Increased Protein Intake in Military Special Operations¹-³

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Abstract

Special operations are so designated for the specialized military missions they address. As a result, special operations present some unique metabolic challenges. In particular, soldiers often operate in a negative energy balance in stressful and demanding conditions with little opportunity for rest or recovery. In this framework, findings inferred from the performance literature suggest that increased protein intake may be beneficial. In particular, increased protein intake during negative caloric balance maintains lean body mass and blood glucose production. The addition of protein to mixed macronutrient supplements is beneficial for muscle endurance and power endpoints, and the use of amino acids improves gross and fine motor skills. Increasing protein intake during periods of intense training and/or metabolic demand improves subsequent performance, improves muscular recovery, and reduces symptoms of psychological stress. Consumption of protein before sleep confers the anabolic responses required for the maintenance of lean mass and muscle recovery. A maximal response in muscle protein synthesis is achieved with the consumption of 20–25 g of protein alone. However, higher protein intakes in the context of mixed-nutrient ingestion also confer anabolic benefits by reducing protein breakdown. Restricted rations issued to special operators provide less than the RDA for protein (~0.6 g/kg), and these soldiers often rely on commercial products to augment their rations. The provision of reasonable alternatives and/or certification of approved supplements by the U.S. Department of Defense would be prudent. J. Nutr. 143: 1852S-1856S, 2013.

How “Special” Are Special Operations?

Whereas units involved in special operations, or SPECOPS⁴ as they are commonly known, have proven their mettle and war-fighting benefits to our country’s defense throughout our history, it is the uniqueness of their missions that highlights the requirement for nutritional examination. In this regard, nutrition must be viewed not merely in light of the fuel required to power a highly trained soldier, but more importantly, how the soldier can function optimally in the most demanding of environments. Although SPECOPS missions tend to be shorter in duration, the operations tempo (optempo), or the required tactical demands, is normally intense, stressful, and unpredictable. Existing data indicate that SPECOPS soldiers routinely expend >5000 kcal/d during combat operations training (1). As such, scheduled nutritional intake, in the traditional sense of military rations, is virtually impossible to achieve and unavailable in many circumstances. The U.S. Department of Defense (DoD) has planned for such occasions by creating rations specific to the high optempo inherent in SPECOPS. Whereas standard rations, such as “meals, ready-to-eat,” are designed to be nutritionally complete and sustain a soldier for ≤21 d, rations designed for SPECOPS-type scenarios are restricted in nutritional content. According to U.S. Army regulation 40-25 (2), restricted rations contain one-half of the nutritional standards of complete operational rations and are considered adequate for operations over a 10-d period. Restricted rations, such as the first-strike ration, are logistically feasible, require little or no preparation, and are designed as “eat-on-the-move” rations. Although each menu provides ~2900 kcal/d, caloric deficit is common due to the high energy demands of this mission type and the limited opportunities for nutritional

¹ Presented at the Efficacy and Safety of Protein Supplements for U.S. Armed Forces Personnel meeting, held at the U.S. Army Research Institute of Environmental Medicine, Natick, MA, 7–8 November 2012. The summit was sponsored by the Department of Defense, Center Alliance for Dietary Supplements Research. The views expressed in these papers are not necessarily those of the Supplement Coordinator or Guest Editors. The Supplement Coordinator for this supplement was Krista G. Austin, U.S. Army Research Institute of Environmental Medicine. Supplement Coordinator disclosures: Krista G. Austin had no conflicts to disclose. This supplement is the responsibility of the Guest Editor to whom the Editor of The Journal of Nutrition has delegated supervision of both technical conformity to the published regulations of The Journal of Nutrition and general oversight of the scientific merit of each article. The Guest Editor for this supplement was Kevin Schalinske, Guest Editor disclosure: Kevin Schalinske had no conflicts to disclose. Publication costs for this supplement were defrayed in part by the payment of page charges. This publication must therefore be hereby marked “advertisement” in accordance with 18 USC section 1734 solely to indicate this fact. The opinions expressed in this publication are those of the authors and are not attributable to the sponsors or the publisher, Editor, or Editorial Board of The Journal of Nutrition.

² Supported by the U.S. Army Research Institute of Environmental Medicine, Natick, MA. Certain presented data (Fig. 2) were derived from an NIH sponsored clinical trial supported by NIH grant R01 AR052293.

³ Author disclosures: A. A. Ferrando, no conflicts of interest.

⁴ Abbreviations used: BCAA, branched-chain amino acid; DoD, Department of Defense; EAA, essential amino acid; optempo, operations tempo; SPECOPS, special operations; USARIEM, U.S. Army Research Institute of Environmental Medicine.

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intake. The protein content of the restricted rations is ~14% (which, based on a standard 79-kg male, equates to ~0.63 g/kg) of the total caloric intake; however, based on the Army’s reference weight for a male (79 kg), this intake equates to ~0.63 g/(kg · d). The U.S. Army Research Institute of Environmental Medicine (USARIEM) has recommended that adequate protein intake in these restricted rations be just above the RDA at 0.86 g/(kg · d). Thus, it is within this framework of a caloric deficit and marginal protein intake that the benefits of increased protein intake for SPECOPS are discussed. In particular, the benefits of increased protein intake during caloric deficit on the maintenance of lean body mass, performance, and recovery are discussed. Whereas direct study of these soldiers would be scientifically gratifying, data from the field are limited. Therefore, existing evidence on the benefits of protein in the athletic community is used to infer potential benefits to soldiers in this unique and demanding environment.

Metabolic Effects of Protein Intake and Exercise on Skeletal Muscle

It is now well established that amino acid and/or protein ingestion in conjunction with exercise, primarily resistance exercise, results in muscle anabolism. Whereas resistance exercise alone does not produce an anabolic response, when combined with amino acids there is an interactive effect such that the net balance, or net anabolic effect, on skeletal muscle is greater than the additive individual responses (Fig. 1) (3,4). The primary metabolic mechanism for improved anabolism with amino acid ingestion alone (without other macronutrients) is an increase in muscle protein synthesis (3,4). Ingestion of intact protein alone (again, without other macronutrients) in conjunction with exercise results in similar increases in muscle protein synthesis (5,6). Furthermore, this short-term interaction translates to an increase in lean mass greater than that achieved by resistance exercise alone (7). Existing evidence suggests that with protein alone, a 20–25-g dose of quality protein provides a maximal synthetic response (6). Whereas the anabolic effects of protein ingestion alone are manifested in an increase in protein synthesis, when included in a traditional mixed meal the anabolic response is derived from a different metabolic mechanism. Recent work in our laboratory has demonstrated that increasing protein intake in the format of a mixed meal promotes whole-body anabolism by reducing protein breakdown. The reduction in whole-body protein breakdown was achieved with a protein intake of ~35 g with each meal. These results indicate that higher levels of protein intake may further enhance anabolism by targeting both synthetic and breakdown sides of the metabolic equation. The results further suggest that an optimal protein intake, in the context of mixed nutrient intake, is considerably higher than 25 g. Taken together, the importance of protein intake on tissue anabolism is clear. In the context of military operations, both ingestion formats must be considered. Special operators often use supplements that are primarily protein, either in bar or powder/beverage form, during operations. Military rations are modular in nature and enable the soldier to select individual components; however, the purchase of protein supplements on the open market is a common practice by special operators. Consumption of assault (restricted) rations provided by the DoD entails whole foods of mixed-macronutrient composition. Thus, consideration of adequate/increased protein consumption during SPECOPS must account for both formats.

Protein Consumption in Light of Caloric Deficit

Whereas the caloric requirement of SPECOPS is widely variable and largely unknown, the opportunity for caloric deficit, given the optempo and restricted rations, is substantial. Energy deficit results in a negative protein balance and loss of skeletal muscle. Within the framework of reduced caloric intake, existing evidence suggests potential benefits to higher protein intake. Recent work by Mettler et al. (8) in young resistance-trained men points to the benefits of higher protein intake with continued training and caloric deficit. After 1 wk of a diet providing 100% of caloric requirements and ~1.6 g/(kg · d) of protein, participants were then given 2 wk of a hypoenergetic (60% of habitual energy intake) diet. During the 2 wk of receiving the hypoenergetic, eucaloric diet, 1 group consumed ~1.0 g/(kg · d) of protein, whereas the other consumed ~2.3 g/(kg · d) of protein. After 2 wk of a hypoenergetic, eucaloric diet and continued resistance training, both groups lost an equal amount of fat mass; however, the low-protein group lost ~1 kg more of lean mass (8). Furthermore, the loss of lean mass was greater in the arms and legs (8). With the restricted-ration protein content based on ~30% protein, or 0.63–0.86 g/(kg · d) (2), the work of Mettler et al. indicates that a greater absolute intake, with approximately the same percentage of the diet (~35%), consumed as protein (8) is beneficial in maintaining lean mass during energy deficit. These data agree with a recent meta-analysis indicating a beneficial effect of greater protein intake on lean mass conservation during energy restriction (9). It is noteworthy, however, that despite the differences in loss of lean mass, there were no differences in strength or muscular performance between groups and that increased protein intake did not maintain performance at prehypoennergetic values (8). It is not unreasonable to suggest that a greater caloric deficit, or a longer period under deficit conditions, would further adversely affect performance. Whereas SPECOPS missions tend to be of shorter duration, in-theater preparation and operations may extend the total duration of caloric deficit, increase the loss of lean mass, and, in turn, decrease functional performance.

One important aspect of performance is the availability of substrate to fuel high-intensity work. In this regard, the ability to

FIGURE 1  Leg-protein balance during various physiologic conditions in volunteers. The figure shows a comparison of leg-protein balance [as determined by phenylalanine (phe) kinetics] during the fasted state (Fasting), after resistance exercise only (Exercise Only), with AA infusion only (AA Only), and during the combination of resistance exercise and AA infusion (Exercise + AA). The combined effects are interactive and greater than the additive effects of exercise and AAs alone. Values are means ± SEMs; n = 5–6/group. *Different from Fasting and Exercise Only, P < 0.05; #Different from AA Only, P < 0.05. Data are from references 2 and 3. AA, amino acid.
maintain glucose availability during energy restriction could be of life-saving importance to the special operator. A recent study from a USARIEM group investigated the effects of increased protein intake during a 7-d period of a 1000-kcal/d energy deficit induced by exercise activity (10). During energy deficit, 1 group consumed 0.9 g/(kg · d) of protein, whereas a second group consumed 1.8 g/(kg · d). The greater protein consumption enabled participants to maintain glucose production from glycogen breakdown (10). Although performance measures were not evaluated in this study, the relationship between the maintenance of blood glucose and higher intensity exercise/work performance is well established (11). Therefore, within the circumstance of energy deficit, whether by dietary intake or energy expenditure, evidence points to the potential benefits of an increased protein intake.

The metabolic and caloric demands resulting from extreme environmental conditions, such as altitude, must also be considered. Operations in Afghanistan require special operators to perform in metabolically demanding conditions. Operations above 5000 m often entail the loss of weight, due in part to a negative energy balance (12). Loss of appetite is common at altitude, and this anorexia becomes more pronounced with duration at altitude (11). To exacerbate the reduction in energy intake, hypoxia and cold have been shown to increase basal metabolic rates (13) by >20% (14). Furthermore, with increasing altitude and duration of exposure, intestinal absorption of nutrients is impaired (12). Predictably, negative energy balance results in a loss of weight, consisting of both fat and muscle mass losses. Muscle biopsies have demonstrated a decrease in muscle fiber size at altitude (15). This muscle atrophy derives from the combination of negative energy balance, reduced fat stores, and the resultant muscle catabolism and a depressed rate of muscle protein synthesis during chronic hypoxia (15). Although increased protein intake would be beneficial in several respects, the solution is not straightforward, given the anorexia and absorption issues, as well as the established preference for carbohydrates in those operating at altitude (12).

**Performance Benefits of Protein Coingestion during Activity**

A recent meta-analysis confirms that increasing protein/amino acid consumption in conjunction with resistance exercise improves both lean mass and strength gains in both younger and older individuals (16). When considering endurance exercise performance, the addition of protein to carbohydrate during exercise has the potential to alter physiologic responses. Whereas protein itself is generally an inefficient energy source that has a minimal contribution to the overall energy demands of exercise, its coingestion during prolonged exercise has demonstrated efficacy. A recent meta-analysis by Stearns et al. (17) indicates that the addition of protein to carbohydrate was beneficial when the performance endpoint was time-to-exhaustion. The authors found no effects when the performance endpoint was a time trial; however, one could argue that the time-to-exhaustion format is more applicable to the special operator and mission demands. In other words, the ability to operate at higher mission intensity for a longer period of time may be more appropriate than the faster performance of 1 task.

Inferential data in a military environment also suggest the benefit of increasing protein intake in conjunction with the other macronutrients. During an 8-wk Infantry Battle School in the United Kingdom, 2 groups of soldiers were provided a standard diet; however, a supplement group received an additional 1220 kcal (46 g of protein) during the first 6 wk and an additional 861 kcal (32 g of protein) during the last 2 wk (18). Whereas the supplement blunted the losses of total, lean, and fat mass, it also maintained performance in strength and muscular power (18). The loss of body fat and lean mass in the control group indicates an activity-induced energy deficit; thus, the results point to the caloric advantages conferred by the supplement. Although the study was not designed to test the effects of additional protein alone, the data indicate that increasing protein intake by 0.4–0.6 g/(kg · d) in the context of a mixed supplement maintains performance outcomes.

The use of free amino acids alone or in combination with intact proteins has been investigated for their performance effects. Leucine is often included in supplements for its established effects on the stimulation of translation-initiation factors of protein synthesis in conjunction with exercise (19). The addition of leucine to milk proteins in male cyclists improved sprint power on a repeat-sprint performance test (20). Furthermore, leucine/protein ingestion reduced the overall perception of tiredness on the profile of a mood states questionnaire by 13% (20). When an amino acid formula high in branched-chain amino acids (BCAAs) was ingested 3 h before performance trials in Australian Rules Football players, players’ scores on an intricate reactive motor skills and agility performance test improved significantly (21). For the SPEOPS soldier, these results suggest that inclusion of amino acids/protein may confer benefits related to tasks requiring gross motor skills, as well as those requiring more specialized motor skills. Furthermore, the inclusion of protein may play a key role in psychological factors related to performance. This attribute of protein may be more prominent when examining the role of protein in recovery from high-intensity activity.

**Role of Protein during Exercise Recovery**

Recent work has highlighted the importance of protein in affecting metabolic and psychological recovery after work/exercise. Res et al. (22) administered 40 g of protein in young men 2.5 h after a resistance exercise bout and ~30 min before sleep. Whole-body and skeletal muscle protein metabolism was measured throughout the night. Protein ingestion significantly increased overnight whole-body and muscle protein synthesis. As a result, whole-body net protein balance during the sleeping period was positive (22). This study demonstrates 2 very important points regarding protein ingestion and recovery. First, protein is effectively digested and absorbed while sleeping. In this regard, peripheral concentrations of essential amino acids (EAAs) are elevated and initiate an anabolic response in skeletal muscle (22,23). Second, the anabolic response stimulates both muscle and whole-body anabolism, leading to a net protein balance. Thus, the metabolic mechanism underlying protein turnover and tissue repair/accretion is intact while sleeping. These results indicate that the special operator may be afforded an important opportunity for adequate protein/calorie consumption. For the SPEOPS soldier, food consumption is done primarily “on the move,” and although sleep generally exists in brief bouts, if at all, an opportunity for respite can also accommodate recovery. Ingestion of food/protein before sleep will facilitate recovery from previous activities.

The relationship between increased protein intake and tolerance to intensive training periods was investigated by Witard et al. (24). Trained cyclists were given a diet containing 3.0 or 1.5 g/(kg · d) of protein during a week of intensive training. Intensive training included daily sessions of high-intensity intervals.
and long, continuous rides such that total exercise time approached 7 h. Greater protein intake attenuated the post-intensive training decrement in time trial performance and restored performance to a greater extent during the following recovery week (24). The investigators also administered a Daily Analysis of Life Demands for Athletes questionnaire and reported a substantial reduction in symptoms of stress described as “worse than normal” with increased protein. Although the improvement in time trial performance was not dramatic, it is important to note that none of the measured outcomes were negatively influenced by increased protein intake. The same laboratory investigated the effects of a BCAA beverage on recovery from intense eccentric exercise in naive participants (25). Participants consumed supplements before exercise, after exercise, between lunch and dinner, and before going to bed. Whereas the decrease in muscle function was unaffected by BCAA supplementation, there was a significant decrease in muscle soreness when the leg was flexed (24). Taken together, these studies indicate that the potential risk:benefit ratio of protein intake >1.5 g/(kg · d) favors the potential for recovery benefits, without detrimental effects or safety concerns. It is important to note that an intake of 1.5 g/(kg · d) of protein is consistent with the current USARIEM position statement included in this supplement issue (26); however, it represents a substantial increase over the previous recommendation [0.86 g/(kg · d)].

There is little known about the role of increased protein intake and recovery from injury. In particular, the effects of increased protein/amino acid intake in the immediate postinjury state are unknown. This may be of limited relevance to the special operator, because injured soldiers are normally expeditiously evacuated from today’s battlefield. However, our recent work indicates that increased amino acid intake during recovery from tissue damage/surgery improves the rate of muscle strength recovery. We recently studied participants after receiving total joint arthroplasty (knee or hip joint replacement). In a recently completed study approved by the University of Arkansas Institutional Review Board, 9 subjects (aged 58 ± 10 y) were randomly assigned to receive usual rehabilitative care and 15 subjects (aged 56 ± 7 y) were assigned to receive usual rehabilitative care plus three 15-g doses of EAAs/d. Participants were followed for 8 wk after total joint arthroplasty, and strength by maximal voluntary contraction of the quadriceps was measured presurgery and again at 2 and 8 wk postsurgery. Four-day diet records were performed every 2 wk postsurgery. After 8 wk, the usual-care group did not show improved leg strength over presurgical values (Fig. 2). EAA supplementation resulted in a significant improvement in affected (surgical) leg strength over presurgical values, and furthermore, a greater rate of improvement from 2 to 8 wk of rehabilitation (Fig. 2). Rehabilitation efforts did not differ between groups, and total caloric intake was similar (Fig. 2). However, when total protein intakes were considered (meal intake plus EAA supplementation), the EAA group consumed ~1.7 g/(kg · d) of protein. It is interesting to note that the usual-care group consumed an amount of protein considered to be the mean consumption for Americans >50 y of age by NHANES data [1.1 g/(kg · d)]. By virtually any established metric, protein consumption in this group would be considered adequate. However, the modest elevation in protein consumption by the EAA group facilitated functional recovery after surgery and tissue damage. Because of the metabolic mechanism of stimulated protein turnover with amino acid/protein ingestion, these data confirm our previous findings in inactivity that stimulated protein turnover results in improved muscle function at the single-fiber level (27).

**Options for Increased Protein Intake**

As discussed above, the DoD provides firststrike rations that contain 15% protein but often fail to meet caloric requirements. The “eat on the move” format of these rations is conducive to off-the-shelf commercial products or specially packaged high-protein snacks designed by the DoD. The use of commercial products, which currently occurs by the soldiers’ initiative, requires further DOD oversight for quality control and production standardization. On the surface, this may appear to be a reasonable option. However, other options exist that take advantage of emerging technology and existing research. With the understanding that only the EAAs are required to stimulate protein synthesis/turover (23), and of the important role of leucine (19,28,29), food bars can be designed to contain free-form amino acids, although challenges in palatability and stability exist. Emerging technology enables the production of synthesized peptides that can be made to contain a high percentage of EAAs. Although the economics of this technology are yet uncertain, these peptides would theoretically improve the solubility, taste, and stability of a high-protein product.

In summary, the conduct of SPECOPS induces metabolic challenges characterized by energy deficit, stressful and demanding conditions, and very little opportunity for physical and mental recovery. These conditions conspire to increase the potential for the loss of lean mass and resulting decrements in performance. Existing evidence points to the advantages of greater protein intake in the following respects: 1) Increased protein intake during periods of negative energy balance improves maintenance of lean body mass and blood glucose availability. 2) Operations at altitude result in negative energy balance, which would benefit from increased protein intake, although adequate ingestion remains a challenge due to alterations in nutrient absorption. 3) Coingestion of protein in a mixed-supplement format imparts performance advantages to both endurance and strength outcomes.
as well as specialized motor skills. 4) Increased protein intake confers benefits on physiologic and psychological recovery. Protein consumption before sleep stimulates muscle and whole-body anabolism and translates to improved performance, muscle recovery, and psychological well-being. 5) A small increase in chronic protein ingestion improves recovery from muscle damage/surgery and rate of recovery of muscle strength.

Future laboratory and field research should be considered to discern the extent of energy deficit and metabolic alterations associated with actual SPECOPS, although the challenges are understandably arduous. Existing research that can be inferred to SPECOPS circumstances indicates a number of potential advantages of greater protein intake.

Acknowledgments
The sole author had responsibility for all parts of the manuscript.

Literature Cited