GATORADE SPORTS SCIENCE INSTITUTE®

FOODS & FLUIDS FOR STRENGTH TRAINING

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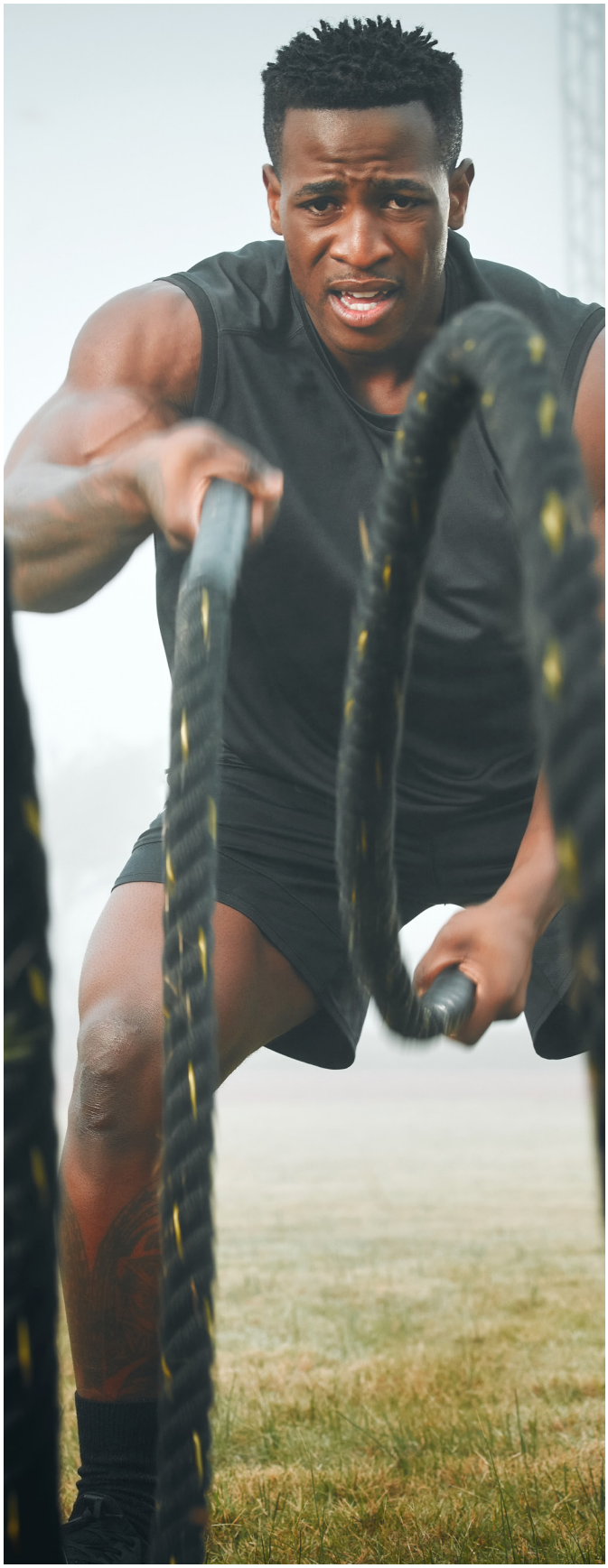
During a strength-training program, two primary adaptations occur. The first is changes in the neuromuscular system, allowing the brain to recruit more muscle fibers. The second is hypertrophy of the muscle, which means the muscle fibers increase in size. Thus, a well-designed, appropriate strength-training program results in increased strength and size of the muscle. Appropriate nutrition can support the adaptations to strength training, especially the increases in muscle size, which will be the focus of this piece.

The carbohydrate needs of an athlete during strength training have not been well researched. However, carbohydrate stored in the muscle (called glycogen) is the primary fuel source for high-intensity muscle contractions. A single strength-training session can actually decrease the amount of muscle glycogen by about 24-40%![1] Therefore, the recommendation for daily carbohydrate intake for an athlete participating in a strength-training program is 4-7 g/kg body weight.[1] Athletes should fall on the higher end of this range if they are involved in additional sport training sessions outside of strength training. The recommendation for protein intake for athletes is 1.2-2.0 g/kg/day.[2] Athletes focused on strength training to gain muscle mass will fall on the upper end of this range. In addition to the total daily amount, the pattern of ingestion is important to promote muscle growth. Consuming ~20 g or 0.24-0.31 g/kg high-quality protein about every 3 hours has been found to more effectively increase muscle protein synthesis (MPS) as compared to larger amounts ingested less frequently.[3,4,5,6] Larger amounts of protein are oxidized and not used for further muscle growth.[1] Consuming high-quality protein prior to sleep may also promote increased muscle protein synthesis. This benefit may be enhanced when performing exercise training in the evening. Research continues on the best type and amount of pre-sleep protein, but between 20-40 g is likely a good target.[7,8]



SUGGESTED DAILY MACRONUTIRENT INTAKE

(per kilogram of body weight)

Carbohydrate:[1] 5-7 g/kg/day

Protein:[5,6] 1.2-2.0 g/kg/day

PRE-WORKOUT FOODS & FLUIDS

Eating carbohydrate before a workout tops off the body's carbohydrate stores (glycogen). Since stored carbohydrate is the primary fuel source for high-intensity muscle contraction, it is likely important for strength athletes to start training sessions with enough carbohydrate stored in their bodies. Specific to strength training, consuming carbohydrate before starting may increase the total amount of work the athlete is able to complete during longer-duration, high-volume training sessions.[1,9] However, recommendations on the specific amount or timing of carbohydrate intake prior to strength training have not been determined.[1] Athletes should try various options and find a solution that provides them with energy without causing fullness or stomach upset.

OPTIONS TO PROVIDE CARBOHYDRATE ENERGY SHORTLY BEFORE TRAINING AND COMPETITION

	Serving Size	Carbohydrate	Sodium
Gatorade Energy Chews	6 chews	21 g	70 mg
Gatorade Endurance Energy Gel	1 gel	20 g	90 mg
Banana	1 medium	27 g	1 mg

Similar to all athletes, strength athletes should begin a training session in a hydrated state. In one study, athletes dehydrated by 3% of their body weight prior to beginning a strength-training session performed fewer repetitions than those beginning in a hydrated state.[10] Athletes should drink ~5-7 mL/kg of fluids with sodium approximately 4 hours prior to a workout or competition and another 3-5 mL/kg about 2 hours prior if the urine is dark or not produced.[11,12] This practice will help an athlete to begin training sessions in a hydrated state.

PRE-WORKOUT KEY MESSAGES

- Carbohydrate stored in the muscle (called glycogen) is the primary fuel source for high-intensity muscle contractions.
- Carbohydrate consumed before a strength-training session may help improve the athletes' performance; however, the ideal amounts or timing have not been identified.
- Adequate fluids should be consumed about 4 hours before a training session.

DURING-WORKOUT FOODS & FLUIDS

More research is needed on the specific fueling needs of athletes during strength training. With the research that is available right now, there does not appear to be a need for carbohydrate and amino acid or protein intake during exercise.[1] However, for athletes who lift first thing in the morning without eating breakfast, carbohydrate ingestion during the training session may improve total session training volume.[13]

DEHYDRATION

Dehydration of a 2% or more decrease in body weight during a training session (approximately a 4-lb loss in a 185-lb athlete) may negatively affect an athlete's performance,[2,12] especially if exercising in hot and humid conditions such as a gym or weight room without air-conditioning.

Answering "yes" to any of these questions may indicate inadequate hydration:

- Am I thirsty?
- Is my urine a dark yellow color (like apple juice)?
- Is my body weight noticeably lower than yesterday?

HYDRATE THE RIGHT WAY

To determine an individual's sweat rate, measure body weight before and after a training session and keep track of all fluid consumed. A rough estimate of sweat rate can be obtained by using the following equation: sweat rate (L/h) = (weight loss (lbs) + fluid intake (L))/exercise time (hours). Reference the Sweat Rate Calculator on page 10.

SODIUM

Athletes sweat, and sweat contains sodium. Consuming fluid with sodium, such as in a sports drink, is important because sodium helps maintain the physiological desire to drink and helps retain the fluid consumed.[11,12] To determine if you are a "salty sweater," wear dark-colored clothing and look for white residue after your training session. Sweat that stings your eyes may be another sign that you're a "salty sweater."

TIPS FOR HYDRATION

- Athletes should determine their individual sweat rate and consume fluids with sodium to minimize body weight changes during training sessions, especially when training in a hot, humid weight room.
- More research is needed, but there does not appear to be a need for strength athletes to consume carbohydrate, protein or amino acids during training.

SODIUM CONTENT OF LOWER CARBOHYDRATE GATORADE PERFORM BEVERAGES

	Sodium (mg/12 fl oz)	Calories (per 12 fl oz)	Carbohydrate (g/12 fl oz)
Gatorade G2	160	20	8
G Zero	160	0	0
G Fit	163	11	2

DURING-WORKOUT KEY MESSAGES

- Athletes who strength train should determine their individual sweat rate, taking into account any equipment and environment, and consume fluids with sodium to minimize body weight changes during training.
- Carbohydrate intake during exercise can help maintain performance levels in "stop and go" activities; if athletes fasted prior to strength training or will be training for >1 hour, they should aim to consume 30-60 g (120-240 calories) per hour of training.
- It is possible to train the gut! If athletes are currently consuming less than the recommendations, gradually increase intake to minimize gastrointestinal issues.

POST-WORKOUT FOODS & FLUIDS

PROTEIN FOR MUSCLE BUILDING

Nutrient intake during recovery is key to maximizing the anabolic response to an individual strength workout. Muscle tissue is continually in flux between muscle protein breakdown and muscle protein synthesis. This process allows for muscle growth when synthesis is greater than breakdown. Consuming the right types of protein following strength training helps to send a signal to the muscle to enhance rates of muscle protein synthesis as well as provides the amino acid building blocks to form the new muscle structure.

TIMING OF PROTEIN INTAKE

Protein eaten after strength training may offer some advantages to muscle building.[14] Protein consumed after exercise, whether from food or shakes and drinks, stimulates muscle protein synthesis to aid in muscle building.[14] However, the muscle remains responsive to protein intake past the immediate post-workout period, and a regular intake pattern of about every 3 hours has been shown to be beneficial.[3,4]

AMOUNT OF PROTEIN

Two dose-response studies, one using egg protein[15] and the other whey,[16] have shown that 20 g of protein consumed following resistance exercise achieved maximal rates of MPS, with no further benefit achieved at 40 g.[15,16] However, both studies utilized a leg-only exercise protocol. In a study using a whole-body resistance exercise protocol, 40 g of whey protein resulted in significantly greater MPS than 20 g, with no difference found when the subjects were segmented for lean body mass.[17] Based on current research, it appears most athletes should aim for ~20 g or 0.24-31 g/kg of protein for recovery following training.[3,5,6,10,15,16,17]

PROTEIN TYPE

Following exercise, athletes should consume some rapidly digested, high-quality, complete protein sources rich in the amino acid leucine.[14] A complete protein contains all of the essential amino acids, or those the body doesn't make on its own. Dairy proteins, particularly whey, meet all these criteria and are considered most beneficial to promote post-exercise MPS.[14] Soy is a complete plant protein; however, it is not as rapidly digested and contains lower levels of leucine.[18,19] Research is emerging on the use of plant-based proteins for recovery and muscle gain. Athletes consuming plant-based proteins should ensure they are eating a variety of foods in order to meet their essential amino acid needs to support recovery and training adaptations.[20]

CARBOHYDRATE

Co-ingesting of carbohydrate with protein does not enhance the response of muscle protein synthesis.[14] However, athletes involved in higher repetition, longer duration strength-training sessions or those combining strength training with additional sessions of sport training should consume carbohydrate to replenish glycogen (carbohydrate stored in the muscle and liver). When co-ingesting carbohydrate with protein following strength training, athletes should aim for 0.8 g/kg/hour.[1]

HYDRATION

Following exercise, athletes should drink 20-24 oz of fluid with sodium per pound of body weight lost to replace the amounts lost during training and competition.[2,12]

PROTEIN CONTENT OF GATORADE RECOVERY PRODUCTS

	Calories	Carbohydrate (g)	Protein (g)	Protein Source
Gatorade Recover Protein Shake	270	45	20	Milk protein concentrate, whey protein concentrate
Gatorade Recover Whey Protein Bar	340-370	42-43	20	Whey protein isolate, whey protein concentrate
Gatorade Whey Protein Powder	120	6	20	Whey protein concentrate, milk protein isolate
Gatorade Super Shake	170-180	10-11	30	Milk protein isolate, whey protein concentrate
Muscle Milk 100% Whey Protein Powder	130	3	25	Whey protein isolate, whey protein concentrate
Evolve Plant-Based Protein Powder	160	21	20	Pea protein isolate

POST-WORKOUT KEY MESSAGES

- Athletes should consume ~20 g or 0.24-0.31 g/kg, of high-quality protein as soon as possible following training to help rebuild muscle tissue and promote the synthesis of new muscle proteins.
- The protein type should be a high-quality, complete protein. Consider milk or whey protein due to the high leucine content.
- Restore carbohydrate with protein to replace used glycogen (carbohydrate stored in the muscle and liver) when completing higher repetition/longer duration bouts or when involved in additional sport training sessions.
- Rehydrate with 20-24 oz of fluid with sodium for every ounce of body weight lost during exercise.

AN EXAMPLE: PUTTING THE SCIENCE-BASED RECOMMENDATIONS INTO PRACTICE

ATHLETE PROFILE

Name: Jeff

Age: 17

Weight: 155 lbs (70.5 kg)

Type of athlete: Boys high school football player

Goal: To gain muscle mass during the off-season

Jeff is a safety on his high school football team. Football season is over, and his goal for the spring weight-training sessions is to gain lean mass to help him improve on the field for his senior year. Jeff also competes in the 800-meter event for the track team in the spring, so he will be involved in workouts beyond just those in the weight room. Jeff is looking for nutrition advice to help him gain the muscle mass he desires for football while still having the energy to compete in track.

Overall calorie intake is important to gain lean muscle mass and support the energy demands of both his strength-training program and track practices/ competitions. To determine his overall energy needs, Jeff will work with a sports dietitian who will assess his daily energy expenditure and recommend calorie goals.

Specific to gaining lean mass while ensuring adequate energy stored as muscle glycogen, Jeff will need to pay particular attention to his carbohydrate and protein intake. Since he is training for and competing in the 800-meter race, his carbohydrate needs should be at the upper end of the recommended range. Based on his energy needs, the sports dietitian has suggested starting at 6 g/ kg/ day and will adjust based on Jeff's feelings of energy and tolerance for the volume of food. At 6 g/kg/day, Jeff should consume ~423 g carbohydrate per day (1,692 calories from carbohydrate). For protein, he should also aim for the upper end of the recommended range, a good place to start may be about 1.7 g/kg/day. At that level, Jeff should consume ~120 g of protein over the course of the day (480 calories from protein), spread out in increments of 17-22 (0.24-0.31 g/kg) or ~20 g per meal or snack. In the first weeks of the plan, Jeff will work with his sports dietitian to tweak the amounts of these two important macronutrients to make sure he is getting what he needs to support his goals without upsetting his stomach. Jeff's plan will also include adequate fat and the right amount of micronutrients from fruits and vegetables to support overall health and performance.

In addition to eating the right amounts of carbohydrate and protein throughout the day, recovery nutrition is especially important for Jeff to meet his goal of increased lean mass. Therefore, Jeff is instructed to eat one of his ~20 g servings of protein as soon as possible after each workout to stimulate the generation of new muscle

proteins, the key to gains in lean mass. This serving of ~20 g should be a complete, high-quality protein source, preferably from milk or whey sources. His sports dietitian has recommended the Gatorade Recover Protein Shake or the Gatorade Recover Whey Protein Bar as convenient ways to get the right type and amount of protein after his training sessions. The shake or bar will also provide adequate carbohydrate to replace muscle glycogen, the important storage form of energy for muscle contraction. A couple of hours later, Jeff should then have another meal or snack with ~20 g of a complete, high-quality protein source. This may again be milk-based or whey or may also be a meal of meat, eggs or a combination of complementary proteins such as rice and beans.

Lastly, it is important for Jeff to make sure he is hydrated during his strength-training workouts, especially since the weight room is hot and humid. Jeff already does a good job drinking water throughout the day, but the sports dietitian has taught him how to monitor his urine color before workouts to make sure it is a light lemonade color before beginning. To develop a hydration plan specific to the strength workouts in the environment of the weight room, the sports dietitian determined his sweat rate by measuring body weight before and after a typical strength workout. By doing this, it was determined that Jeff should drink a 20 oz bottle of Gatorade G2, G Zero or Propel for every hour in the weight room to replace the fluid and electrolytes he loses in his sweat.

By following this plan, Jeff should have energy for effective strength and track workouts, and will have the nutrition to support his training in obtaining the goal of increased muscle mass. Good luck to Jeff in his senior football season!

Any opinions or scientific interpretations expressed in this document are those of the author and do not necessarily reflect the position or policy of PepsiCo, Inc.

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CALCULATIONS/YOUR WORKSHEET

1. BODY WEIGHT

For many calculations, you need to know your body weight in kilograms. To do this calculation:

Body weight in pounds _____ / 2.2 = [ ] kg

2. DAILY MACRONUTRIENT NEEDS

Carbohydrate:

_____ body weight (kg) * 5 g/kg = [ ] grams per day

TO

_____ body weight (kg) * 7 g/kg = [ ] grams per day

Protein:

_____ body weight (kg) * 1.2 g/kg = [ ] grams per day

TO

_____ body weight (kg) * 2.0 g/kg = [ ] grams per day

Amounts within these ranges should be determined based on the requirements of the individual sport and athlete.

3. BEFORE-EXERCISE CARBOHYDRATE NEEDS

A. Enter the time before exercise you like to eat (1-4 hours): _____ (h)

B. Enter your desired amount of carbohydrate (1-4 g/kg body weight): _____ (g)

C. Pre-exercise carbohydrate intake = _____ body weight (kg) * _____ carbohydrate amount from line 2 (g/kg) = [ ] g carbohydrate

4. BEFORE-EXERCISE FLUID NEEDS

A. 4 hours prior to exercise:

_____ body weight (kg) * 5 mL/kg = [ ] mL

TO

_____ body weight (kg) * 7 mL/kg = [ ] mL

B. 2 hours prior to exercise (if needed):

_____ body weight (kg) * 3 mL/kg = [ ] mL

TO

_____ body weight (kg) * 5 mL/kg = [ ] mL

To convert mL to oz: _____ mL * 0.03 = _____ fluid oz

5. DURING-EXERCISE CARBOHYDRATE NEEDS

The recommendation is 30-60 g/hour, no calculation needed. Amount should be determined based on the requirements of the individual sport and athlete.

6. DURING-EXERCISE FLUID NEEDS

A. Pre-exercise weight = _____ lbs

B. Fluid consumed during exercise = _____ L

(_____ fluid oz / 33.8 = _____ L)

C. Post-exercise weight = _____ lbs

D. Weight change = Pre-exercise weight _____ lbs - Post-exercise weight _____ lbs = [ ]

E. Exercise time = _____ hours

F. Sweat rate = (Weight change _____ + Fluid intake _____ L) / _____ hours = [ ] L/h

7. POST-EXERCISE CARBOHYDRATE NEEDS (WHEN <8 HOURS RECOVERY)

body weight _____ (kg) * 1 g/kg = [ ] g carbohydrate

TO

body weight _____ (kg) * 1.2 g/kg = [ ] g carbohydrate

8. POST-EXERCISE FLUID NEEDS

Weight lost = Pre-exercise weight _____ lbs - Post-exercise weight _____ lbs = [ ]

Fluid needs:

_____ body weight lost * 20 oz = [ ] oz

TO

_____ body weight lost * 24 oz = [ ] oz

9. POST-EXERCISE PROTEIN NEEDS

About 20 g is appropriate for most athletes; however, to calculate your individual needs use this equation:

body weight _____ (kg) * 0.25 g = [ ] g protein

TO

body weight _____ (kg) * 0.3 g = [ ] g protein


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