

# Chapter 21

## PERFORMANCE NUTRITION

PATRICIA A. DEUSTER, PhD, MPH,\* AND JONATHAN SCOTT, PhD†

---

### INTRODUCTION

### DEFINITIONS

### HISTORY OF MILITARY NUTRITION

Importance of Nutrition and Mission Success  
Committee for Military Nutrition Research

### BACKGROUND

Establishing Nutrient Requirements  
Evolution of Performance Nutrition

### SCOPE OF PRACTICE

### KEY CONCEPTS

Nutrient Timing  
Protein Requirements  
Dietary Supplements  
Caffeine Dosing

### PERFORMANCE NUTRITION AND THE MILITARY MEDICAL OFFICER

Role of the Military Medical Officer  
Guidance to Commanding Officer

### RESOURCES

### SUMMARY

\*Professor and Director, Consortium for Health and Military Performance (CHAMP), Uniformed Services University of the Health Sciences, Bethesda, Maryland

†Assistant Professor, Department of Military & Emergency Medicine, Uniformed Services University of the Health Sciences, Bethesda, Maryland

## INTRODUCTION

The contributions of nutrition to health and performance are well established,<sup>1-3</sup> and within the Department of Defense (DoD), nutritional fitness (NF) is a key component of total force fitness (TFF). NF is intricately woven into each TFF domain, including the medical, behavioral, psychological, environmental, physical, social, and spiritual domains. Nutritional choices and habits affect every aspect of life: sleep, mood, physical and cognitive performance, sense of purpose, health, and more.

The readiness status of current and future service members is markedly affected by their NF. Fast food restaurants and physically passive recreational outlets (eg, video games, television, movies) are omnipresent in civilian and military communities alike. NF must be a priority of military medical and line leaders at every level. Importantly, a comprehensive/holistic approach can ensure NF and serve to inform the military enterprise and bases, and teach leaders and troops how to promote, implement, achieve, and maintain good

health in addition to demanding, endorsing, and supporting the concept of NF.

DoD Instruction (DoDI) 6130.05, *DoD Nutrition Committee*,<sup>4</sup> directs nutrition education within the DoD, and nutrition education is key to NF. Education must encompass performance nutrition, health promotion, dietary supplements, and optimal fuel choices in dining facilities and other fueling environments. First and foremost, performance fueling needs to be incorporated into all leadership courses and into various types of individual and unit training, including unit mission-essential task lists, joint exercises, and predeployment training (to provide nutrition information specific to environmental conditions and threats in the area of operations). This will ensure performance fueling is taught from the individual through the unit level. Additionally, the application of performance fueling must be incorporated into all military doctrine to ensure its continuation across time.

## DEFINITIONS

Exhibit 21-1 defines a variety of important nutrition terms commonly used within the DoD, including NF, performance nutrition, and the military dietary reference

intakes (MDRIs). Likewise, Exhibit 21-2 presents key nutrition terms and definitions used across the nation to ensure comparability with regard to nutrient intake.

## HISTORY OF MILITARY NUTRITION

The military community has a long history of interest in nutrition, and many military leaders made extraordinary strides in the nutritional sciences. In 1753, Dr James Lind, a Scottish physician who is considered the father of military nutrition, wrote *A Treatise of the Scurvy*, detailing experiments he conducted in an effort to prevent and treat scurvy in the Royal Navy. Ultimately, he determined citrus fruits, specifically oranges and lemons, could be used to prevent and treat scurvy because they contained Vitamin C, an essential nutrient. In 1778, American Dr Benjamin Rush wrote *Directions for Preserving the Health of Soldiers*, which advocated for a diet consisting chiefly of vegetables for soldiers. Military nutrition research in the United States formally began in 1917 when the Surgeon General's Office established a food division for the purpose of "safeguarding the nutritional interests of the Army."<sup>5</sup> Military nutrition has always been associated with safety, health, readiness, and performance.

In 1940, the US Food and Nutrition Board was established to investigate nutritional issues that might "affect national defense."<sup>6</sup> Areas of interest included the safety and adequacy of the US food supply and

principles and guidelines for good nutrition. Now a part of the US Department of Health and Human Services (HHS), the Food and Nutrition Board remains an authority on how nutrition and food choices affect overall health and disease.

In 1949, when the National Military Establishment was renamed the Department of Defense (DoD), the energy and nutritional demands of service members engaged in training and missions became of interest. The activities of service members are often unique and vary greatly from the general population, particularly with regard to environmental exposures (eg, heat, cold, depth, and altitude) and physical activity. Service members must be well nourished to remain healthy and fit for service. Today, developing, implementing and evaluating effective nutritional strategies to optimize performance before, during, and after training and operations remains a high priority for the DoD.

### Importance of Nutrition and Mission Success

Mission success has always hinged upon adequate nutrition. From the ancient Egyptians to the Greeks,

## EXHIBIT 21-1

## DEPARTMENT OF DEFENSE NUTRITION TERMS

- **Nutritional fitness.** Having the appropriate quantity, quality, choice, and timing of safe fuels, nutrients, and fluids and the requisite nutritional environment to sustain and optimize physical and cognitive performance, wellness, and health; accelerate healing; and protect against disease. An eating environment that makes healthy choices the easy choice, along with performance-based nutrition education, will help promote nutritional fitness and a resilient and fit force. When necessary, dietary supplements may be recommended to supplement the diet.
- **Performance nutrition.** Nutritional contribution to the execution of physical and cognitive actions by the human body to the greatest degree attainable under specified conditions and objectives.
- **Military dietary reference intakes.** Nutritional standards for military feeding, operational rations, and for restricted rations, as noted in US Army Regulation 40-25 (AR 40-25, OPNAV Instruction 10110.1, Marine Corps Order 10110.49, Air Force Instruction 44-141). The proponent of AR 40-25 is the Army surgeon general, who has the authority to approve exceptions or waivers to the regulation that are consistent with controlling laws and regulations. MDRIs are identical to recommended nutrient intakes cited in the above references, except when known differences in the military population require adjustment of a particular nutrient.

Persians, and Romans, every successful military relied on appropriate nutrition. The universal quote highlighting the importance of military nutrition comes from either Fredrick the Great or Napoleon Bonaparte: "A military marches on its stomach."

Never were such words truer than during Napoleon's 1812 winter campaign in Russia. During this period Napoleon lost nearly 500,000 men due to their deviations from supply train routes and instructions to live off the land.<sup>7,8</sup>

## EXHIBIT 21-2

## NATIONAL ACADEMY OF SCIENCES NUTRITION TERMS

- **Dietary reference intakes.** A set of four reference values that are quantitative estimates of nutrient intakes to be used for planning and assessing diets for healthy people:
  - **Estimated average requirement.** Reflects nutrient intake levels to meet the needs of ~50% of healthy individuals.
  - **Recommended dietary allowance.** Daily dietary intake level considered sufficient by the Food and Nutrition Board to meet requirements of nearly all healthy individuals (97%–98%) in each life-stage and gender group. RDAs are revised every 5-10 years.
  - **Adequate intake.** The recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate. Used when an RDA cannot be determined.
  - **Tolerable upper intake levels.** Highest level of daily consumption that current data have shown to cause no side effects in humans when used indefinitely without medical supervision.
- **Daily value.** The percent of daily value is shown on the labels of dietary supplements and foods and is usually similar to the RDA or adequate intake for that nutrient. This term was developed by the Food and Drug Administration to help consumers determine how much (what percentage) a serving of the product contributed to the daily value of various nutrients.
- **Acceptable macronutrient distribution range.** Reflects an intake range for carbohydrate, protein, and fat associated with reduced risk of chronic disease while providing adequate nutrients.

In the US Revolutionary War, rations provided to soldiers consisted of salt-cured meat, beans or peas, rice or “Indian meal” (cornmeal), milk, flour or hard bread, and spruce beer or cider. During the Civil War, cattle drives followed soldiers in an effort to provide them with more fresh meat. World War I saw the advent of canned foods. As many as 23 different rations were available to meet the diverse needs of service members during World War II and the Korean War. During the Vietnam War, freeze-dried rations became available to forward operating Special Forces units in an effort to remove metal containers from rations. The first Meal, Ready-to-Eat (MRE) was developed in 1980 and was widely distributed to service members in 1983. MREs are still used and serve as the main individual ration for the deployed service member. In addition to the MRE, 16 additional categories of rations are produced to meet a variety of needs from religious dietary restrictions to survival situations and humanitarian efforts.<sup>9</sup>

Service members today operate all over the world in a variety of climates, environments, and altitudes. Accordingly, the Combat Feeding Directorate is tasked with developing rations to meet the nutritional needs of all service members. The directorate’s mission is to “sustain the Department of Defense’s most decisive weapons platform—the individual Warfighter.”<sup>10</sup> MREs must comply with the nutritional requirements described in Army Regulation 40-25, *Nutrition and Menu Standards for Human Performance Optimization*.<sup>11</sup> Additionally, the Joint Services Operational Rations Forum meets annually to approve new rations and changes to components within rations.

On average, one MRE provides approximately 1,300 calories, 170 g of carbohydrates (CHO), 40 g of protein, and 50 g of fat. The number of rations provided to service members is dependent upon gender and activity level. MREs are designed to meet all nutritional requirements of the service member when consumed in their entirety. MREs can be used as the sole source of calories for up to 21 days. Currently, 24 different MRE options are available.<sup>10</sup>

New rations continue to be developed to meet the needs of service members around the world. The First Strike Ration (FSR) is the newest individual ration developed by the Combat Feeding Directorate. Fielded in 2008, the FSR was specifically developed for multi-day, high-intensity combat missions. The FSR consists of several hand-held items designed to be eaten while moving. On average, one FSR provides approximately 2,900 calories, 375 g of CHO, 100 g of protein, and 110 g of fat. Service members are provided one FSR per

day, and FSRs can be used as the sole source of calories for up to 10 days. Currently, nine different FSR options are available.<sup>10</sup>

### Committee for Military Nutrition Research

The Committee on Military Nutrition Research was established in October 1982 under the direction of the assistant surgeon general of the Army. Committee members, who served a 3-year term, had diverse backgrounds including human nutrition, nutritional biochemistry, performance physiology, immunology, food science, and psychology.<sup>12</sup> The committee’s mission was to advise the DoD on nutrient requirements for performance during operational missions and deployment and to identify gaps within military nutrition research.<sup>12</sup> The committee had four tasks:

1. identify nutritional factors that may critically influence the physical and mental performance of military personnel under all environmental extremes;
2. identify deficiencies in the existing database regarding the relationship between diet and performance of military personnel;
3. recommend research that would remedy these deficiencies as well as approaches for studying the relationship of diet to physical and mental performance; and
4. review and advise on standards for military feeding systems.

A subcommittee was established to review topics specifically related to female service members. Topics of interest included postpartum return-to-duty standards, military recommended dietary allowances, and individual and collective impact of physical activity and nutritional practices on the health, fitness, and readiness of female service members. Subject matter experts in body composition assessment, physical fitness and performance, pregnancy and lactation, women’s nutrition, weight management, epidemiology and survey design, and cognitive performance were included. Additionally, a liaison panel of service members from the Army, Navy, and Air Force with expertise in body composition, fitness, and nutrition research and policy-making were included to ensure military relevance.<sup>12</sup> Between 1992 and 2011, the committee produced approximately 18 publications on a variety of nutritionally relevant topics; it disbanded in 2013.<sup>13</sup>

## BACKGROUND

### Establishing Nutrient Requirements

In 1941, the Food and Nutrition Board released the first recommended dietary allowances (RDAs). The committee developed RDA values for selected nutrients known at the time, based on age and gender, as well as for women during pregnancy and lactation. The first RDAs were intended to be “a table of allowances which would represent the best available evidence on the amounts of the various nutritive essentials desirable to include in practical diets.”<sup>14</sup> Essential nutrients were identified when dietary deficiency led to the development of a well-defined disease or a failure to grow. An animal growth model was used to identify essential nutrients and to quantify requirements. RDAs were updated every 5 to 10 years over the next 5 decades as new science emerged.<sup>15</sup>

In the mid-1990s, the United States and Canada set out to establish a single set of nutrient-based dietary reference intakes (DRIs) to replace the RDAs. More than 40 nutrients were reviewed and recommendations were based on the totality of available scientific evidence. Nearly 20 years later, six volumes of DRI recommendations have been released. Each nutrient DRI is intended to meet the needs of healthy people (not individuals with disease), including age-specific recommendations that reflect the current knowledge of biological patterns, and providing sex-specific recommendations if reasonable scientific evidence was available. DRIs are not updated on a regular basis but rather as new bodies of scientific literature emerge.<sup>16,17</sup>

### Evolution of Performance Nutrition

The first Olympiad of ancient Greece was held in 776 BCE. Written text from the 3rd century CE documents the importance of nutrition and athletic performance dating back to the 6th century BCE.<sup>18</sup> Ancient text describes athletes consuming a diet of figs, moist cheese, and wheat.<sup>18</sup> Further evolution of dietary practices in ancient Greece incorporated meat from oxen, bulls, deer, and goats, along with bread made from barley and unleavened bread made from wheat. Ancient texts also highlight the negative effects of excessive wine consumption on athletic performance by stating that overeating was not the problem, but rather drunkenness.<sup>19,20</sup>

Upon conclusion of the last Olympiad in 393 CE, limited scientific papers examining nutrition and athletic performance were produced over the next 15 centuries. At the 1936 Olympics, scientist Paul Schenk meticulously recorded what Olympians from nearly all countries ate in the Olympic village. According to Schenk’s analysis, athletes consumed an average of 320 g of protein, 270 g of fat, 850 g of CHO, and up to 7,300 kcals per day. Unfortunately, Schenk did not analyze his data for relationships between dietary intake and athletic performance, but he did acknowledge the importance of fruits and vegetables for Olympic athletes regardless of sport.<sup>20</sup> Few changes in sports nutrition occurred over the next 3 decades due to the outbreak of World War II and the limited methodologies available for metabolic and exercise physiology research.

During the 1960s and 1970s, Swedish researchers demonstrated that CHO consumed during exercise could delay fatigue. Further, Ahlborg and colleagues found a direct relationship between a high-carbohydrate diet and endurance performance, thus starting the “carbo-loading” craze of the 1970s.<sup>21</sup> CHO continue to be the body’s preferred fuel source for endurance activities; however, recent publications suggest ketone bodies, a class of organic compounds that can be used for fuel, may be a superior fuel source for aerobic activity.<sup>22,23</sup> Ketone bodies are produced by the liver, derived from fat. Production is increased during periods of prolonged fasting or adherence to a strict ketogenic diet.

Sports nutrition became a recognized field of study during the 1980s, coinciding with the increase in exercise physiology research. Early on, the majority of sports dietitians worked with endurance athletes due to their unique energy and CHO requirements. By the late 1990s, sports dietitians were becoming an integral part of collegiate, professional, and Olympic teams. In 2009, the American Dietetic Association, American College of Sports Medicine, and Dietitians of Canada released a joint position paper evaluating the totality of evidence regarding nutrition and athletic performance.<sup>24</sup> Recognized benefits of sports nutrition now apply to athletes from young to old, elite to recreational, civilian and military. Sports nutrition continues to expand into new fields. If one considers the warrior athlete paradigm, military applied nutrition is consistent with sports nutrition.

## SCOPE OF PRACTICE

A registered dietitian (RD) who practices sports nutrition is commonly referred to as a sports RD. A sports RD may receive further credentialing from the Academy of Nutrition and Dietetics with a board certification as a specialist in sports dietetics (CSSD). CSSD eligibility includes meeting a minimum practice experience requirement (1,500 hours of specialty practice) and successfully passing a nationally accredited examination. Sports RDs implement evidence-based knowledge in physical activity and exercise/training to address the diverse nutritional needs of physically active individuals. A sports RD's individual scope of practice includes assessment, diagnosis, intervention, monitoring, and evaluating of what, how much, and when to consume foods and fluids.

Although individual client goals differ, general goals of sports RDs include maintenance of health,

appropriate body weight and composition, and instruction on how to properly fuel the body for physical activity and exercise, training and conditioning, and physical performance. Sports RDs educate individuals regarding energy, nutrient, and fluid intake before, during, and after exercise, as well as on menu planning, recipe modification, grocery shopping, and food preparation and storage. Sports RDs facilitate behavior change and promote problem solving, adaptation, and progression toward achieving nutritional goals that promote overall health and wellness. Regularly, sports RDs evaluate dietary supplements for legality, safety, effectiveness, quality, and application to sport. Lastly, sports RDs provide guidance regarding compliance with the rules and regulations of sports organizations and governing bodies.<sup>25</sup>

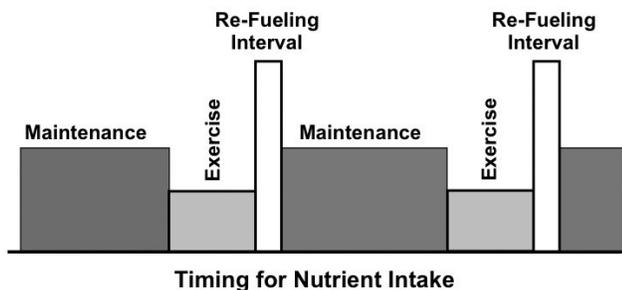
## KEY CONCEPTS

### Nutrient Timing

Overall goals of training include optimization of physiologic and molecular adaptations. Training goals are realized when appropriate nutritional strategies are implemented before, during, and after training. "Nutrient timing" is the term originally coined by doctors John Ivy and Robert Portman<sup>26</sup> to indicate that "when food is consumed" is as important as "what food is consumed." Ivy and Portman describe nutrient timing as "a revolutionary new system of exercise nutrition that will allow you to build more strength and lean muscle mass in less time than ever before."<sup>26</sup> The three phases of nutrient

timing are shown in Figure 21-1: (1) during exercise; (2) the refueling interval immediately after exercise (recovery); and (3) the time between exercise sessions (maintenance and growth).

Various strategies have been developed to maintain adequate energy stores, enhance recovery, stimulate muscle protein synthesis, maximize glycogen repletion, and minimize/protect against training injuries.<sup>24</sup> Nutrient timing, combined with adequate rest and recovery periods, are important components to any training program. However, another consideration for optimal performance is familiarity: foods and fluids consumed before and during exercise should be consistent with those used in training to minimize possible gastric distress from unfamiliar foods. The overall goals of nutrient timing are noted in Exhibit 21-3.



**Figure 21-1.** The three major phases for nutrient timing: maintenance and growth, exercise, and the refueling interval for recovery. Heights of the bars are indicative of protein and carbohydrate balance; exercise indicates the breakdown of energy stores; the refueling interval reflects rebuilding energy stores; and maintenance represents homeostasis.

### EXHIBIT 21-3

#### GOALS OF NUTRIENT TIMING

- Enhance performance.
- Accelerate recovery.
- Improve/maintain muscle integrity.
- Increase muscle mass/nitrogen balance.
- Replete glycogen stores.
- Prevent musculoskeletal injuries.
- Restore skeletal muscle integrity.

### ***Pre-Exercise Meal/Snack***

No consensus statement for optimal content and timing of a pre-exercise meal or snack has been published. However, consuming a meal or snack providing 200 to 300 g of CHO 3 to 4 hours before heavy training or competition will allow sufficient time for the food to be digested and for gastric emptying to occur. Consuming up to 25 g of protein before exercise may be important for those primarily engaged in strength training to maximize training adaptations.<sup>27</sup> If a larger meal is desired, more time should be allowed for digestion.

### ***During Exercise***

During exercise, energy stores are being used to provide energy to the working muscles and muscle protein is being broken down. Consuming small amounts of CHO at regular intervals can minimize metabolic distress and enhance athletic performance, especially when the exercise duration is longer than 1 hour.<sup>28</sup> During exercise lasting longer than an hour, ingesting CHO in a fluid can also help sustain hydration. Studies have shown that ingesting 0.7 g CHO per kilogram of bodyweight (approximately 30–60 g CHO/h or 7–20 g CHO every 15–20 min) can extend endurance performance.<sup>27</sup> When the exercise duration is greater than 3 hours, CHO intakes of up to 110 g per hour may be needed, depending on the intensity of the exercise.<sup>29</sup> For exercise longer than 3 hours, individuals typically eat both solid and liquid foods to meet CHO needs.

Service members should try various foods during training to determine which are most suitable. The amount of CHO and fluid required and tolerated by any individual will be determined by the exercise intensity, duration, environmental conditions, and mode of exercise (running vs marching vs manual labor). The service member should simulate mission events to determine his or her optimal fuel sources. Consuming protein during events confers no discernable benefit.<sup>30</sup>

### ***Recovery: Refueling Interval***

After exercise, the metabolic environment within the body needs to transition from a catabolic state to an anabolic one to promote recovery and restore what was depleted during the exercise phase. This is the “refueling interval.” Release of insulin, an important hormone for inhibiting muscle protein breakdown, is stimulated by ingestion of both CHO and certain amino acids.<sup>31</sup> Thus, the recommended time to begin the refueling interval is no later than 60 minutes after

activity, when glycogen stores and muscle protein synthesis are lowest; this provides the body with the requisite nutrients and fuels. To enhance muscle glycogen synthesis following prolonged, strenuous exercise (over 60 minutes), consuming approximately 50 g of CHO within 60 minutes after the activity is recommended, followed by approximately 1.0 to 1.5 g per kilogram of bodyweight (0.5–0.7g/lb) CHO (as liquid, gel, or solid food) at 2-hour intervals for up to 6 hours.<sup>24,27,28</sup>

Although somewhat controversial, it is generally believed that ingesting some protein (12–25 g) with CHO during recovery can increase muscle protein synthesis and improve nitrogen balance more effectively than consuming CHO without protein.<sup>24,32</sup> Consuming foods with essential amino acids—especially leucine—will promote the post-exercise muscle protein synthesis needed for building and repairing muscle tissue.<sup>33,34</sup> Foods containing leucine include eggs, dairy, and chicken. Without appropriate refueling after a hard training session or mission, performance may be compromised, especially if a second workout or mission is required the same day or in less than 24 hours.

### **Protein Requirements**

The RDA for both men and women is 0.80 g of high-quality protein per kilogram of body weight (or 0.36 g/lb body weight).<sup>35</sup> The recommendation is based on careful analyses of published nitrogen balance studies. The acceptable macronutrient distribution range for protein is 10% to 35% of total energy intake. Given that 1 g of protein is equivalent to 4 calories, on a 3,000-calorie diet, protein intake would be 75 g at 10% and 262 g at 35% of the total energy. There is no upper intake level for protein due to insufficient data to define an upper limit. However, it must be remembered that amino acids are not good sources of energy. Protein recommendations for service members can be met through diet alone, without the use of protein or amino acid supplements (Table 21-1).

### **Dietary Supplements**

According to the Dietary Supplement Health and Education Act of 1994, the term dietary supplement refers to “a product (other than tobacco) intended to supplement the diet that bears or contains one or more of the following dietary ingredients: a vitamin; a mineral; an herb or other botanical; an amino acid; a dietary substance for use by man to supplement the diet by increasing the total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any ingredient.”<sup>36</sup>

**TABLE 21-1**  
**PROTEIN RECOMMENDATIONS BASED ON PHYSICAL ACTIVITY LEVELS**

Activity Level/ Conditions	Grams/lb body weight	Grams/kg body weight
Low to moderate*	0.4–0.5	0.8–1.0
Endurance <sup>†</sup>	0.5–0.6	1.2–1.4
Strength <sup>‡</sup>	0.5–0.9	1.2–2.0
High energy demands combined with insuff- icient calories	0.7–0.9	1.5–2.0

\*Low- to moderate-level activities include sitting quietly or engaging in light exercise such as a brisk walk, yoga, hiking, or softball.

<sup>†</sup>Endurance training is vigorous exercise that challenges the aerobic system. Examples include running, cycling, swimming, and sports such as basketball or racquetball. For endurance athletes, about 0.5 to 0.6 g of protein per pound of body weight each day is sufficient to sustain events.

<sup>‡</sup>Strength training involves resistance exercise such as weight training, lifting heavy objects, and use of resistance bands. Typically the goal of muscle building is to increase lean body mass without gaining fat, so it's important to eat right and maintain energy balance. About 0.5 to 0.9 g of protein per pound of body weight each day is enough protein for strength training, even for the hardcore bodybuilder, as long as energy intake is sufficient to support daily activities.

The use of dietary supplements has become increasingly popular among service members to enhance performance. Consumers of dietary supplements should be aware that although the Food and Drug Administration (FDA) regulates dietary supplements, the regulations are not as strict as they are for drugs. Consequently, some unsafe and contaminated products end up on the market. FDA has identified certain “high-risk” dietary supplement categories: bodybuilding, weight-loss, and sexual enhancement products; these products are more likely than vitamin and mineral supplements to contain unsafe and con-

taminated ingredients. In addition, many “high-risk” supplements may not conform to the labeling regulations required by FDA and may contain illegal (eg, analogues of drugs, amphetamines) or controlled (eg, steroids) substances. Such ingredients may be intentionally left off the label because they would not meet the definition of a dietary supplement. Thus, service members should be careful when purchasing dietary supplements. Operation Supplement Safety is a DoD initiative to educate all service members on how to select safe supplements (<http://opss.org>).

Supplements displaying seals from third-party verification/certification programs are better choices (Figure 21-2) because they are (a) unlikely to contain contaminants; (b) likely to have ingredients present in the amounts listed on the Supplement Facts panel; and (c) likely to have accurate labels. Service members should also be aware that (a) concentrations and combinations of ingredients are arbitrarily created by manufacturers with little to no supporting scientific research, and (b) using any dietary supplement, especially those in high-risk categories, increases the probability of experiencing an adverse event. Adverse events associated with dietary supplements can range from very mild physical discomfort to severe, life-threatening incidents. Healthcare providers should report adverse events and should educate patients on how to report adverse events through Natural Medicines’ MedWatch website (<http://naturalmedicines.com/tools/natural-medwatch.aspx>). Service members should always proceed with caution when considering and using dietary supplements. Primary care providers should query their patients about supplement use and discuss general safety issues with all patients.

**Caffeine Dosing**

Caffeine is the world’s most widely consumed psychoactive substance. Previous research on caffeine has demonstrated positive effects on several military-



**Figure 21-2.** Examples of logos and seals from organizations that third-party verify/certify dietary supplements. Reproduced with permission from each.

relevant tasks including marksmanship, reaction time, vigilance, and logical reasoning.<sup>37-41</sup> In athletics, the ergogenic benefits of caffeine include improvements in endurance and time to exhaustion, and a reduction in perceived effort of exertion. Previous studies used a wide range of caffeine doses, ranging from 200 to 400 mg or 3 to 5 mg per kilogram of body weight

(1.4-2.3 mg/lb).<sup>37-41</sup> However, the ergogenic benefits of caffeine are dose-dependent, with adverse events often reported when intake exceeds 500 to 600 mg; the recommended dosing is 100 to 200 mg every 4 hours. Caffeine is provided in military rations in various forms, including some chewing gum, mints, applesauce, pudding, and mini First Strike bars.

## PERFORMANCE NUTRITION AND THE MILITARY MEDICAL OFFICER

### Role of the Military Medical Officer

The military medical officer (MMO) must be a performance nutrition role model. The MMO should not only be familiar with concepts related to performance nutrition, but should also practice these concepts on a daily basis in front of subordinates and superiors alike. MMOs should be competent in key topics, including nutrient timing, macronutrient distribution, and strategic use of caffeine. Additionally, knowledge about service-specific and DoD regulations and guidance regarding healthy body weight and dietary supplements is critical. Lastly, the MMO is responsible for knowing where to obtain reliable information.

Service-specific guidelines detail height, weight, and body composition standards required for all service members. Guidance is provided under Army

Regulation 600-9,<sup>42</sup> Air Force Instruction 36-2905,<sup>43</sup> Navy OPNAV Instruction 6110.15J,<sup>44</sup> Marine Corps Order 6110.3,<sup>45</sup> and DoDI 1308.3.<sup>46</sup>

### Guidance to the Commanding Officer

The commanding officer has the responsibility of understanding and promoting performance nutrition with regard to time and access to quality food. Further, the commanding officer should create an environment supportive of performance nutrition. Like the MMO, the commanding officer should model appropriate nutritional behaviors to subordinates. Additionally, the commanding officer needs to understand who he or she can contact for assistance on any issues related to performance nutrition and may rely on the MMO for information if a unit RD is not available.

## RESOURCES

Several electronic DoD resources are publicly available. The Consortium for Health and Military Performance (CHAMP) at the Uniformed Services University of the Health Sciences hosts the Human Performance Resource Center (HPRC) (<http://hprc-online.org/>). HPRC is a clearinghouse for evidence-based information regarding TFF and contains key resources to help service members and their families in all aspects of performance. HPRC is comprised of eight domains representing TFF, including physical fitness, environment, nutrition, family and relationships, and mental fitness.<sup>47</sup>

Operation Supplement Safety (OPSS) (<http://opss.org>) is a DoD-wide effort, including partnerships with other government and professional organizations, to provide evidence-based, up-to-date information on dietary supplements. OPSS educates service members and retirees, their family members, leaders, healthcare providers, and DoD civilians about dietary supplements and gives them tools to be informed supplement users. OPSS has also partnered with the US Anti-Doping Agency to develop a dietary supplements high-risk list. The high-risk list is intended to help service members and DoD

civilians identify supplements that might pose a risk to their health or career. Other good sources of information on supplements include the Academy of Nutrition and Dietetics (<http://www.eatright.org>) and the Office of Dietary Supplements (<http://ods.od.nih.gov/>).

HPRC has partnered with the Natick Soldier Research, Development, and Engineering Center and the US Army Research Institute of Environmental Medicine to host the Combat Rations Database (ComRaD) (<https://www.hprc-online.org/page/combat-rations-database-comrad>). ComRaD is an interactive, educational website designed for visitors to view accurate, up-to-date nutritional information on individual combat ration menus (MREs, FSRs, and Meal Cold Weather/Long Range Patrol), group rations (Unitized Group Ration-A and Unitized Group Ration Heat & Serve), and an enhancement pack (Modular Operational Ration Enhancement), as well as the individual food components packed inside them. ComRaD enables service members, military RDs, food service officers, and leaders to learn about the nutritional content of their combat rations and use this information to help with fueling for optimal performance.

The National Academies of Sciences' Engineering and Medicine Health and Medicine Division, formerly the Institute of Medicine, is an independent, nonprofit organization that works outside of government to provide unbiased and authoritative advice to decision-makers and the public. The division focuses on asking and answering the nation's most relevant questions regarding health and healthcare. All Engineering and Medicine Health and Medicine Division reports are available electronically (<http://www.nationalacademies.org/hmd/Reports.aspx>) at no cost. Hundreds of reports are available on a variety of topics from food and nutrition to public health, diseases, and veterans' health.

*Nutrition and Menu Standards for Human Performance Optimization*<sup>11</sup> details the unique nutrition requirements of service members known as MDRIs. The MDRIs are based on DRI updates from the Food and Nutrition Board. Differences in nutri-

tional requirements based on height, weight, gender, level of physical activity, and environmental factors including cold environments, hot environments, and altitude are discussed within the regulation. Compliance with this regulation is required for all food service operations including the DoD Combat Feeding Program.<sup>11</sup>

The US Department of Agriculture (USDA) provides a multitude of resources to consumers on a variety of topics related to nutrition. The USDA and HHS are responsible for developing the Dietary Guidelines for Americans,<sup>48</sup> which encourages Americans to eat a healthful diet; MyPlate (<https://www.choosemyplate.gov/>),<sup>49</sup> a visual depiction of how eat according to the Dietary Guidelines; and SuperTracker (<https://www.supertracker.usda.gov/>),<sup>50</sup> a free online food and activity tracking program. The Academy of Nutrition and Dietetics (<http://www.eatright.org>) also provides free publications and electronic resources.

## SUMMARY

Military nutrition has always been associated with safety, health, readiness, and performance. Nutrition plays a vital role in every aspect of life: sleep, mood, physical and cognitive performance, sense of purpose, and health. The activities of service members are often unique and vary greatly from the general population, particularly with regard to environmental exposures and physical activity. Service members must be well nourished to remain healthy and fit for service. Today, developing, implementing and evaluating effective nutritional strategies to optimize performance before,

during, and after training and operations remains a high priority for the DoD. Consistent messaging surrounding nutrition must encompass performance nutrition, health promotion, dietary supplements, and optimal fuel choices in dining facilities and other fueling environments. To support nutrition efforts, the DoD has intricately woven components of nutrition into several important policy documents. Support from MMOs and commanding officers is mission critical and will drive successful implementation of performance nutrition.

## REFERENCES

1. Butterwick RF. Impact of nutrition on ageing the process. Bridging the gap: the animal perspective. *Br J Nutr.* 2015;113(Suppl):S23–25.
2. Frazier-Wood AC. Dietary patterns, genes, and health: challenges and obstacles to be overcome. *Curr Nutr Rep.* 2015;4:82–87.
3. Hale MW, Spencer SJ, Conti B, et al. Diet, behavior and immunity across the lifespan. *Neurosci Biobehav Rev.* 2015;58:46–52.
4. US Department of Defense. *DoD Nutrition Committee.* Washington, DC: DoD; 2011. DoD Instruction 6130.05.
5. Murlin JR, Miller CW. Preliminary results of nutritional surveys in United States Army camps. *Am J Pub Health.* 1919;9(6):401–413.
6. National Research Council, Food and Nutrition Board. *The Food and Nutrition Board: 1940-1965: Twenty-Five Years in Retrospect.* Washington, DC: National Academy of Sciences, NRC;1966.
7. Hill N, Fallowfield J, Price S, Wilson D. Military nutrition: maintaining health and rebuilding injured tissue. *Philos Trans R Soc Lond B Biol Sci.* 2011;366(1562):231–240.

8. Rose A. *Napoleon's Campaign in Russia, Anno 1812, Medico-Historical*. New York, NY: A Rose; 1913.
9. US Army Natick Soldier Research, Development and Engineering Center Combat Feeding Directorate. An overview of us military rations: yesterday, today, and tomorrow. Updated March 7, 2010. [http://hotchow.natick.army.mil/history/Historical\\_Rations.pdf](http://hotchow.natick.army.mil/history/Historical_Rations.pdf). Accessed November 24, 2017.
10. U.S Army Research, Development, and Engineering Command. *Operational Rations of the Department of Defense*. 9th ed. Natick, MA: RDECOM; 2012. Natick Pamphlet 30-25.
11. US Department of the Army. *Nutrition and Menu Standards for Human Performance Optimization*. Washington, DC: DoD; 2017. Army Regulation 40-25, OPNAV Instruction 10110.1, Marine Corps Order 10110.49, Air Force Instruction 44-141.
12. National Research Council. *Committee on Military Nutrition Research: Activity Report 1994-1999*. Washington, DC: National Academies Press; 1999.
13. National Academies of Sciences, Engineering, and Medicine. Publications. [http://www.nationalacademies.org/hmd/Reports.aspx?sa.x=0&sa.y=0&sa=Search&site=iom\\_reports&client=iom\\_frontend&output=xml\\_no\\_dtd&filters=inmeta:activity%3DMilitary+Nutrition+Research&getfields=nap\\_id.description.report\\_date&sort=date:D:R:d1&filter=0&ie=UTF-8&ip=216.230.117.99&access=p&entqr=3&entqrm=0&wc=200&wc\\_mc=1&q=site:nationalacademies.org/hmd+inmeta:activity%3DMilitary%2520Nutrition%2520Research&dnavs=inmeta:activity%3DMilitary%2520Nutrition%2520Research&ulang=&q=\(filetype:html+%7C+filetype:aspx+\)&start=0](http://www.nationalacademies.org/hmd/Reports.aspx?sa.x=0&sa.y=0&sa=Search&site=iom_reports&client=iom_frontend&output=xml_no_dtd&filters=inmeta:activity%3DMilitary+Nutrition+Research&getfields=nap_id.description.report_date&sort=date:D:R:d1&filter=0&ie=UTF-8&ip=216.230.117.99&access=p&entqr=3&entqrm=0&wc=200&wc_mc=1&q=site:nationalacademies.org/hmd+inmeta:activity%3DMilitary%2520Nutrition%2520Research&dnavs=inmeta:activity%3DMilitary%2520Nutrition%2520Research&ulang=&q=(filetype:html+%7C+filetype:aspx+)&start=0). Accessed February 2, 2018.
14. National Research Council. *Recommended Dietary Allowances*. Washington, DC: National Academies Press; 1941. <https://doi.org/10.17226/13286>. Accessed February 2, 2018.
15. Harper AE. Origin of Recommended dietary allowances—an historic overview. *Am J Clin Nutr*. 1985;41(1):140–148.
16. Sheffer M, Taylor CL. *Development of DRIs 1994-2004: Lessons Learned and New Challenges: Workshop Summary*. Washington, DC: National Academies Press; 2008.
17. Atkinson SA. Defining the process of dietary reference intakes: framework for the United States and Canada. *Am J Clin Nutr*. 2011;94(2):655s–657s.
18. Laertius D. *The Lives and Opinions of Eminent Philosophers*. London, England: GH Bohn; 1853.
19. Applegate EA, Grivetti LE. Search for the competitive edge: a history of dietary fads and supplements. *J Nutr*. 1997;127(5 Suppl):869s–873s.
20. Grivetti LE, Applegate EA. From Olympia to Atlanta: a cultural-historical perspective on diet and athletic training. *J Nutr*. 1997;127(5 Suppl):860s–868s.
21. Ahlborg B, Bergström J, Ekelund L-G, Hultman E. Muscle glycogen and muscle electrolytes during prolonged physical exercise. *Acta Physiol Scand*. 1967;70(2):129–142.
22. Cox PJ, Clarke K. Acute nutritional ketosis: implications for exercise performance and metabolism. *Extrem Physiol Med*. 2014;3:17.
23. Volek JS, Noakes T, Phinney SD. Rethinking fat as a fuel for endurance exercise. *Eur J Sport Sci*. 2015;15(1):13–20.
24. Rodriguez NR, Di Marco NM, Langley S. American College of Sports Medicine position stand. Nutrition and athletic performance. *Med Sci Sports Exerc*. 2009;41(3):709–731.
25. Steinmuller PL, Kruskall LJ, Karpinski CA, Manore MM, Macedonio MA, Meyer NL. Academy of nutrition and dietetics: revised 2014 standards of practice and standards of professional performance for registered dietitian nutritionists (competent, proficient, and expert) in sports nutrition and dietetics. *J Acad Nutr Diet*. Apr 2014;114(4):631–641.e643.
26. Ivy JL, Portman R. *Nutrient Timing: The Future of Sports Nutrition*. Laguna Beach, CA: Basic Health Publications, Inc.; 2004: 449.

27. Kerksick C, Harvey T, Stout J, et al. International Society of Sports Nutrition position stand: nutrient timing. *J Int Soc Sports Nutr.* 2008;5:17.
28. Burke LM. Fueling strategies to optimize performance: training high or training low? *Scand J Med Sci Sports.* 2010;20(Suppl 2):48–58.
29. Stellingwerff T, Cox GR. Systematic review: Carbohydrate supplementation on exercise performance or capacity of varying durations. *Appl Physiol Nutr Metab.* 2014;39(9):998–1011.
30. McLellan TM, Pasiakos SM, Lieberman HR. Effects of protein in combination with carbohydrate supplements on acute or repeat endurance exercise performance: a systematic review. *Sports Med.* 2014;44(4):535–550.
31. Martinez-Lagunas V, Ding Z, Bernard JR, Wang B, Ivy JL. Added protein maintains efficacy of a low-carbohydrate sports drink. *J Strength Cond Res.* 2010;24(1):48–59.
32. Howarth KR, Phillips SM, MacDonald MJ, Richards D, Moreau NA, Gibala MJ. Effect of glycogen availability on human skeletal muscle protein turnover during exercise and recovery. *J Appl Physiol (1985).* 2010;109(2):431–438.
33. Pasiakos SM, McClung HL, McClung JP, et al. Leucine-enriched essential amino acid supplementation during moderate steady state exercise enhances postexercise muscle protein synthesis. *Am J Clin Nutr.* 2011;94(3):809–818.
34. Pasiakos SM, McClung JP. Supplemental dietary leucine and the skeletal muscle anabolic response to essential amino acids. *Nutr Rev.* 2011;69(9):550–557.
35. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients).* Washington, DC: National Academies Press; 2005.
36. Dietary Supplement Health and Education Act of 1994. Pub L No. 103-417. <https://www.congress.gov/bill/103rd-congress/senate-bill/784>. Accessed February 2, 2018.
37. Brunye TT, Mahoney CR, Lieberman HR, Giles GE, Taylor HA. Acute caffeine consumption enhances the executive control of visual attention in habitual consumers. *Brain Cogn.* 2010;74(3):186–192.
38. Judelson DA, Preston AG, Miller DL, Munoz CX, Kellogg MD, Lieberman HR. Effects of theobromine and caffeine on mood and vigilance. *J Clin Psychopharmacol.* 2013;33(4):499–506.
39. Kamimori GH, McLellan TM, Tate CM, Voss DM, Niro P, Lieberman HR. Caffeine improves reaction time, vigilance and logical reasoning during extended periods with restricted opportunities for sleep. *Psychopharmacology (Berl).* 2015;232:2031–2042.
40. Lieberman HR, Stavinoha T, McGraw S, White A, Hadden L, Marriott BP. Caffeine use among active duty US Army soldiers. *J Acad Nutr Diet.* 2012;112(6):902–912, 912.e901-904.
41. Tharion WJ, Shukitt-Hale B, Lieberman HR. Caffeine effects on marksmanship during high-stress military training with 72 hour sleep deprivation. *Aviat Space Environ Med.* 2003;74(4):309–314.
42. US Department of the Army. *The Army Body Composition Program.* Washington, DC: DA; 2013. Army Regulation 600-9.
43. US Department of the Air Force. *Air Force Fitness Program.* Washington, DC: DAF; 2013. Air Force Instruction 36-2905.
44. US Department of the Navy. *Physical Readiness Program.* Washington, DC: DN; 2011. OPNAV Instruction 6110.1J.
45. US Department of the Navy. *Marine Corps Body Composition and Military Appearance Program.* Washington, DC: DN; 2008. Marine Corps Order 6110.3.
46. US Department of Defense. *DoD Physical Fitness and Body Fat Programs Procedures.* Washington, DC: DoD; 2002. DoD Instruction 1308.3

47. Uniformed Services University of the Health Sciences. Human Performance Resource Center. <http://hprc-online.org/>. Accessed May 6, 2015.
48. US Department of Agriculture. *Dietary Guidelines for Americans, 2015–2020*. 8th ed. Washington, DC: DoA; 2015.
49. US Department of Agriculture. ChooseMyPlate.gov. <http://www.choosemyplate.gov/>. Accessed May 6, 2015.
50. US Department of Agriculture. SuperTracker. <https://www.supertracker.usda.gov/>. Accessed May 6, 2015.

