International Journal of Sport Nutrition and Exercise Metabolism, 2016, 26, 179-184
http://dx.doi.org/10.1123/ijsnem.2015-0216

Human Kinetics
CASE STUDY

Case Study: The Role of Milk in a Dietary Strategy to Increase Muscle Mass and Improve Recovery in an Elite Sprint Kayaker

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Flatwater kayaking requires upper-body muscle strength and a lean body composition. This case study describes a nutrition intervention with a 19-year-old male elite sprint kayaker to increase muscle mass and improve recovery posttraining. Before the intervention, average daily energy intake was 13.6 ± 2.5 MJ (*M* ± *SD;* protein, 1.8 g/kg; carbohydrate, 3.6 g/kg), and the athlete was unable to eat sufficient food to meet the energy demands of training. During the 18-month intervention period, the athlete's daily energy intake increased to 22.1 ± 3.8 MJ (protein, 3.2 g/kg; carbohydrate, 7.7 g/kg) by including milk-based drinks pre- and posttraining and before bed and an additional carbohydrate-based snack midmorning. This simple dietary intervention, along with a structured strength and conditioning program, resulted in an increase of 10 kg body mass with minimal change in body fat percentage. Adequate vitamin D status was maintained without the need for supplementation during the intervention period. In addition, the athlete reported the milk-based drinks and carbohydrate snacks were easy to consume, and no adverse side effects were experienced. This was the first time the athlete was able to maintain weight during intensive phases of the training cycle.

Keywords: muscle protein synthesis, energy balance, training

The case study is a 19-year-old male sprint kayaker racing over 200-, 500-, and 1,000-m distances and a member of the British Canoe Union Olympic Development Program and National under-23 training squad based at Teddington. Because kayaking is a sport that requires upper-body muscle strength and a lean body composition (Michael et al., 2008), the athlete's aim was to focus on his physical development and increase muscle mass and strength. He was set a target by his Great Britain sprint coach to increase body mass from 78 to 85 kg by January 2014 and to 90 kg by January 2015. The dietary intervention took place between January 2013 and October 2014, and the athlete was referred for nutrition support by his strength and conditioning coach, who was concerned that he was fatigued and not recovering well between training sessions. A further consideration was that the athlete had undergone wrist surgery in September 2013 and had a 6-week rehabilitation period before resuming weight training in November 2013. The athlete has read, approved, and provided written permission for this case study to be published.

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Background and Rationale

A dietary intervention was developed to support the athlete's training goals. An important focus was to ensure day-to-day energy needs were met and a positive energy balance for growth and development of muscle mass. A Sports Dietitians Australia position statement (Desbrow et al., 2014) has also advised that developing athletes typically have higher energy requirements to support daily training volume, lifestyle activity, and growth and recommended a regular spread of high-quality carbohydrate and protein sources over the day, especially immediately after training. A further goal for the athlete was to maintain weight during intensive training phases, overseas training camps, and racing regattas because he had previously lost lean mass gained from winter weight training.

Postexercise nutrition was therefore a priority to improve recovery via replenishment of glycogen stores and fluid and electrolyte losses and to optimize muscle protein synthesis (MPS). Studies have demonstrated that protein ingestion postexercise increases the rate of MPS and suppresses muscle protein breakdown (Phillips et al., 2005). Moore et al. (2009) concluded that the optimum protein intake for promoting net muscle protein gain was 20 g; therefore, 20–25 g protein with carbohydrate was advised postexercise. A growing body of evidence has suggested that dairy proteins are most effective in stimulating MPS and whole-milk ingestion postexercise promoted gains in fat-free mass (Tipton et al., 2004). Men who consumed milk after resistance exercise compared with soy protein or a carbohydrate drink had improved gains in lean muscle mass and greater hypertrophy after 12 weeks training (Hartman et al., 2007; Moore et al., 2009). These results were attributed to the higher proportion of essential amino acids, particularly leucine in whey protein and differences in digestion and absorption kinetics affecting uptake of amino acids into muscle (Katsanos et al., 2006; Wilkinson et al., 2007). A further study (Cockburn et al., 2008) compared semiskim milk and a flavored milk drink with a sports drink or water after eccentric exercise. Results showed improved recovery from muscle-damaging exercise in those who consumed both the milk and the flavored milk drink but not in those who consumed the sports drink or water.

Notably, milk has a naturally high electrolyte content with sodium levels of approximately 133 mg/250 ml, comparable with typical levels (115–211 mg/250 ml) provided by sports drinks (Roy, 2008; Shirreffs, 2009). Furthermore, studies have shown that consumption of low-fat milk postexercise was more effective than water or a 6% carbohydrate electrolyte drink at restoring and maintaining hydration (Shirreffs et al., 2007; Watson et al., 2008).

Evidence for the role of vitamin D in stimulating MPS and improving musculoskeletal performance has come to the fore in recent years. It was therefore important that the athlete maintain an adequate serum vitamin D3 status of at least 70–80 nmol/L 25(OH) D throughout the training cycle, especially during winter months (Close et al., 2013; Willis et al., 2008).

Case Presentation

The athlete lived with his parents and was studying for A levels. He trained two times per day with 1 rest day (Sunday) and attended Great Britain under-23 training sessions at Dornay, Teddington, and Bisham one weekend per month, which involved staying in a shared house with the London-based kayakers and preparing his own food. Table 1 describes a typical training and school day routine.

Dietary Assessment

An initial assessment of nutritional intake and energy requirements was performed along with body composition analysis and a blood test to measure vitamin D status. The athlete was asked to complete a 7-day food and fluid diary and instructed to estimate portion sizes using standard household measures. Training sessions undertaken

Table 1 Typical Daily Food Intake and Training Activity Preintervention

Activity	Food or drink
5:30 a.m.: 1st breakfast	Porridge oats (80 g), milk (284 ml), orange juice (200 ml), water
6:00–7:00 a.m.: Training Morning paddle 5×/week A typical aerobic session consisted of 1 × 1 hr steady-state paddling, whereas an anaerobic race preparation session consisted of 4 × 1,000 m at increasing stroke rate (60, 70, 75, 85) and paddling back between	
7:30 a.m.: 2nd breakfast	2 eggs scrambled (120 g), 2 slices whole wheat toast (62 g), cream cheese (30 g), orange juice (200 ml)
8:30 a.m.: School	
1:00 p.m.: Lunchbox at school	Pasta salad with peppers, tomato, basil, olive oil (335 g), ham (46 g), mascarpone (30 g)
3:50 p.m.: Pretraining snack	Ready-made quiche (200 g)
6:00–7:00 p.m.: Training Strength training 3×/week Paddle then stretch 1×/week Swim then stretch 1×/week Run or bike 1×/week	
8:00 p.m.: Dinner	Chicken breast (200 g), apricot and coriander couscous (230 g), tomatoes (85 g)
10:00 p.m.: Bed	

over the same 7-day period were also recorded. Where possible, information on food labels and photographs of meals were provided to estimate amounts consumed. On completion of the diary, the athlete was contacted by telephone to ask about any foods that may have been forgotten and to clarify preparation methods. The food records were then analyzed using dietary analysis software (Compeat Pro, Nutrition Systems, Banbury, UK), and energy requirements were estimated from Department of Health (1991) reference nutrient intakes for age and physical activity level.

The athlete's mean daily energy intake preintervention was 13.6 ± 2.5 MJ. When compared with the reference nutrient intake (RNI) for age and physical activity level, an energy deficit of 1.3 MJ per day was noted. Furthermore, mean carbohydrate intake was just 282 ± 128 g (3.6 g/kg) and below the recommended level of 5–7 g/kg (International Olympic Committee, 2010). Mean daily protein intake was 139 ± 33 g (1.8 g/kg) and within the acceptable range for elite athletes, but intakes up to 2.5g/kg are considered beneficial during intense training (Phillips & Van Loon, 2011).

Anthropometry

The athlete attended the High Performance Sports clinic at the University of Kent for physiological and anthropometrical testing. Body fat percentage was assessed using skinfold calipers (Harpenden, UK) by a qualified sport and exercise scientist. The baseline test used a seven-site skinfold measure and subsequent tests of three sites. Body fat percentage was determined using seven- and three-site equations (Jackson & Pollock, 1978). Anthropometric and nutritional assessments are shown in Table 2.

Overview of the Nutritional Intervention

A planned approach to recovery within 30 min of training sessions was developed to ensure replenishment of glycogen stores and sufficient quantity and quality of protein to stimulate MPS. Flavored milk was recommended because it provides a source of high-quality dairy proteins along with carbohydrate, minerals, and electrolytes to replenish muscle glycogen and restore hydration. A bespoke homemade recovery shake was designed using 568 ml semiskim milk, 50 g skim milk powder fortified with vitamins A and D, and 50 g of commercial milkshake flavor (Nesquik, Nestle UK, Carlisle, UK) fortified with iron, magnesium, calcium, phosphorus, B vitamins, and vitamins A, C, and D. The milkshake flavor also provided additional carbohydrate to that naturally present in milk. The nutritional composition of the homemade recovery shake per 568 ml was 2,248 kJ, 39 g protein, 103 g carbohydrate, 537 mg sodium, and 4.6 µg vitamin D.

The athlete also had access to Maxiraw and Maxifuel nutritional supplements via the GlaxoSmithKline partnership with the British Canoe Union. In accordance with U.K. antidoping guidelines (U.K. Anti-Doping, 2013), it was confirmed that these products were batch tested and registered with Informed Sport. Their nutritional composition was evaluated in relation to the athlete's nutritional requirements and compared with the homemade recovery shake. Other factors—for example, cost, convenience, and availability of products during overseas training camps and regattas—were also discussed. The Maxiraw whey protein (per 25 g) made with water provided insufficient carbohydrate and electrolytes for recovery. An alternative Maxifuel recovery drink (per 75 g) offered a better balance of protein (14.5 g) and carbohydrate (55 g), but sodium (90 mg) was significantly lower than in the milk-based shakes. Nutritional comparisons concluded that two servings along with additional electrolytes were required to achieve the more favorable energy, protein, carbohydrate, and sodium content of the homemade recovery shake. The athlete decided to use the homemade recovery shake on a day-to-day basis after training and continued to use it at racing regattas and during a 3-week overseas training camp in Seville. A carbohydrate-based midmorning snack was also advised to enhance replenishment of glycogen stores, as was a probiotic drink (Yakult,

Table 2 Anthropometric and Nutritional Assessment of the Athlete

Athlete characteristic	Preintervention	Postintervention
Age (years)	18	19
Height (m)	1.93	1.93
Body mass (kg)	78	88
Body mass index (kg/m2)	20.9	23.6
Body fat (%)	5.8	6.8
Mean energy intake (MJ; *M* ± *SD* [RNI])	13.6 ± 2.5 (14.8)	22.1 ± 3.8
Mean protein intake (g; *M* ± *SD* [g/Kg body mass])	139 ± 33 (1.8)	273 ± 35 (3.2)
Mean carbohydrate intake (g; *M* ± *SD* [g/Kg body mass])	281 ± 128 (3.6)	671 ± 152 (7.7)
Mean vitamin D intake (µg; *M* ± *SD* [RNI[a]])	3.5 ± 1.1 (0–10)	17.8 ± 1.8
Serum vitamin D (nmol/L; 70–200 nmol/L replete)	120	78

Note. RNI = reference nutrient intake.

[a]Currently under review

South Ruislip, UK) with breakfast to prevent respiratory illness (Gleeson et al., 2011). Table 3 describes the athlete's typical daily food intake during the intervention.

The 6:00 a.m. water-based training presented a challenge because the athlete found eating a large bowl of porridge difficult to manage and bulky before an intensive training session. A trial was undertaken using a breakfast shake made with 568 ml full-fat milk, 50 g skim milk powder, 50 g milkshake flavor, two bananas, and a 36-g sachet of instant porridge that provided a higher energy (4,559 kJ), protein (48 g), and carbohydrate (172 g) content than the porridge. The athlete preferred the convenience of the shake, which he prepared before leaving home and consumed on the journey to the river, and felt more comfortable during training. The athlete's dietary intake and body mass was monitored on a regular basis, and contact was maintained during overseas training camps via email and telephone to address any concerns.

Outcome of the Intervention

Body mass increased by 10 kg to 88.0 kg during the 18-month intervention (Table 2). The initial increase from 78.0 kg to 85.8 kg during the weight-training phase was maintained throughout the intensive training camp in Seville but decreased to 84.6 kg during the racing season. After a review, the athlete was advised to increase energy intake further to reflect a higher resting metabolic rate and energy requirement associated with increased muscle mass. This increase was achieved by replacing semiskim milk in the homemade shakes with full-fat milk. Thereafter body mass increased to 88.0 kg and was subsequently maintained, indicating an appropriate energy intake. Body fat initially increased from 5.8% to 8.2% postsurgery (November 2013) and on return to training decreased to 7.6% (July 2014), 7.9% (September 2014), and 6.8% (March 2015).

Average daily energy intake increased by 8.4 MJ/day to 22.1 ± 3.8 MJ during the intervention, and protein intake increased from 139 ± 33 g (1.8 g/kg) to 273 ± 35 g (3.2 g/kg) and carbohydrate intake from 282 ± 128 g (3.6 g/kg) to 671 ± 152 g (7.7 g/kg). The milk-based shakes and drinks supplied 58% of energy intake and 52% and 66% of protein and carbohydrate intake, respectively, making a significant contribution to the athlete's increased nutritional intake. No change to the athlete's other food intake was noted. Average vitamin D intake increased to 17.8 ± 1.8 μg, and serum vitamin D status was 78 nmol/L 25(OH) D3 without supplementation at the end of winter training. Table 4 presents the nutritional contribution of milk-based drinks.

Table 3 Typical Daily Food Intake and Training Activity During the Intervention

Activity	Food or drink
5:30 a.m.: 1st breakfast	2 × 65-ml bottles fermented milk (Yakult, UK), 200 ml orange juice, water breakfast shake made with 568 ml full-fat milk, 50 g SMP, 50 g milkshake flavor (Nesquik, Nestle UK), 2 bananas (200 g), and a 36 g sachet of instant porridge
6:00–7:00 a.m.: Paddle 5×/week 7:30 a.m.	Homemade recovery shake within 30 min of training made with 568 ml full-fat milk, 50 g SMP, and 50 g milkshake flavor (Nesquik, Nestle UK)
7:45 a.m.: 2nd breakfast	2 eggs scrambled (120 g), 2 slices whole wheat toast (62 g), cream cheese (30 g), 200 ml orange juice
8:30 a.m.: School	
Midmorning snack	Fig roll biscuits (3 × 17 g) or 2 slices malt loaf (70 g), fruit (e.g., purple grapes; 100 g)
1:00 p.m.: Lunchbox at school	Pasta boiled (160 g) with Italian tomato sauce (170 g), chicken breast (200 g), spinach leaves (70 g), parmesan cheese (20 g)
3:50 p.m.: Pretraining snack	Bowl of muesli (50 g), blueberries (50 g), full-fat milk (200 ml)
6:00–7:00 pm: Training 6×/week 7:30 p.m.	Homemade recovery shake within 30 min of training made with 568 ml full-fat milk, 50 g SMP, and 50 g milkshake flavor (Nesquik, Nestle UK)
8:00 p.m.: Dinner	Baked ham risotto (380 g) with broccoli (80 g) and peas (60 g)
10:00 p.m.: Bed	Chocolate milkshake made with 568 ml full-fat milk and 50 g milkshake flavor (Nesquik, Nestle UK) or hot chocolate drink made with 568 ml full-fat milk and 36 g drinking chocolate powder

Note. SMP = skim milk powder.

Table 4 Contribution of Milk-Based Drinks to the Athlete's Total Nutritional Intake

Food (per serving)	Energy (kJ [kcal])	Protein (g)	Carbohydrate (g)	Fat (g)	Sodium (mg)	Vitamin D (µg)
Breakfast shake	4,559 (1,089)	48.0	172.0	28.5	607	4.6
Recovery shake 1	3,156 (754)	38.0	103.0	24.0	537	4.6
Recovery shake 2	3,156 (754)	38.0	103.0	24.0	537	4.6
Chocolate milk (568 ml)	2,068 (494)	17.5	63.0	21.0	295	0
Intake (total [%])	12,941 (58)	141.5 (52)	441 (66)	97.5 (53)	1,976 (28)	13.8 (77)

Results and Conclusion

The athlete gained a total of 10 kg during the intervention to weigh 88.0 kg with minimal change in body fat percentage. This was the first time he had been able to maintain weight throughout the training cycle and was close to his target of 90 kg. Before the intervention, the athlete found it difficult to eat the quantity of food required to meet the high energy demands of his training program, and the initial dietary assessment indicated a chronic shortfall in energy intake. This intervention demonstrated that milk-based shakes and midmorning snacks were a simple yet effective approach for the athlete to achieve a significant increase in energy and nutritional intake to support MPS and recovery after exercise. Furthermore, the athlete reported no adverse side effects from the milk-based shakes, found them easy to consume around training, and preferred them to commercial nutritional supplements.

Practitioner Reflections

Although there are a number of variables in sprint kayaking performance, this intervention highlighted the importance of maintaining a positive energy balance to ensure energy availability for growth and development of muscle mass, especially during intensive training phases. Overall, this case study shows the significant contribution that milk can make when used in nutrition interventions with athletes to increase and maintain muscle mass.

Acknowledgments

Karen Reid is the director of Performance Food Ltd and a member of the U.K. Sport and Exercise Nutrition Register (SENr). The work described in this case study was undertaken as part of her consultancy work with Performance Food Ltd. and subsequently submitted for the Dairy Council Sports Nutrition Awards 2014. Karen Reid received the Dairy Council Sports Nutrition Professional award. The author has no conflict of interest to disclose.
SENr is a voluntary, competency-based register for sport and exercise nutritionists, and the Dairy Council is a founding partner of the UK SENr. For further information and to find a registered sport and exercise nutritionist visit http://www.senr.org.uk

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PLEASE ANSWER ALL THE QUESTIONS
(There is only one correct answer per question.)

1. Kayaking is a sport that requires upper-body muscle strength and lean body composition. For the purpose of the case study the athlete's aim was to focus on __________________
[a] Increase muscle mass and strength
[b] Low body-fat percentage
[c] normal BMI

2. Initial assessment of nutritional intake and energy requirements was performed along with body composition analysis and blood test measuring ______________
[a] iron status
[b] vitamin C status
[c] vitamin D status

3. A carbohydrate-based midmorning snack was also advised to enhance replenishment of glycogen stores, as was a probiotic drink (Yakult), with lunch to prevent respiratory illness.
[a] true
[b] false

4. A trial was undertaken using a breakfast shake made with 568 ml full-fat milk, 50 g skim milk powder, 50 g milkshake flavour, two bananas, and a 36-g sachet of instant porridge that provided a higher energy (4,559 kJ), protein (x% of the energy), and carbohydrate (y% of the energy) content than the porridge.
[a] 27.36% protein and 53.96% carbohydrate
[b] 17.69% protein and 63.38% carbohydrate
[c] 20.50% protein and 65.50% carbohydrate

5. An increase in energy was achieved by replacing semi-skim milk in the homemade shakes with _____________. Thereafter body mass increased to 88.0 kg and was subsequently maintained, indicating an appropriate energy intake.
[a] whey powder
[b] milk powder
[c] full-fat milk

6. The milk-based shakes and drinks supplied 58% of energy intake and 52% and 66% of protein and carbohydrate intake, respectively, making a significant contribution to the athlete's increased nutritional intake.
[a] true
[b] false

7 The chocolate milk drink's contribution to the athlete's total nutritional intake consist of
[a] 3156kJ; 38g protein; 103g carbohydrate; 24g fat
[b] 4559kJ; 48g protein; 172g carbohydrate; 28.5g fat
[c] 2068kJ; 17.5g protein; 63g carbohydrate; 21g fat

8 This intervention demonstrated that milk-based shakes and midmorning snacks were a simple yet effective approach for the athlete to achieve a significant increase in energy and nutritional intake to support _____________________
[a] Muscle protein synthesis and recovery after exercise.
[b] muscle mass and strength
[c] glycogen store restoration

9. The athlete preferred _____________, found them easy to consume around training, and preferred them to commercial nutritional supplements.
[a] protein shakes
[b] milk-based shakes
[c] all the above

10. This intervention highlighted the importance of maintaining a positive ___________ balance to ensure energy availability for growth and development of muscle mass, especially during intensive training phases.
[a] protein
[b] carbohydrate
[c] energy

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