THE INTERNATIONAL MOUNTAINEERING AND CLIMBING FEDERATION
UNION INTERNATIONALE DES ASSOCIATIONS D'ALPINISME

Office: Monbijoustrasse 61 • Postfach
CH-3000 Berne 23 • SWITZERLAND
Tel.: +41 (0)31 3701828 • Fax: +41 (0)31 3701838
e-mail: office@uiaa.ch

CONSENSUS STATEMENT OF THE UIAA MEDICAL COMMISSION

VOL: 4

Nutritional Considerations in Mountaineering

Intended for Doctors, Interested Non-medical Persons and Trekking or Expedition Operators

A. Morrison, V. Schöffl, Th. Küpper

2008

1 Introduction

"The importance of adequate caloric and fluid intake must be rated as least as highly as that of oxygen" [1]

Although Pugh wrote this with reference to the successful scientific study and ascent of the Everest expedition in 1953, further studies analysing nutritional issues at high altitudes have largely been limited to the past 20 years.

Mountaineering in its numerous variations - such as alpine climbing, trekking or expedition climbing - are physically and physiologically demanding high-performance sports. Increasing numbers of people are travelling to higher altitudes for sport, altitude training and recreation for longer durations lasting up to several months. And in common with any sportive activity, health and performance will both be enhanced by proper nutrition and fluid intake. However, this is often easier said than done when at altitude, and in a remote and challenging environmental setting.

There are many additional nutritional issues that must be considered when preparing for any mountaineering pursuit, especially those of longer duration. With increases in altitude come contaminant increases in hypoxia (reduced ambient oxygen to breathe), and complex physiological adaptations. Appetite and taste perception will be reduced. Physical exercise can now require more than double the energy (caloric intake) than at sea level. These combined effects may result in weight loss, and altered body composition (% body fat and muscle).

Therefore the aim of this paper is to briefly outline evidence-based nutritional considerations and strategies that can be adopted to minimise weight loss, and improve health and performance.

2 Reasons for weight loss at altitude

Assuming sufficient palatable food rations are taken, regularly prepared, and eaten in relative comfort, there may still a problem in actually eating and drinking enough.

Appetite and taste perception are both suppressed at high altitude. Increased satiety occurs with reduced meal sizes – i.e. you fill feel 'full' on smaller portion sizes. This 'mountain anorexia' effect can result in a significant loss of body weight beginning at altitudes around 3600m for some, and at around 5000m for most (i.e. weight loss 1-2 kg/week) [2]. This is thought to be induced by changes in hormonal levels experienced at altitude, notably leptin. Weight loss (especially body fat) was greater amongst Caucasians versus Sherpas on an Everest expedition, especially above 5400m [3]. The Sherpas with 9.1% body fat at base camp maintained this and limb circumference at altitude, unlike the Caucasians who had 18.4% body fat and lost body fat and limb circumference. Another study stimulating the an Everest trek in a hypobaric chamber for 40 days found subjects lost 7.4±2.2kg of which 2.5kg was body fat.

This weight loss is independent to any symptoms of acute mountain sickness (AMS) where the affected person will feel hungry, but has no desire to eat or drink due to nausea. AMS can occur at moderate altitudes (normally >2500m).

Poor personal hygiene is one of many reasons that may result in diarrhoea and is covered by UIAA Standard No.5. Diarrhoea will result in weight loss and electrolyte imbalances at any altitude (refer to UIAA Standard No. 5 *Traveller's Diarrhoea*). A basic electrolyte replacement drink is provided on page 6.

Other reasons contributing to weight loss may include a loss of appetite because of a change of menu, comfort and/or habits, or separation from friends/family. Eating and drinking can also be overshadowed by the need to concentrate on physical tasks and climbing, or even survival [4].

Irrespective of one's physical training status, hypoxia can also alter which energy source (fat or carbohydrate) is preferentially used by the body, and this can vary between genders [5].

Body composition changes with weight lost at altitude, and this is dependent on the altitude profile, existing body composition and gender. Fluid balance in the body can be altered by hypoxic conditions.

When sufficient palatable food is readily available and eaten in a relatively comfortable setting, any potential weight loss can be minimised [6], [4], [2], [7].

3 BEFORE THE EXPEDITION

3.1 How to decide what food rations should be taken on expedition

Deciding what rations should be taken on expedition is dependent on the dietary needs of the individuals in the group, and length of expedition. Have you teeth checked and any suspected dental work done before an expedition.

As there are likely to be times when energy intake is insufficient to meet energy expenditure (i.e. caloric intake can be reduced by a third when at around >5000m), it is important that the diet be palatable, satisfying, and easy to prepare and eat to minimise any potential weight loss [2].

Having a variety of energy-dense foods and easily prepared carbohydrates for self-selection at meals or that can be put in pockets for easy access while climbing (especially carbohydrates) can be a useful strategy. Maintain a varied food intake. It's useful to take a variety of spices for self-selection to increase palatability when taste perception is reduced at altitude. For example, one Everest study used all 2.3kg of cayenne pepper within a matter of weeks [6]

Ensure the cooking pot/s taken are easy to clean to save time, effort, and possibility of acquiring some gut infection because pot was not thoroughly cleaned from previous meal. Using a lid will save energy. One-pot meals that cook quickly, use minimum cooking fuel, and require a minimum amount of water for preparation and for washing up cooking utensils afterwards are often preferred. For example, in one study on an Everest expedition, Lhotse west face camp III was precariously situated on 45º slope of solid ice. Food preparation was limited to those items (usually high carbohydrate foods) that could be eaten without cooking, or those that could be prepared by simply mixing with hot water [4]. Many military studies using eat-to-eat rations specifically designed to meet the energy and nutritional requirements of personnel undergoing field training exercises at altitude typically report that when rations are opened, food items that are not liked are discarded (typically 10-20%, but up to 40%), before eating the remaining rations, thereby creating an energy deficit [6]. Civilian studies also reinforce such a finding.

There is no point carrying up food that is not going to be eaten. Carefully consider the dietary needs, food likes and dislikes of your expedition members. The ease with which a meal can be prepared at altitude, and in the cold, is critical to ensure a greater possibility of matching energy intake and palatability to the energy needs.

Sample diets are not included in this information sheet as there is great variation in an individual's dietary needs dependent on:

what a normal diet is (vegetarian, ovolacto, omnivore)

religion (strict vegetarian, Kosher)

any restrictive eating practices

age and gender

food intolerances / allergies

health (gastric problems, diabetes)

physical training status

% of body muscle versus fat

preference for sweet vs. savoury

medications taken may be incompatible with some foods

Where severe food allergies are present, these foods should be excluded from all rations if possible. In the event of anaphylaxis, ensure emergency adrenaline (i.e. epipen) will work at temperatures encountered if required.

Where will food rations be purchased – home or abroad? Consider shelf life of rations, temperature they are stored at, weight and packaging of foodstuff, and who will be carrying this (you or porters?). How/when will food packaging be discarded?

Once this dietary information is known, there is no shortage of media resources to help plan a diet that meets a person's dietary needs and preferences. If the organisers of the expedition are in charge of food provision, ensure they can provide for the dietary profiles of the expedition team.

3.2 Experiment by preparing/eating foods on expedition at home first

Experiment with cooking the type of food that will be consumed on expedition. Try powdered versions of: milk, eggs, cheese, etc. Try dehydrated vegetables, stock cubes, dried fruits, and different nuts. If foil pre-prepared packs of food are used, ensure these are sufficiently palatable to eat. Foods such as lentils, oats and dehydrated foods should be well soaked before using; otherwise they will absorb water from your digestive tract and may cause constipation or gastric upset. Remember, at higher altitudes you won't feel like eating and can't taste food properly either.

Experiment by storing food rations at a temperature that will be present during the expedition. Hot climates can change the texture of food or cause it to perish easily. Extreme cold can result in some foods becoming too hard or brittle to chew easily uncooked (i.e. caramel, nougat), and this may result in emergency dental work (cracked teeth, lost fillings).

3.3 Check Iron Status well before an expedition!

Have your iron status checked by your doctor before setting out, and correct the cause and any imbalance before a major expedition/sojourn! It can take 3-6 months to reverse iron deficiency. Women and vegetarians are at special risk and should be checked before going to high altitude.

4 DURING THE EXPEDITION

4.1 How to keep properly hydrated at altitude and avoid problems concerning dehydration and diarrhoea

There is little question that AMS, HAPE and HACE have poorly understood pathological effects that are characterised by body fluids being retained in the wrong places of the body (See UIAA Standard No.2). Being dehydrated – ie either by insufficient fluid intake, sweat or diarrhoea - can also independently create serious health problems. At sea level a 2 to 5% loss in body weight due to fluid loss can result in thirstiness, headaches, fatigue, profuse sweating, impaired mental/physical performance, dry mouth, chills and clamminess; and an 8% loss will result in death. At altitude (ie >2500m), maintaining water balance is more physiologically complex and influenced by the altitude profile, but it is no less serious. Assuming you have already prepared enough safe water to drink regularly and when needed at altitude, it can still be difficult to understand whether you should just be having water or a refreshment with electrolytes in it (ie sodium, glucose). The following may help inform your hydration strategy at altitude.

Urine should be very pale yellow when you're hydrated properly, and your urine should be sufficient in volume. The more dark yellow, even light brown urine becomes, as well as being scant in volume, this suggests increasing to severe dehydration or even acute mountain sickness.

It is not possible to prescribe how much water should be drunk each day as this will vary according to weather conditions, intensity/amount of physical activity, individual variations in sweat losses and gender, etc. For example one study on Everest showed water losses of 3.0±0.5 L/day in sedentary subjects, and more in climbers at 3.3± 0.6 L/day. Another study comparing water losses in identical environmental conditions but at differing altitudes 5000-7000 m and 7000-8848 m, reported losses of 3.7±0.6 L/day and 3.3±0.8 L/day respectively [2].

By way of comparison, in a temperate climate, the basic fluid requirements at sea level (from food and drink) for an average 70 kg male and 55 kg woman would be 2.5 L/day and 2.2 L/day respectively, or approximately 1.2 L/day of fluid alone (6-8 glasses). But once activity levels and/or temperatures are raised, sweat losses can be very variable among individuals, and can easily amount to 1-2 L/hour.

And heavy sweating is not just water. Sweat also contains other elements such as iron, potassium and sodium (salt). For example, if someone has heavy sweat losses that create salt stains on their clothing or their sweat stings their eyes, this suggests higher sodium sweat losses than normal, and additional salt in food/drink may be required to replace these in addition to the water losses – at least that is normal at sea level. However there is no known data examining the use of electrolyte drinks at altitude; and it is not possible to prescribe a set value for sodium requirements daily at altitude. This is what some expeditions did: the army's development of cold-weather rations in 1994 included 4500 kcal of energy, 4500mg sodium, and 90g of protein; a medic reporting on a Special Forces Alaskan climbing study using this ration suggested the exhaustion experienced by the team was due to salt depletion, rather than glycogen depletion or dehydration; a 1989 Everest Expedition study used zero additional salt on their food (though salt is in already in many foods); another anecdotal report on a team forcing themselves to drink up to 4L of an electrolyte drink daily became ill because their sweat losses were not great and it was thought they were 'overdosing' on electrolytes [6]. Pugh (2004) stated climbers living at 19000 ft consumed 12 oz of sugar daily, normally dissolved in beverages [7]. If caffeinated drinks are consumed, they should probably be avoided at the end of the day to avoid interference with sleep.

Perhaps the take home message can be summarised as: remember to drink regularly, insensible water losses increase with physical activity and this is more 'water' based, a more electrolyte-like drink may be required following exhaustive exercise or excessive sweating (along with sufficient carbohydrates). Don't overdrink in single sessions either as plasma electrolytes can become further diluted, or hyponatremia.

However, it can be very difficult to just keep properly hydrated at altitude. Water availability can be problematic – i.e. melting enough snow, drinking enough chemically sterilised water, or just remembering to drink enough regularly. Try drinking iodised water if that is what will be provided on expedition to get used to taste. Experiment by adding effervescent vitamin C tablets or similar to help mask the taste to make it more palatable if needed. Glaciers can produce vigorous meltwater streams that contain abrasive rock powder or high mineral salt content that may create a laxative effect; so before drinking such water, allow it to settle, filter it, and purify by boiling or using chemical tablets. Drinking water from streams along popular routes can have faecal contamination requiring sterilisation. Sterilisation with chlorine containing tablets (i.e. Puritabs^{R}, MultiMan^{R}, Mikropur^{R}, Certisil^{R}), or iodine solution (8 drops/L water) take 20 minutes minimum to be effective (more comprehensive advice in UIAA MedCom Standard No. 6 "Water disinfection"). Remember, taste can't get in the way of drinking enough for health and performance.

In the event of dehydration for adults from diarrhoea, a **basic electrolyte solution** can be prepared using: 1 teaspoon salt and 1 Tablespoon sugar in 1 litre (1.75 pints) of sterile water (more comprehensive advice for electrolyte solutions in from UIAA MedCom Standard No.5 Traveller's Diarrhoea). For children get advice of a doctor and prefer industrial oral rehydration products (ORS) with the correct dose for the child.

4.2 Water retention in Acute Mountain Sickness (AMS)

Although the composition of an average body shows 50 to 60% fluid content, the distribution of fluid in our body's tissues varies considerably. For example, the amount of fluid in blood, the brain, muscle, and bones are approximately 91, 81, 76, and 13% respectively. It is therefore not surprising that both physical and mental performance will be increasingly affected by increasing levels of dehydration. Any level of physical activity will be compromised in a dehydrated state, so ensure you are well hydrated before setting off between camps, and find ways of drinking regularly if required – ie use of a camelback hydration system in warmer climates, or fill a flask with hot beverage at night and put it in your sleeping bag so that a beverage is immediately available in the morning.

Hypoxic exposure can alter hormonal balances, create fluid shifts between tissue compartments in the body, and even alter amount of urination. Some studies suggest that when individuals are exposed to acute hypoxia, those who experience fluid retention in the first few hours are more likely to develop AMS (see UIAA MedCom Standard No. 2 How to manage AMS, HAPE and HACE).

Those who develop AMS will reduce both energy intake and water intake simultaneously, independent of any other weight loss that occurs for reasons already mentioned. In AMS, fluid retention is accompanied by a reduction in total body water lost (including urine retention). One study demonstrated a significant increase in total body fluid (a shift of at least 1 litre from intracellular to extracellular compartments) over 4 days. Another controlled study where 55 adults were exposed to an altitude of 4880m at rest for 12 hours found those who developed AMS symptoms experienced greater fluid retention in the first few hours than those who did not. Many reports have found a direct association between fluid retention and AMS. In any case:

Acclimatise properly!

4.3 ***Micro*nutrient deficiencies- (vitamins and minerals)**

The scope of this paper does not allow for a thorough analysis of all *micro*nutrients - those small but significant components of food known as vitamins and minerals. To ensure an adequate intake of micronutrients, eat a wide variety of foods, preferable unrefined, or fortified with vitamins and minerals (ie cereals, grains). Mineral deficiencies typically found in an athletic population, especially female athletes and vegetarians, are calcium, iron and zinc. This is normally due to energy intake restriction, avoidance of animal products such as fish, meat, dairy products or poultry, and combining foods in a manner that prevents optimal uptake of these minerals. For example, iron is poorly absorbed when combined with phytates (found in bran, products with refined flour or rice, soybeans) or calcium (found in dairy products), but well absorbed when found in the form of animal-based haem products (meat, fish) and when eaten with vitamin C.

4.4 Understanding and calculating energy needs

In an ideal world:

ENERGY INTAKE = ENERGY EXPENDITURE

In a mountaineering world, especially at higher altitudes,

ENERGY INTAKE < ENERGY EXPENDITURE

(…hence the weight lost!)

To help understand and calculate how much energy you may need on a daily basis, the following explanation of how energy expenditure occurs at sea level and at altitude is explained. The calculation in Table 1 is easy to do! Many people are surprised to learn that our greatest energy requirements are just to keep our body functioning and maintaining a stable core body temperature, and this can be challenging when exposed to hotter or colder climatic temperatures.

Energy Intake (EI) is the sum of caloric (kcal, kJ or MJ) intake from fluids and foods.

> Energy intake is influenced by age, gender, body composition (% fat, % muscle), size, health, genetics, climate, BMR, and physical activity undertaken. Each pound or 0.45kg in body weight is equivalent to 3500 kcal. So an energy deficit of 3500 kcal will result in loss of weight of one pound/0.45kg.
>
> (Note: to convert **kcal** to kJ multiply by 4.18; to convert kcal to **MJ** multiply by 0.0042)

Energy expenditure (EE) is the sum of daily energy 'spent' by the body in 3 separate ways (daily percentages shown in brackets):

- Basal Metabolic Rate (60-75%)
- Physical activity (20-35%)
- Energy used for digestion (4-7%)

These individual points are now explored more fully as they have nutritional implications in response to altitude and to cold exposure.

4.4.1 Basal Metabolic Rate (BMR)

BMR is the energy needed by the body to keep itself functioning without any physical activity - ie energy for sleeping and arousal metabolism, cell renewal/repair, maintaining a stable core body temperature, etc. BMR will be higher on days when exercise took place the previous day as muscle is very metabolically active.

BMR normally accounts for 60-75% of 24-hour EE. It's accurately measured using respiratory gas exchange analysis when a person is lying down in physical/mental rest in warm setting at least 12 hours after a meal. As this is impossible to access for most people, an estimate can be easily obtained by using the calculation in Table 1.

BMR is higher in active verses inactive people as they have more metabolically active muscle. Body composition is probably the most important physiological determinant of thermoregulatory tolerance in cold weather [6]. Understanding and minimising the effects of the cold, and cold injury, has nutritional implications. There are two key physiological responses to cold weather – a) peripheral vasoconstriction to limit heat loss and conserve energy and; b) physical activity, shivering or both act to increase heat production, and thus increase energy needs [6]. In extreme cold environments, BMR can be increased fivefold at rest because of the body shivering to try and keep warm. In a tropical climate, it is raised by 5-20%, plus another 5% when exercise performed. On first reaching a new high altitude, BMR is increased at altitude by 10-20% or more. Therefore in climate extremes, body composition, physical activity levels, altitude, and behavioural thermoregulatory responses to the weather (ie clothing worn, shelter) will obviously directly influence BMR, and the amount of energy required. And don't forget to factor in the extra energy needed to cover for bad weather days.

4.4.2 How to calculate energy needs and Physical Activity

Physical activity needs additional energy intake, which depends on amount, type and intensity of physical exercise undertaken. This additional energy (kcal) should be added to daily BMR, and the calculation is provided below.

Table 1. Formulae for the prediction of BMR (Department of Health, UK 1991)

	Age range (years)	Regression formula for daily BMR (MJ/day)
Men	10-17	0.074(wt)*+ 2.754
	18-29	0.063(wt) + 2.896
	30-59	0.048(wt) + 3.653
	60-74	0.0499(wt) + 2.930
Women	10-17	0.056(wt) + 3.434
	18-29	0.062(wt) + 2.036
	30-59	0.034(wt) + 3.538
	60-74	0.0386(wt) +2.875
		*(wt) = body weight in kg

For example, to calculate daily BMR for 25-year-old male weighing 70kg, use correct calculation from Table 1:

0.063(70kg) + 2.896 = 7.306 MJ/day

To convert MJ to kcal, divide by 0.0042:

7.306/0.0042 = 1740 kcal/day

This 1740 kcal is the amount of energy the body uses just to keep this young man functioning daily without any physical activity or eating etc. It is the baseline figure (assigned an EE value of 1.0) from which additional energy intake to match energy needs must be calculated.

This physical activity index is the most variable component of EE. As a multiple of BMR, it ranges from the absolute minimum of value of 1.0 for someone who does not eat or move, to between 1.5 for a sedentary person, to 2.0 for an active person. Values over 2.5 cannot be maintained without specific food supplements. One expedition to Everest found the index to be 2.2±0.3, a value close to a highly trained endurance athlete [2]. Another study with ascents >6000m found higher values of 3.0±0.7[2]. In these studies EI did not meet EE.

4.4.3 Diet-induced energy expenditure

Diet-induced energy expenditure normally accounts for 10% of EE due to heat losses through digestive processes. However, since many people are in a negative energy balance at altitude, and food malabsorption is not significant, this thermic loss of diet-induced EE (heat lost in faeces etc) is not significant. Some studies have reported 4-7% diet-induced energy expenditure at altitude [2].

4.5 *MACRO*NUTRIENTS - CARBOHYDRATES, FATS, and PROTEIN - DISTRIBUTION AT ALTITUDE

Foods/fluids are a combination of *macro*nutrients (big food groups) - carbohydrates, fats, proteins as shown in Table 2. The site, rate and extent of digestion of carbohydrates are highly dependent on food processing, and have significant implications on health and performance. Avoid highly refined carbohydrates with low micronutrient content, fortified grains and flours are preferred.

Observations reported and other studies suggest where climbers can self-select foods at high altitudes, a greater proportion of energy comes from fats. The assumption that carbohydrate rich foods are preferred at the highest altitudes is not consistent in studies. However, carbohydrates will always make up the greatest proportion of a diet (55-65%) as they are the preferred fuel for muscles, and helps achieve a balanced diet.

Muscles have a limited store of carbohydrate – in the form of glycogen – that needs constant replacement when muscles are working. Trained muscles can store significantly higher amounts of carbohydrates which makes them more efficient. For example, the amount of glycogen that can be stored in 100g of muscle is: 13g when muscle is untrained, or 32g when trained; and when trained muscle is loaded fully with carbohydrates it can hold 35 to 40g of glycogen. Muscle glycogen depletion is closely related to muscular fatigue. Therefore carbohydrate snacks that are easily accessed from pockets or backpack while trekking or climbing are desirable to help fuel, maintain or even build muscles, and avoid the possibility of gastric upset or bloating resulting from excessive carbohydrates eaten in a single meal. **Note:** pure glucose should be avoided!

The body may also prefer to metabolise fats depending on intensity of exercise, gender, training status etc. Fats required more water to break them down and result in a greater fluid loss that needs replacing. Maintaining or increasing muscle mass requires a careful balance of water, carbohydrate, and protein eaten at the right times.

Muscle wasting that occurs at altitude can be the result of simply not meeting energy needs – either because not enough food is eaten in the first place and / or there is increased physical activity not matched by additional energy. There are also altitude induced physiological adaptations taking place that can influence what and how much you eat and which ‘fuel’ your body prefers for energy. Insufficient energy to meet energy needs may result in say protein from that meal being used for fuel instead of valuable protein related functions, such as synthesis and maintenance of muscle, and the creation of hormones and enzymes. Protein used as fuel can also increase water loss that may increase the risk of dehydration

At sea level, meals, even snacks, combining small amounts of protein with carbohydrate are recommended as soon as possible after strenuous exercise to replenish glycogen stores (as well as topping up with any fluid loss). This carbohydrate refuelling should be 1.5g/kg body weight in first 30 minutes, and again every 2 hours for 4 to 6 hours to replace glycogen stores. These recommendations may be difficult to implement at altitude, though further notes provided in Table 2.

Also, by way of having some type of reference at sea level, typical daily dietary <u>intakes per kg of an athlete’s body weight</u> are: carbohydrates 6 to 10g/kg body weight, protein 1.2 to 1.4g/kg body weight. but higher for strength training athletes at 1.6-1.7g/kg; there is no health or performance advantage to a diet with <15% fat of total dietary intake, and recommendations range between 15-25% dependant on sport [8].

Some studies suggest where climbers can self-select foods, the % distribution of macronutrients did not vary significantly as altitudes increased, ie where daily intake throughout an Everest expedition was consistently maintained at Fat 20%/ Carbohydrate 65% or 35% Fat/ Carbohydrate 50% there was no difference in the performance or climbers who summitted Everest.

Table 2. Macronutrient (Major Food Group) Distribution at Altitude

Macronutrient / Energy Source	Amount of ener-gy (kcal / gram)	Energy equivalent of oxygen (kJ/l)	Approximate % of daily diet at altitude	Food examples	Other relevant notes
CARBOHYDRATE (CHO) (needed to maintain blood glucose levels and glycogen stores, therefore eat frequently. It's the preferred fuel for moderate to high intensity exercise)	4	21.1 Also all muscle has CHOs reserves (glycogen) for intense exercise that needs constant replacement.	Around 56% (studies show daily intake of between 50-65%) **Note:** excessive intakes recommending around 70% may cause gastric upset and are likely to result in an unbalanced diet as it can inhibit bioavailability of other vitamins/minerals	Rice, pasta, noodles, cereals, potato, crackers, bread, glucose polymer beverages, tinned & dried fruits, chocolate, sugar	Predominant energy source for physical activities as muscles are best fuelled by CHOs. Has highest yield of energy per mole of oxygen. As it's the largest % of diet, should not be highly refined - any flours, grains should preferably be fortified with minerals/vitamins. Eat sufficient CHO before/during/soon after strenuous exercise lasting >1 hour to help maintain stable blood sugar levels. Military studies at altitude recommend CHO of at least 400g/day ([6] pg74)
FAT (provides essential fat soluble vitamins; high energy food; an essential elements of cell membrane)	9	19.6	Around 28% (studies show a daily intake at between20-35%) [1]	Cooking oil, liquid margarine, ghee, tinned foods in oil, peanut butter, nuts, oil from tinned fish	More energy (kcal) than CHO per gram. Has the best taste of all macronutrients –often improves flavour perception/pleasing texture/increased palatability. At sea level, there is no health or performance advantage to a diet with less than 15% fat. Try to avoid saturated fats, use monounsaturated oil
PROTEIN (if other energy intake is inadequate, protein will be used also be an energy source - not good! Protein is needed to build and repair muscle, tissues)	4	18.7	15%	Cheese, retort sausages, beef sticks, tinned fish, eggs, pulses, lentils	Most satiating of macronutrients. Suggested that it should not be more than 15% of diet due to high thermic effect.
ALCOHOL	7		0%		High in calories, and very detrimental to sporting activity as it's dehydrating, a diuretic impairs mental judgement & physical performance. It is also a vasodilator that increases peripheral heat loss.

References

1. Pugh, L.C.G.E., *Metabolic problems of high altitude operations*, in *Nutritional Requirements for Survival in the cold and at Altitude*, L. Vaughn, Editor. 1965, Arctic Aeromedical Laboratory: Ft. Wainwright, AK. p. 299-342.

2. Westerterp, K.R., *Energy and water balance at high altitude.* News Physiol Sci, 2001. **16**: p. 134-7.

3. Boyer, S.J. and F.D. Blume, *Weight loss and changes in body composition at high altitude.* J Appl Physiol, 1984. **57**(5): p. 1580-5.

4. Reynolds, R.D., et al., Intakes of high fat and high carbohydrate foods by humans increased with exposure to increasing altitude during an expedition to Mt. Everest. J Nutr, 1998. **128**(1): p. 50-5.

5. Braun, B., et al., Women at altitude: carbohydrate utilization during exercise at 4,300 m. J Appl Physiol, 2000. **88**(1): p. 246-56.

6. Marriott, B.M. and S.J. Carlson, *Nutritional Needs in Cold and High-Altitude Environments: Applications for Military Personnel in Field Operations*, I.o.M. Committee on Military Nutrition Research, Editor. 1996, National Academic Press: Washington D.C.

7. Pugh, L.G., Himalayan rations with special reference to the 1953 expedition to Mount Everest. 1954. Wilderness Environ Med, 2004. **15**(2): p. 125-34.

8. N.N., Joint Position Statement: nutrition and athletic performance. American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada. Med Sci Sports Exerc, 2000. **32**(12): p. 2130-45.

Members of UIAA MedCom (in alphabetical order)

C. Angelini (Italy), B. Basnyat (Nepal), J. Bogg (Sweden), A.R. Chioconi (Argentina), S. Ferrandis (Spain), U. Gieseler (Germany), U. Hefti (Switzerland), D. Hillebrandt (U.K.), J. Holmgren (Sweden), M. Horii (Japan), D. Jean (France), A. Koukoutsi (Greece), J. Kubalova (Czech Republic), T. Kuepper (Germany), H. Meijer (Netherlands), J. Milledge (U.K.), A. Morrison (U.K.), H. Mosaedian (Iran), S. Omori (Japan), I. Rotman (Czech Republic), V. Schoeffl (Germany), J. Shahbazi (Iran), J. Windsor (U.K.)

History of this recommendation paper

The version presented here was approved at the UIAA MedCom Meeting at Adršpach – Zdoňov / Czech Republic in 2008.