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Optimal nutrition is important for physically active people, whether they are competing at an elite level or exercising on a routine basis. There is growing interest in the potential use of fluid milk and whey protein for athletes and active individuals wishing to improve their training diet and/or their recovery after exercise. This report reviews the emerging research showing that milk, unflavored or chocolate, after exercise may be as effective as some commercial sports drinks in helping the body refuel, recover, and rehydrate from intense exercise. It reviews the research showing that milk's high-quality protein helps build and repair muscles, and provides protein intake recommendations for athletes and those who exercise regularly.

Scientific Status Report

Introduction

Optimal nutrition is important for physically active persons, whether competing at an elite level or exercising on a routine basis.[i,ii] Individual nutritional needs will vary depending on age, gender, the training status of the exerciser, the type, duration, and intensity of exercise, and the environment (e.g., altitude, temperature).[i] Adequate intake of carbohydrate and fluids before, during, and after exercise and high-quality protein before and after exercise helps to maintain body weight and blood glucose levels during exercise, maximize sports performance, and improve recovery.[i,ii] There is growing interest in the potential use of dairy, whether in the form of fluid milk or as a protein ingredient (e.g., whey protein), as options for athletes and active individuals wishing to improve their training diet and/or post-exercise recovery.[iii,iv] Milk, including flavored milk, is a nutrient-rich beverage that provides high-quality protein to help rebuild muscle and reduce muscle breakdown, carbohydrates to help refuel muscles (restore muscle glycogen), fluid and electrolytes to rehydrate and replenish what is lost in sweat after intense exercise, and vitamins and minerals to help build and maintain strong bones and support overall health.[iii] Whey protein, a high-quality protein found in milk, is an ingredient that can be added to a variety of foods (e.g., yogurt, nutrition bars) to help promote post-exercise muscle repair and recovery.[iv]

Milk as a Post-Exercise Recovery Beverage

Emerging research shows that drinking milk, unflavored or chocolate, after a workout may be as effective as some commercial sports drinks in helping the body recover and rehydrate from exercise.[iii]

Milk helps replenish fluids and electrolytes lost during exercise. Consuming sufficient fluid before, during, and after exercise is important to limit dehydration (loss of water greater than 2% to 3% of body mass).[i,ii] Dehydration, especially in warm and high-altitude environments, can compromise performance. Strategies to enhance fluid recovery are particularly important for athletes participating in several events in a short period of time.[ii] Drinking milk after an exercise event has been demonstrated to be an excellent strategy to replace fluids and electrolytes lost during exercise, and may even be more effective at maintaining hydration after exercise than water or traditional sports drinks.[iii,v,vi] Milk's natural electrolytes (e.g., potassium, sodium) likely contribute to its ability to restore fluid balance.[v] Also, milk's protein may contribute to its hydration effects.vii When fluid retention following intake of a carbohydrate-milk protein solution was compared to a carbohydrate solution matched in energy density, fat content, and electrolyte concentration in [8] males after exercise-induced dehydration, it was found that milk protein was more effective in improving fluid retention than carbohydrate alone.[vii]

Milk helps rebuild muscle. Several studies support the benefits of milk consumed as a post-workout beverage in increasing the body's ability to make new muscle and potentially improve body composition.[iii,viii,ix,x] In a short-term investigation in eight young males, consumption of fat-free milk following resistance exercise (weightlifting) promoted a greater overall increase in net muscle protein balance and muscle protein synthesis compared to an equivalent amount of a soy protein beverage.[viii] A later study by the same group of investigators examined whether these short-term benefits would lead to increased gains in lean body mass over the long-term.[ix] In this investigation of 56 healthy young men who participated in 12 weeks of weightlifting,

regularly consuming fat-free milk immediately and one hour after resistance exercise promoted greater body composition benefits – measured as increased gains in lean body mass and reductions in body fat – compared to consuming a fat-free soy beverage (equal in protein content and calories) or a carbohydrate-based beverage (equal in calories).[ix] A study of 20 young untrained women engaged in resistance exercise showed that consumption of 2 cups of fat-free milk immediately and again one hour after exercise, 5 days/week for 12 weeks, resulted in greater gains in muscle mass, greater losses of body fat, increased gains in strength, and a beneficial effect on bone turnover indicators compared to those who consumed an isoenergetic carbohydrate drink.x

Emerging research suggests that consuming milk following resistance exercise may suppress exercise-induced muscle damage, although additional research is needed. To examine the effects of milk on post-exercise muscle damage, 24 men who regularly participated in team sports were randomized to consume reduced-fat milk, a low-fat chocolate milkshake (i.e., a milk-based protein-carbohydrate drink), a commercially available carbohydrate sports drink, or water.[xi] The men consumed 2 cups of the assigned beverage immediately and again within 2 hours after resistance exercise that was designed to induce acute muscle damage. Consumption of milk and a milk-based protein-carbohydrate drink led to a reduction in markers of exercise-induced muscle damage 48 hours later.[xi] This study suggests that a combination of protein and carbohydrate may be a key nutrition factor for attenuating exercise-induced muscle damage.xi In a study of 13 male soccer players, a marker of muscle damage (serum creatine kinase) was significantly lower in those who consumed low-fat chocolate milk after each of four days of training compared to a high carbohydrate recovery beverage.[xii]

Research indicates that consuming chocolate milk may be an ideal beverage choice for enhancing recovery after endurance exercise, in turn improving subsequent performance.[iii,xiii] In a study of nine endurance-trained male cyclists, those who drank low-fat chocolate milk immediately after intense exercise and again after two hours of recovery were able to bike longer before reaching exhaustion during a second workout compared to cyclists who drank a commercially available sports beverage (i.e., a carbohydrate-protein replacement drink) and as long as those who consumed a commercially-available fluid replacement drink.[xiv] The researchers suggest that because of chocolate milk's carbohydrate and protein content, it may be considered an effective recovery aid between two exhausting glycogen-depleting exercise bouts.[xiv] Additional support for chocolate milk as a post-exercise recovery beverage was found in a similar study consisting of three experimental trials in which nine male trained cyclists consumed one of three isocaloric beverages immediately after the first cycling exercise, and again two hours after intense exercise.xv The cyclists consuming chocolate milk sustained subsequent exercise for 51% and 43% longer than when consuming a commercially available carbohydrate or fluid replacement sports drink, respectively.[xv] Likewise, performance (treadmill time to exhaustion) was better for male runners who consumed fat-free chocolate milk post-exercise than a non-nitrogenous, isocaloric carbohydrate control beverage.xvi This study also showed increased muscle protein synthesis and suppression of markers of muscle breakdown in the runners who consumed chocolate milk.[xvi]

Recent studies carried out at the University of Texas at Austin add support to the beneficial effects of drinking low-fat chocolate milk after endurance exercise on performance, exercise

recovery, and body composition (i.e., more muscle, less fat). In one study, 10 trained endurance cyclists and tri-athletes who rode a bike for 90 minutes at moderate intensity, then for 10 minutes of high intensity intervals, consumed one of three recovery drinks - low-fat chocolate milk, a calorie and fat-matched carbohydrate beverage, or non-caloric flavored water - immediately and two hours following exercise.[xvii] Results showed that low-fat chocolate milk improved performance in a second bout of exercise (reduced ride time for the same distance) by an average of six minutes compared to the carbohydrate sports drink or calorie-free water. Also, low-fat chocolate milk increased signals for muscle protein synthesis, which leads to the repair and rebuilding of muscles, and was more effective than water in restoring carbohydrate fuel in the muscle.xvii Findings of a similarly designed study in 32 healthy, untrained participants who followed a 4 ½ week aerobic training program consisting of one hour of moderately intense cycling, five days each week, showed that drinking low-fat chocolate milk after exercise improved aerobic power and body composition (i.e., increased lean muscle, decreased body fat) more than carbohydrate alone.[xviii] Other studies have demonstrated that consumption of carbohydrate beverages with added protein by trained athletes after exercise improves performance beyond that of carbohydrate alone.[xix,xx]

Milk's High-Quality Protein Helps Build and Repair Muscles

Consuming an adequate intake of dietary protein or essential amino acids proximal to resistance exercise has been demonstrated to increase muscle protein synthesis, which can result in a positive net protein balance and may promote muscle growth.[iii,iv] A growing body of evidence suggests that the source of dietary protein influences exercise-induced muscle protein synthesis.[iv,xxi] Milk protein has been shown to elicit a greater response in post-exercise muscle protein synthesis than soy protein.[viii,ix,xxii,xxiii] In particular, attention has focused on the beneficial effect of whey protein in stimulating muscle protein synthesis when consumed following resistance exercise.[iv,xxi,xxiv, xxv] Whey protein, a complete protein naturally found in milk, is rapidly digested, thereby more quickly increasing the availability of essential amino acids, which may enhance muscle synthesis.[iv,xxvi] Also, whey protein is a rich source of the branched chain amino acid leucine,[iv] which is unique in its ability to initiate muscle protein synthesis.xxvii A randomized crossover study in eight adults found that muscle protein synthesis following exercise was 33% greater after consuming a leucine-enriched amino acid supplement during one hour of moderate cycling compared to intake of a similar amino acid supplement lower in leucine. xxviii A recent review of human intervention studies examining the effects of whey protein on muscle protein synthesis led the authors to conclude that the combination of whey protein and resistance exercise is effective in promoting muscle protein synthesis.xxv Whey protein may also enhance recovery from heavy exercise .[iv,xxix]

Intake of 20 g of whey protein has been demonstrated to maximally stimulate muscle protein synthesis following resistance exercise in young adults, whereas for older adults 40 g of whey protein is necessary.[xxx] With respect to timing of intake, there is general agreement that consuming protein such as whey in close temporal proximity to exercise can help promote muscle protein synthesis which may lead to accretion of muscle mass.[xxi,xxii,xxiii]

Protein Intake Recommendations for Competitive Athletes and Adults who Exercise Regularly

The American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada, in their joint position statement, "*Nutrition and Athletic Performance*," recommend protein intakes ranging from 1.2 to 1.7 g per kg body weight per day (0.5-0.8 g/lb body weight per day) – an amount greater than the Recommended Dietary Allowance (RDA) for protein of 0.8 g/kg (0.4 g/lb) per dayxxxi – for athletes.i Similarly, the International Society of Sports Nutrition recommends higher daily protein intakes for active adults participating in vigorous exercise and sports – 1.0 – 1.6 g/kg/body weight for endurance exercise, 1.4-1.7 g/kg/body weight for intermittent sports (e.g., soccer), and 1.6 – 2.0 g/kg body weight for strength/power exercises (e.g., weight lifting).[xxxii] Not only is it recommended that athletes participating in high intensity exercise consume dietary protein in daily amounts greater than those recommended for the general population, but also that foods containing high-quality protein be consumed regularly throughout the day and in particular soon after exercise.[ii] The International Olympic Committee recommends intake of foods and beverages providing 15 to 25 g of high-quality protein after each training session "to maximize the synthesis of proteins, to aid in long-term maintenance or gain of muscle and bone and in the repair of damaged tissues." [ii]

A review of the science led one researcher to recommend consumption of at least 25 g of high quality protein containing at least 8-10 g essential amino acids consumed as soon as possible after exercise for optimal stimulation of post-exercise muscle protein synthesis.[xxi] Moreover, a large, single dose of protein (25 g of whey protein) consumed immediately after resistance exercise appears to stimulate muscle protein synthesis more effectively than smaller amounts consumed over time.xxxiii Milk, including flavored milk, is a good source of high-quality protein, providing about 8 g per 8 fluid oz serving (1 cup). [xxxiv]

Conclusion

Emerging research shows that drinking low-fat milk, unflavored or chocolate, after resistance exercise may be as effective as some commercial sports drinks in helping the body refuel, recover, and rehydrate from exercise. Consuming low-fat milk as a post-exercise beverage can help meet the increased protein needs of adults engaged in vigorous exercise, such as athletic activities and regular exercise training, as well as the 2010 Dietary Guidelines for Americans' recommendation for adults to consume 3 daily servings of low-fat and fat-free milk and milk products.[xxxv] Also, whey protein, a versatile dairy-based functional ingredient that can be added to foods such as smoothies, nutrition bars, yogurt, and oatmeal can provide athletes with additional options to help enhance their training diet and post-exercise recovery.

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