NUTRITION

The Fear of **Calories Part II**

by Dan Benardot – U.S. Track & Field Team Dietitian

The chronic failure to consume sufficient energy (calories) in the right amount, of the right type, and at the right time causes profoundly difficult problems for runners. Such energy inadequacy results in a diminished level of performance that belies the athlete's conditioned state, creates a higher risk for injuries, produces poor endurance and power, and infuses a general malaise that can take otherwise talented runners out of the competitive pool. Injury avoidance is important because returning to a competitive state following an injury takes a great deal of time, sometimes forcing runners to miss entire seasons. Injured athletes find it difficult to sustain even a marginally acceptable level of conditioning. Some injuries become so enduring that runners find it impossible to return to the pre-injury conditioned state. It is important, therefore, for runners to carefully consider the energy-delivery strategies they follow, because even subtle but habitual mistakes can result in devastating and long-lasting difficulties.

While the fear of calories is most common in aesthetic sports such as gymnastics, skating, and diving, it is also commonly found in runners, wrestlers, lightweight crew, and racehorse jockeys.[1] A failure to satisfy energy needs affects up to 75% of young female athletes, including runners.[2, 3, 4] In fact, the fear of calories has become a commonality in virtually all sports and for both male and female athletes, with the notable exception of football and sumo wrestling. Regardless of the sport, when energy restriction becomes part of the athlete's training regimen, common problems occur.

Effect of Energy Inadequacy on Performance

Energy inadequacy results in a loss of metabolic (lean) mass and, therefore, a lower metabolic rate. While these consequences may not appear to be problematic, both create major difficulties for runners that are difficult to recover from. Lean mass is lost because the poor delivery of energy creates a necessity for the body to 1) find the needed energy and 2) lower the need for energy.

Energy inadequacy leads to an adaptation that lowers the need for energy, but this adaptation is overzealous, and it creates an excess efficiency. It does this by lowering lean mass more than can be explained by the level of restriction that occurred.[5] While the result is the ability to sustain existing weight on fewer calories, the remaining weight is lower in muscle and higher in fat than before the energy restriction occurred. This is, of course, the opposite of what runners wish to achieve, so the fear of calories becomes more intense and the energy restriction becomes worse. The inevitable result is a gradual spiraling down of the consumed energy to thwart the body's over-adjustment to the inadequate energy intake. Put simply, the less you eat, the less you can eat.

The constant downward spiral of energy intake may eventually lead to an eating disorder that carries its own set of risks,[6] but even in the absence of a diagnosable eating disorder the reduced food consumption results in a reduced nutrient intake, with vitamin and mineral deficiencies becoming a greater risk to both health and performance *(See Figure 1)*. Vitamin and mineral supplements may partially fill the gap between nutrient demand and supply, but supplements carry an entirely different set of risks, not the least of which is the inclusion of unlisted banned substances that can disqualify an athlete.[7] It is important to consider that consumption of energy without adequate vitamins and minerals makes little sense, as there would be no way for cells to metabolize the energy. But it also makes little sense to have high dose supplements of nutrients with

Figure 1: Traditional view of energy balance through the perspective of energy thermodynamic theory

Energy Balance =	24 hour energy intake / 24 hour energy expenditure	
Positive Energy Balance =	2500 calories / 2000 calories	[Weight goes up]
Negative Energy Balance =	1500 calories / 2000 calories	[Weight goes down]
Perfect Energy Balance =	2000 calories / 2000 calories	[Weight stays the same]

Adapted from: Melby CM & Hickey M. Energy balance and body weight regulation. Sports Science Exchange 2005; 18:2.

inadequate energy, as the nutrients would have no energy to metabolize. Cells have a simultaneous and balanced requirement for both energy and nutrients, and a failure to satisfy one without the other only creates cellular difficulties.

Energy inadequacy can also lead to performance degradation through reduced power and strength, particularly if the restricted eating causes a dramatic reduction in consumed carbohydrate. Higher exercise intensities result in a greater muscular reliance on carbohydrate as a fuel. Therefore, power activities or the sprint at the end of a long race are highly carbohydrate dependent. However, if the fear of calories keeps athletes from consuming sufficient carbohydrates or reduces eating opportunities, it becomes increasingly likely that muscle glycogen stores will be compromised along with the athlete's capacity to perform higher intensity activities.

Some athletes are so invested in achieving a desired body profile that they purposefully avoid the consumption of any foods or drinks during or after exercise to maximize the energy expenditure. This strategy, however, negatively affects muscle recovery from exercise and also inhibits glycogen replenishment, both of which are needed for subsequent exercise bouts.[8, 9] You could hardly imagine a more powerful strategy for reducing athletic performance than depleting glycogen stores and purposely doing nothing to correct exercise-associated muscle soreness.

Injury risk is, of course, also higher in athletes with depleted energy stores, particularly if the timing of carbohydrate intake fails to sustain blood sugar and the function of the central nervous system (i.e., brain). Poor central nervous system control makes all athletes injury prone, which is (of course) counter to an athlete's training goals. Regardless of the sport, injuries occur with greater frequency at the end of training or competition, when energy stores (including blood sugar) are more likely to be depleted.[10]

Impact of Energy Inadequacy on Short- and Long-Term Health

There is an increasing body of knowledge showing that athletes place themselves at higher disease risk with nutrient deficiencies. Iron deficiency is a particularly severe problem in young female athletes because of multiple athlete-related issues associated with faster red blood cell breakdown: higher blood acidity, greater red blood cell velocity, extra-vascular compression of the major working muscles, and higher plantar surface compression at foot strike.[11] The result is that the mean life of red blood cells in runners is 80 days versus the typical 120 days in non-athletes. This faster red blood cell breakdown increases the dietary need for iron so that red blood cells can be manufactured at a faster rate. An average healthy female would require approximately 3,000 calories/day consuming an average healthy omnivorous diet to provide the recommended iron intake of 18mg/day. It is hard to imagine how an energy-restricting athletic female, who needs more iron, could get enough. The result of inadequate iron intake is poor immune function resulting in reduced disease resistance, an increased risk of amenorrhea resulting in lower bone density and higher risk of stress fractures, plus lower oxygen carrying capacity that would compromise the utilization of fat as an energy substrate and reduce endurance performance.

Energy inadequacy is now recognized to be the major cause of amenorrhea (cessation of the menstrual period) and oligomenorrhea (irregular menstrual period). The associated drop in estrogen is very serious, and the standard of practice is to recommend estrogen replacement therapy for any female who is 16 years of age and has never experienced a period (primary amenorrhea).[12] The logic behind this recommendation is sound. In females, estrogen inhibits the activity of cells that break down bone (osteoclasts), thereby favoring cells (osteoblasts) that increase bone density. Without estrogen, bones fail to achieve the desired density and are predisposed to fracture. This reality is so common in athletes that the "female-athlete-triad" has become an established syndrome describing the interrelatedness between eating disorders, amenorrhea, and low bone density. It is unlikely that an amenorrheic female could continue in sport without having her career compromised from stress fractures. Don't be misled, however, with the idea that only someone with an eating disorder can be at risk. In fact, anyone who fails to match the energy demand with the energy supply is at risk, even in the absence of an eating disorder. For instance, a runner who has increased the habitual level of training to prepare for an upcoming race, but has failed to satisfy the increased need for energy created by the higher training level is also at risk. Any situation that creates inadequate energy availability relative to the need for energy creates both health and performance risk.

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Hormonal and Metabolic Outcomes Resulting from Energy Inadequacy

Of particular concern for athletes who fail to consume sufficient energy is the rise of the adrenal hormone cortisol, which is a catabolic hormone.[13, 14] As energy supply fails to meet demand, cortisol production is increased to tear

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down tissue needed as a source of energy. A measurable increase in cortisol is almost always associated with both a decrease in lean mass (muscle) and a decrease in bone density, neither of which help to support the athletic endeavor. As if to compound the negative tissue effect of cortisol, the liver produces less insulin-like growth factor-1 (IGF-1), which is associated with the manufacture of lean tissue. Together, the increased production of cortisol and the lower production of IGF-1 results in a lower level of lean mass and an increased difficulty in replacing the lean mass in the presence of energy inadequacy.[15]

Leptin, a hormone produced by fat cells, is decreased in the presence of energy inadequacy, increasing the likelihood that fat cells will enlarge and body fat percent will rise. In fact, people who have a chronic inability to produce leptin are usually obese.[16]

The main thyroid hormone, thyroxin, as measured by Total T3 (thiiodothyronine) is also decreased with energy inadequacy, resulting in a slowdown of the metabolic rate (i.e. the rate at which energy is expended).[17] But, as indicated earlier, the metabolic rate slowdown appears to overreach, possibly because of the collective effects of lower T3, higher cortisol, and lower IGF-1 working to make the body sufficiently energy efficient so that it can sustain weight on a lower caloric load. This results in a total weight that consists of less muscle and more fat, a lower strength-to-weight ratio, and a lower body density. The resulting increase in size for the same weight would be considered an undesirable change by any runner wishing to improve.

Self-Assessment Questions

Has exercise intensity increased recently and, if so, has there been a concomitant increase in food intake to satisfy the higher energy need?

A failure to match energy intake when exercise intensity and frequency increase creates difficulty in sustaining lean mass, and generally causes overtraining syndrome with poor sleep, agitation, fatigue, and increased injury risk.

Is it increasingly difficult to sustain current weight without constantly reducing energy intake?

Constantly having to ratchet down food intake to sustain weight is a good sign that energy intake and energy requirement are not dynamically matched. Make a graph that estimates the times of day you are expending the most and least energy, and then make a graph of when you are consuming the most and least energy. The peaks in energy intake should closely match the peaks in energy expenditure, but should be about 2 to 3 hours earlier.

Are you sleeping well and regularly?

Failure to sleep well and regularly is a sign that you may be overworked and undernourished. Take a close look at your schedule to see if you can make a better match between energy intake and expenditure. Also make certain you are consuming sufficient fluids to satisfy your fluid requirements (is your urine nearly clear in color?)

How many meals per day do you eat? Do you have snacks between meals?

Most runners should have at least six eating opportunities per day, not counting the carbohydrate-containing sports beverages consumed between meals and during training sessions. Failing to do this will almost certainly unfavorably affect body composition and weight.

When is your largest meal consumed?

Many athletes post-load their energy intake (i.e., consume energy after it is needed) often making the last meal in the day a 'recovery' meal. Much like you have to put fuel in a car before it can take you where you want to go, you should do the same with fueling your muscles.

Do you avoid certain 'categories' of foods?

Athletes often avoid whole categories of foods because they label foods as 'good', 'bad', or 'fattening'. Runners with the fear of calories, for instance, often give carbohydrates the label of 'fattening'. Avoiding whole categories of foods is a guaranteed formula for creating malnutrition and poor athletic performance. All foods can be fattening if too much is consumed at one time. By spreading out the food intake and consuming smaller meals, athletes can avoid the hormonal shifts that encourage muscle loss and fat gain.

Have you had a stress fracture recently?

Stress fractures may be a sign that protein is too high (excess protein increases urinary calcium losses), that estrogen is too low (in females), or that cortisol is too high (cortisol is increased with energy inadequacy and is highly catabolic to bone.) Having a stress fracture should cause runners to seriously evaluate whether the training regimen and the nutrition regimen are appropriately matched.

(If female) Are your menstrual periods regular throughout the year?

Irregular or a cessation of the menstrual period is a good sign that the energy consumed is not sufficient to support the training regimen. As little as three years with low bone density, often a result of the low estrogen associated with irregular menses, can permanently predispose otherwise talented athletes to stress fractures and, later in life, early osteoporosis.

Strategic Solutions for Runners

Runners should consider performing a self-evaluation with key questions that could help determine the adequacy of energy intake, and then take appropriate corrective action. Consider that changes in energy intake are best made gradually, and that eating smaller more frequent meals is better than eating larger less frequent meals. Therefore, the observation that energy intake may, indeed, be low should not be followed by belly-busting meals to correct the situation. Instead, eating opportunities should be increased with a small increase in food volume at each eating opportunity.

Summary

Energy inadequacy can lead to hormonal changes that create health risks and are counterproductive in the athlete's drive to improve competitiveness. Athletes with a poor match between energy supply and demand typically catabolize lean mass in an adaptation to lower energy requirement, and increase relative fat mass. It is conceivable for an athlete to lose weight with a negative energy balance, but the resulting weight is likely to have a high body fat percent and the energy intake must constantly be reduced to sustain the lowered weight as energy efficiency increases. Lower energy intake is associated with lower nutrient intake, which predisposes athletes to a multitude of nutritional problems.

The hormonal adjustment to inadequate energy intake is clear: cortisol, a catabolic hormone, increases with a resultant loss of lean and bone mass; thyroid hormone is lower, with a resultant decrease in energy metabolism; estrogen is lower, predisposing female athletes to low bone density; IFG-1 is lower, making it more difficult to sustain or increase lean mass; and leptin is lower, making higher fat mass more likely. Counteracting the fear of calories by better matching energy supply and demand will correct these problems and help runners achieve their athletic goals.

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Take Away Message

Runners must learn that energy should be supplied on-time and in the right amounts to satisfy muscular fuel needs and avoid the metabolic adaptations associated with energy inadequacy. Getting *enough* calories *on-time* should be the mantra for any runner wishing to overcome the fear of calories.

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