts, whole grains, brewer's yeast, broccoli, wine, cheese, egg yolks, asparagus, dark chocolate, and some beers.

Should strength/power athletes worry about iron?

"Pumping iron" should not be reserved only for the weight room—it should also happen in the kitchen. Strength/power athletes perform a variety of activities that often involve high-intensity, weight-bearing movements causing hematuria. Hematuria is the presence of hemoglobin or myoglobin in the urine caused by a breakdown of red blood cells (i.e., hemolysis) or damage to muscle tissue, respectively. Hemolysis has been observed in weight lifters as a result of the mechanical stress of lifting heavy weights. As is the case for hemoglobin, iron is also essential for the formation of myoglobin, which stores oxygen inside muscle cells until it is needed for chemical reactions and muscular contraction.

Sprint swimmers are a unique group of strength/power athletes that have been found to have low iron levels, even though a majority of their training is non-weight-bearing. A study conducted by Brigham and colleagues[67] examined 25 female college swimmers for iron status as well as the effectiveness of iron supplementation during the competitive season. The baseline tests revealed that 17 swimmers had depleted iron stores and 5 swimmers were classified as anemic. The experimental group consumed 39 milligrams of iron per day, which was successful in preventing a further decline in iron status as compared to the control group. However, the authors suggested that a higher dosage might be indicated to increase iron stores to a healthy range. The best line of defense is to prevent an iron deficiency from occurring by ensuring that athletes are consuming plenty of iron-rich foods daily. If anemia is suspected, a physician should be consulted before iron supplements are taken.



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Strength/power athletes should focus on sources of heme iron found in foods such as beef, poultry, and fish as well as nonheme iron, which is found primarily in plant foods such as soy products, dried fruits, legumes, whole grains, fortified cereals, and green leafy vegetables. Nonheme iron's bioavailability can be enhanced by eating nonheme foods with either a meat product or a vitamin C source.

Is magnesium supplementation important for strength/power athletes?

Magnesium has become a popular supplement in the area of strength/power sports. Because of its role in muscle contraction and protein synthesis, magnesium supplementation has been touted to increase muscle mass and strength. However, only a few studies have demonstrated an ergogenic effect, and many of the studies have not been well controlled. Therefore, the verdict is still out on whether intake of magnesium above the RDA will provide any benefit. Until the picture becomes clearer, athletes should focus on consuming magnesium-rich foods such as whole grains, green leafy vegetables, legumes, nuts, and seafood.

Why is zinc important for strength/power athletes?

Zinc has a variety of functions in the body, including roles as an antioxidant, a regulator of growth and development, and a wound healer. Strength/power athletes benefit from all these functions of zinc. Many athletes, especially those on calorie-restricted diets, may not be consuming adequate amounts of zinc, and thus it should become a focus of attention. Zinc is found in a variety of foods, including beef and other dark meats, fish, eggs, whole grains, wheat germ, legumes, and dairy products. Zinc supplements are generally not necessary when an athlete is consuming enough food.

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There is little research to support taking specific vitamins or minerals to provide an ergogenic benefit to strength/power athletes, unless an individual is deficient in a nutrient. Athletes should focus on whole foods first, ensuring balance, variety, and moderation of all food groups on a daily basis.

Is multivitamin/mineral supplementation necessary for strength/power athletes?

It is a common practice for athletes to take a multivitamin/mineral supplement on a regular basis. Although this may be a good practice for nutrient "insurance," it may not be ergogenic. Several research articles have been published reporting no performance benefit from multivitamin/mineral supplementation for athletes participating in strength/power sports.[68,69] If an athlete is looking for insurance, it is best to choose a brand containing no more than 100–200% of the Daily Value for each nutrient to prevent side effects that could be caused by ingesting large doses of vitamins and minerals.

Food for Thought 13.3

Dietary Analysis of a Power Athlete

In this exercise, you will analyze the meal plan of an athlete whose goal is to gain weight.

Are fluid needs different for strength/power athletes?

Fluid consumption and hydration are important for all types of athletes. Muscle tissue is composed mainly of water, and therefore when dehydration sets in muscular function and performance decline. Consuming adequate amounts of fluid before, during, and after strength/power training sessions and competitions will ensure that an athlete feels energetic; has the stamina for long, intense workouts; and recovers well after each session.

What issues are of concern regarding the fluid intake of strength/power athletes?

Muscle function and performance will decline when athletes are in a dehydrated state. To be well hydrated at the onset of any training session or competitive event, strength/power athletes should adhere to fluid consumption recommendations. Note that fluid losses during exercise are in addition to daily fluid recommendations. Because of the frequency, intensity, and duration of strength/power athletes' training and competition sessions, maintaining euhydration is of utmost importance and should be a dietary focus every day.

One aspect of strength/power sports that often leads to a restriction of daily fluid intake and dehydration is the weight-class system. Sports such as boxing, judo, wrestling, and weight lifting classify athletes based on body weight for competitive events. The goal for these athletes is to maximize their strength/power relative to their body weight. To gain an advantage over a competitor, many athletes will aim for weight reduction immediately prior to a weigh-in for competition so that they can compete in a lower weight category. Competing in a lower body weight category can allow the athlete theoretically to dominate an athlete who legitimately has a lower body weight and possibly also less strength and power. One of the quickest, yet unhealthiest, ways to cut weight quickly is to dehydrate the body through a variety of methods such as rubber suits, steam rooms, and the restriction of fluid intake. The magnitude of weight loss can range from a couple pounds to as high as

9.1 kilograms.[70] Athletes may aim to lose weight on a regular basis, often weekly, during the competitive season. This continuous pattern of weight loss, and then often subsequent weight gain, leads to a pattern of weight cycling, which not only can be detrimental on a daily/weekly basis, but also can have a cumulative effect over the course of an entire season. Some of the negative effects of severe and intentional dehydration include poor thermoregulation; loss of electrolytes, thus increasing the risk for cardiac arrhythmias; and extra strain on the kidneys, potentially affecting short-term function. Because of the harmful nature of these practices, many governing bodies have made changes in policies and established strict guidelines to prevent the life-threatening combination of severe dehydration and high-intensity competition.

cardiac arrhythmia A disturbance in the normal rhythmic pattern of heart activity. Severe arrhythmias can lead to sudden death.

The sport of wrestling has recently received attention for its efforts to prevent health-related problems caused by dehydration by changing its policies and procedures related to establishing a minimum weight for all athletes. Currently, both the National Collegiate Athletic Association and the National Federation of State High School Associations have minimum weight standards in place.[71,72] Minimum weight for wrestlers is established through body composition testing to ensure that athletes do not drop to unhealthy weights and body fat levels. In addition to weight and body fat testing, all colleges and many high schools are also measuring hydration through urine specific gravity, requiring a specific gravity of 1.020 or higher before assessing a minimum weight. Changes to wrestling policies and procedures are a positive step forward in safeguarding the athletes' health and performance. The established guidelines provide an example to other sports on the importance of enforcing daily hydration for athletes.

Although severe dehydration is mainly a health concern, it should be noted that it can also significantly decrease strength/power performance. The impact on performance for very short duration activities (< 30 seconds) is not as profound as for activities requiring more endurance; however, even in short bursts of effort, muscle function has been found to suffer.[73] As the duration of the event increases, the impact of dehydration becomes more evident. **Table 13.3** summarizes the known effects of dehydration on strength/power sports (adapted from Wilmore[74]).

TABLE 13.3 Effects of Rapid and Moderate Rates of Dehydration and Rehydration on Physiological Function and Strength/Power Performance

Variables	Dehydration	Rehydration
Cardiovascular		
Blood volume	↓	↓*
Cardiac output	↓	?
Stroke volume	↓	?
Heart rate	↑	?
Metabolic		
Anaerobic power (Wingate test)	↔, ↓	↔, ↓
Anaerobic capacity (Wingate test)	↔, ↓	↔, ↓
Buffer capacity of the blood	↓	?
Muscle/liver glycogen	↓	↓
Blood glucose during exercise	Possible ↓	?
Protein degradation during exercise	Possible ↑	?
Thermoregulation and Fluid Balance		
Electrolytes (muscle and blood)	↓	↔
Core temperature	↑	?
Sweat rate	↓	?
Skin blood flow	↓	?
Strength/Power Performance		
Muscular strength	↔, ↓	↔, ↓
Muscular power	?	↓†
Speed of movement	?	?
Wrestling simulation tests	↓	↔, ↓†

↓, decrease; ↑, increase; ↔, no known change or return to normal values; ?, unknown.

* From Burge et al.[75]

† Oopik et al.[76]

Source: Adapted from Wilmore JH. Weight category sports. In: Maughan RJ, ed. *Nutrition in Sport*. Malden, MA: Blackwell Science; 2000:637–645. Data acquired from reviews written by Fogelholm,[77] Horswill,[78] Keller et al.,[79] and Oppliger et al.[80]

Another unique aspect of weight classification sports is that there typically is a period of time between weighing in and the actual competition. Therefore, in between, food and fluids can be consumed in an attempt to replenish the body for high-intensity efforts and optimal performance. However,

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Strength/power athletes should make optimal hydration a top nutrition priority on a daily basis. Athletes should be educated on the harmful effects of rapid weight loss caused by dehydration and encouraged to manage weight on a long-term basis using healthy nutrition and exercise practices.

can a complete replenishment of the body actually be achieved after such a depletion? Unfortunately, very little research exists to fully explain the physiological responses and performance rebounds with rehydration. Table 13.3 summarizes the current research examining the physiological and performance effects of rapid rehydration after dehydration.

How are fluid needs during strength/power activities determined?

Maintaining euhydration during strength/power sports is similar to endurance and team sports. Athletes need to make accurate estimations of individual sweat rates, practice the consumption of the estimated amounts while exercising, and overcome any logistical barriers to fluid availability.

How do you determine individual sweat rates?

Coaches, athletic trainers, and dietitians working to keep athletes well hydrated during training and competitions need to be aware of the differences in sweat loss among different sports and treat each athlete individually based on his or her own sweat and fluid replacement needs. Not only do sweat rates need to be determined individually, but athletes also need to discover the impact of various environments on their sweat rates. For example, Grant is a 200-meter sprinter. His training consists of a combination of strength training indoors in an air-conditioned facility and sprint workouts on an outdoor track. His workouts are typically at 4:00 P.M., and therefore the outdoor track can reach temperatures of 80–95 degrees with 70–90% humidity, while the weight room is maintained at 68–72 degrees and 50–60% humidity. Performing two different sweat trials in the two different environments revealed the following:

Weight Room Sweat Trial

1. *Determine body weight lost during exercise:* Grant reported that his body weight before his weight training session was 171 pounds, and 170 pounds afterward. Therefore, he lost 1 pound of water weight during his 1-hour weight-training session indoors (171 – 170 = 1 pound of water weight loss).
2. *Determine the fluid equivalent, in ounces, of the total weight lost during exercise:* Grant lost the equivalent of 16–24 ounces of fluid during his weight training session (1 × 16–24 ounces = an additional 16–24 ounces should have been consumed to maintain fluid balance during this weight-training session).
3. *Determine the actual fluid needs of the athlete during a weight room workout:* Grant understands the benefits of euhydration for exercise performance, and therefore brings a bottle to all of his workouts. However, in the weight room he often forgets to drink, consuming only about 8 ounces of fluid in a 1-hour workout. Based on the amount of weight he lost in the weight-training workout, he should be consuming 24–32 ounces of fluid per hour in the weight room (8 ounces of fluid consumed +16–24 ounces he should have consumed to establish fluid balance =24–32 ounces of total fluid needs).
4. *Determine the number of fluid ounces needed per hour of exercise:* Because his sweat trial was performed for a 1-hour workout, Grant knows that he ideally needs to consume 24–32 ounces of fluid per hour to maintain hydration during weight-training workouts indoors in a climate-controlled environment.

Outdoor Track Sweat Trial

1. *Determine body weight lost during exercise:* Grant reported that his body weight before his track workout session was 170.5 pounds, and 168 pounds afterward. Therefore, he lost 2.5 pounds of water weight during his 1-hour outdoor track workout (170.5 – 168 = 2.5 pounds of water weight loss).
2. *Determine the fluid equivalent, in ounces, of the total weight lost during exercise:* Grant lost the equivalent of 40–60 ounces of fluid during his track workout (2.5 × 16–24 ounces = an additional 40–60 ounces should have been consumed to maintain fluid balance during this outdoor track workout).
3. *Determine the actual fluid needs of the athlete during an outdoor workout:* Grant brought a bottle to his workout; however, he consumed only a couple of sips equaling about 4 ounces. Based on the amount of weight he lost, he should be consuming 44–64 ounces of fluid per hour on the track (4 ounces of fluid consumed + 40–60 ounces he should have consumed to establish fluid balance = 44–64 ounces of total fluid needs).

4. *Determine the number of fluid ounces needed per hour of exercise:* Because his sweat trial was performed for a 1-hour workout, Grant knows that he ideally needs to consume 44–64 ounces of fluid per hour to maintain hydration during an outdoor track workout in hot, humid temperatures.

Reviewing the two sweat trials, there is a substantial difference between the two trials in different climates: 24–32 ounces of fluid are needed in a cool, dry indoor environment, whereas 44–64 ounces are required in a hot, humid outdoor setting. Grant should ensure that he is consuming the appropriate amount of fluid for each setting to prevent under- or overhydration and to optimize performance.

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Each athlete should perform several sweat trials in various indoor and outdoor environments. Sweat rates can vary dramatically, so to promote optimal hydration at all times, individual variations need to be discovered and documented, and appropriate hydration plans need to be implemented.

What should athletes drink and when should they drink it?

Similar to other sports, strength/power athletes should focus on water and sports beverages for fluid replacement during training sessions and competitive events. Water is appropriate for training sessions lasting less than 1 hour, whereas sports beverages are the preferred beverage for any activity lasting longer than 60 to 90 minutes.

Logistically, it is slightly more challenging for strength/power athletes to actually ingest adequate amounts of fluid during training, but certainly not impossible. Strength/power athletes should take hydration breaks at least every 10 to 15 minutes during training sessions. Sufficient amounts of water or sports drinks should be consumed at each break to meet individual sweat rate requirements over the course of an hour. Athletes need to take personal responsibility for maintaining hydration by bringing bottles filled with adequate amounts of water and sports beverages to every practice and drinking consistently.

How much fluid should strength/power athletes drink after training sessions and competitive events?

Strength/power athletes can lose modest to copious quantities of fluid while training and competing, which need to be replaced as quickly as possible after exercise. Athletes should strive to consume optimal (i.e., as determined by sweat trials) amounts of fluids in a timely manner.

What meal-planning/event logistics need to be considered during strength/power events?

The logistics for consuming fuel and fluids during strength/power sports are very manageable compared to other sports because of their intermittent nature. However, athletes still need to plan ahead to prepare snacks, water bottles, and recovery foods. The following sections include some ideas for snacks to eat in between efforts at competitive events as well as for quick snacks that provide optimal recovery after high-intensity workouts.

What are high-quality options for snacks between events at meets?

For strength/power sports such as track and field or swimming meets, an athlete may have several events to compete in over the course of 1 day. These situations usually entail a hard, intense effort, and then a long recovery and wait period before the next event. Athletes need to make sure they are staying fueled and hydrated throughout the day. However, at a meet their total energy expenditure is relatively small, and therefore their nutrition intake in between events should be modest. The goal is to supply enough energy to keep blood glucose and overall energy levels up, while minimizing the risk of gastrointestinal fullness and discomfort. The following small snacks would be appropriate to supply fuel to athletes between events at a meet:

- Whole fruit and juices
- Granola or energy bars
- Half a lunchmeat sandwich (access to a cooler or refrigeration is critical)
- Yogurt and low-fat milk (access to a cooler or refrigeration is critical)
- Bagels or English muffins with jelly or a small amount of peanut butter
- Fig bars
- Sports beverages and water

Athletes should practice consuming snacks during training sessions to ensure that no gastrointestinal distress will occur on competition day. Nothing new should be consumed on the day of a competitive event!

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Strength/power athletes need to take time to plan ahead for day-long meets and competitive events. Nonperishable items should be packed for between events, focusing on carbohydrate sources and fluids. After the day's events are complete, athletes should consume a carbohydrate- and protein-rich snack to begin the recovery process.

What are high-quality options for snacks after competition?

Similar to training sessions, it is imperative that athletes feed their bodies properly after competitive events to initiate the recovery process. Ideally, athletes should consume a snack within 15 to 30 minutes of completing their final event at a competitive meet. Often, the athlete is far from home and therefore dependent on packed items or food/fluid that can be purchased on the road. Planning ahead by packing a snack is always the best option. The following are several suggestions of snacks that can be packed, without refrigeration, to be consumed immediately following a competition:

- Peanut butter and jelly sandwiches
- Whole fruit
- Juices and soy milk packaged in aseptic containers (drink boxes)
- Instant breakfast powders that can be mixed with water
- Energy bars containing a combination of carbohydrates and protein
- Homemade dried fruit, dry cereal, and nut mixes

If the athlete relies on fast food or convenience store options, the best choices include:

- Cartons of low-fat milk and yogurt
- 100% juices
- Deli sandwiches
- Grilled meat sandwiches and burgers (skip excessive sauces, mayonnaise, or dips)
- Granola and energy bars

Everyone's appetite is different after hard physical efforts. Athletes need to experiment with a variety of postcompetition snacks to determine what tastes the best, settles well, and can be conveniently packed in a gear bag.

It pays to plan. The nutritional value of food/fluid options on the road is typically not as high quality as snacks packed at home. The benefits of having nutritious, familiar foods and beverages on-hand at all times far outweighs the small amount of time needed to plan ahead.

Food for Thought 13.4

You Are the Nutrition Coach

Apply the concepts from this chapter to several case studies.

The Box Score

Key Points of Chapter

- Strength athletes participate in sports that demand high levels of muscle force production. Power athletes participate in sports requiring the combination of great strength with speed of movement. Despite the difference, strength/power activities can be characterized as short, intense bouts of muscle activity.
- Short, intense bursts of muscle activity require an immediate supply of energy to the muscle. As a result, the primary system relied upon for energy during a strength/power activity is the phosphagen system. As the duration of the activity increases, the anaerobic system begins to contribute to a greater extent.
- The main dietary concern with individuals involved in strength/power sports is the consumption of adequate amounts of total daily calories. Adequate daily caloric intake not only ensures adequate energy for training, competition, and recovery, but also helps the athlete to conserve or build upon his or her current level of muscle mass. Low calorie intake can result in muscle tissue being metabolized to meet the body's energy demands. Loss of muscle tissue is detrimental to strength/power athletes.
- Because many strength/power sports rely on anaerobic metabolism, carbohydrates are the main fuel. However, because of the short duration of the effort, depletion of carbohydrate stores in the muscle is rarely the cause of fatigue in strength/power events. Therefore, carbohydrate-loading prior to competition is not necessary for strength/power sports.
- A daily intake of 6–10 grams of carbohydrates per kilogram of body weight has been shown to replenish and maintain glycogen stores in strength/power athletes. This corresponds to approximately 55–65% of the day's total calorie intake.
- Most research supports carbohydrate consumption 2 to 4 hours prior to and during strength/power sports; however, some athletes feel they perform better on an empty stomach. Because depletion of energy stores is rarely the cause of fatigue in these sports, the athlete and coach should experiment with various dietary plans and adopt one that is psychologically and physiologically compatible with the athlete.

- Ingestion of carbohydrates as soon as possible after training or sport performance is important to accelerate the replenishment of glycogen stores, provide for muscle tissue growth, and possibly attenuate immunosuppression resulting from intense training or competition.
- Protein intake is essential to accommodate the body's need for muscle repair and tissue building resulting from strength and power training. However, there is a ceiling effect, and excessive protein intake (i.e., > 2 grams per kilogram body weight) does not promote more muscle growth than the training in and of itself stimulated. Unused amino acids are converted to fat, not muscle.
- Consuming carbohydrates and protein prior to as well as after strength/power training appears to have a positive synergistic effect in regard to protein synthesis. Consuming at least 6 grams of essential amino acids with 35 grams of carbohydrates will not only aid in muscle protein synthesis, but will also speed replenishment of energy reserves.
- Fats are not a major energy source during strength/power events, and therefore special dietary consideration prior to, during, and immediately after training or competition is not required. However, fats are critical to a strength/power athlete's balanced diet and should be consumed in moderation (i.e., less than 35% of total daily calories), with the majority of fats being unsaturated.
- Vitamin and mineral supplementation in strength/power athletes has not been shown to speed recovery from training or enhance sport performance above that provided by a balanced diet. A multivitamin/mineral tablet can be taken for nutritional insurance, but the doses provided should not exceed 100 to 200% of the Daily Value.
- As with any athlete, fluid intake is essential not only for normal physiologic functioning of the body, but also for survival. Because of the differences in environmental conditions in which strength/power sports may occur, performing sweat trials will help assess an athlete's individual fluid needs.
- Rehydrating with water is appropriate for training sessions lasting less than an hour; sports beverages are preferred for activities lasting longer than an hour. A rule of thumb for rehydration is to drink 16–24 ounces of fluid for every pound of weight lost over the course of a training session or competition.
- The logistics for consuming food and fluids during strength/power sports is very manageable because of their intermittent nature. The goal is to supply enough energy to keep blood glucose and overall energy levels up, while minimizing the risk of gastrointestinal fullness and discomfort.

Study Questions

1. What is the difference between strength and power? Which group of competitive weight-lifting athletes relies more on power, power lifters or Olympic lifters? Explain.
2. What energy system provides the majority of energy during the performance of a 400-meter sprint? Which macronutrient would be most important to these athletes and why?
3. What energy system provides the majority of energy during the performance of a javelin throw? During recovery between throws, which energy system is most important?
4. How are the daily energy requirements of strength/power athletes different from endurance athletes? Discuss the specific nutritional needs of strength/power athletes and how this might affect their dietary plan.
5. For athletes wishing to gain weight, how many extra calories do they need to consume each week? What problems are associated with gaining weight too fast?
6. How much protein should be consumed, and when is it best to ingest protein if maximizing protein synthesis is the goal?
7. How would you rank the three macronutrients in order of importance to the strength/power athlete? Defend your answer.
8. How would you determine the fluid requirements for a particular strength/power athlete? What are current recommendations about the quantity and type of fluid to be used while rehydrating?
9. What are the main nutritional goals for a strength/power athlete on the day of competition?

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