# Involuntary Weight Loss and Protein-Energy Malnutrition: Diagnosis and...

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## INVOLUNTARY WEIGHT LOSS AND PEM AND ITS CONSEQUENCES

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### Defining the Terminology

It is essential to understand the terminology of PEM because each key term describes an important concept (Table 1).

**Table 1. Terminology of Protein Energy Malnutrition**

| Term | Definition |
|---|---|
| Energy | The capacity to do work |
| Energy production | Defined in terms of standard energy units produced per time |
| Energy consumption | Energy used/time (eg, kcal/hour or mL $0_2$/minute) |
| Kilocalorie (kcal) | Standard measure of the quantity of energy obtained from nutrients (often referred to as a calorie) |
| Metabolism | Sum (body) total of all chemical reactions required for cell function -- an energy-requiring process |
| Hypermetabolism | Increase in metabolic rate above normal |
| Anabolism | Constructive metabolism or new tissue formation with protein synthesis |
| Catabolism | Destructive metabolism or tissue degradation with protein breakdown |

**PEM.** PEM is defined as a pathologic state characterized by inadequate intake of energy and protein. This state is the most common form of malnutrition in the acutely injured, chronically ill, or incapacitated populations.[7,8]

There is a high prevalence of PEM in chronic wound patients, and it is a cause of poor healing and the development of wounds such as pressure ulcers. Initial symptoms of fatigue (cell-energy crisis) are followed by a progressive weight loss, including both fat and lean mass. The magnitude of lean mass loss, however, is what produces the morbidity and mortality of PEM.

**Unintentional weight loss.** The definition of significant weight loss is a loss of 10% of body weight over a 6-month period. Because unintentional weight loss is related to the degree of malnutrition and is easy to monitor, it is used as a crude marker of the degree of malnutrition and body compromise in injured or ill patients. Weight loss itself is used as a medical quality-assurance marker for the status of nutrition in patient populations at risk. To improve quality of care for the elderly and the incapacitated, the federal government defined specific healthcare criteria in the Omnibus Reconciliation Act (OBRA) of 1987.

The OBRA Act defines significant unintentional weight loss as a 5% loss in 30 days and a 10% loss in 6 months and considers this process a deviation from proper care (Table 2).

### Table 2. Definition of Significant Involuntary Weight Loss

| | |
|---|---|
| Involuntary weight loss producing a significant health risk: | |
| | ≥ 5% weight loss in 30 days |
| | ≥ 7.5% weight loss in 90 days |
| | 10% weight loss in 180 days |
| Involuntary weight loss in association with any stress or comorbid factors may complicate many disease states. | |

Those at high risk for unintentional weight loss are those suffering major burns and trauma and those with spinal cord injury. Others at increased risk for unintentional weight loss are patients in outpatient rehabilitation and in nursing homes due to comorbid factors such as aging and disability (Table 3).

### Table 3. At-Risk Population for Unintentional Weight Loss

| **Patient Population** | **Incidence** |
|---|---|
| Major burns and trauma[*] | 80% |
| Spinal injury rehab[*] | 50% |
| Outpatient rehab[†] | 20% to 40% |
| Nursing home | ≥ 25% |

[*] considered a characteristic of the disease

[†] all post injury or surgery

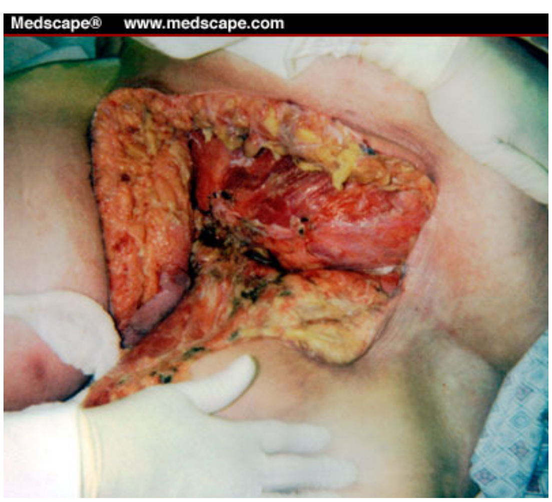
It is evident that, due to the high metabolic demands in those patients severely injured or ill, tremendous weight loss occurs, despite good nutritional practices. In the chronically ill population, unintentional weight loss is usually attributable to a prior insult and a chronic state of poor nutrition.

**Starvation.** Starvation is the pathologic process whereby there is inadequate nutrient intake to meet demands. If prolonged, starvation will result in malnutrition (Figure 1). Normal humans can adapt to inadequate intake by readjusting nutrient use. Therefore, the deleterious effects on metabolism, healing, and organ function may not be evident for several weeks. The most important adaptive response is maintaining optimum "protein and energy partitioning," where the majority of energy comes from fat metabolism (90% to 95%) and only 5% from protein.[7-10]

**Figure 1.** Inadequate nutrition in the absence of injury.


**Stress response.** The host response to illness, injury, or infection is an amplification of the flight or fright reaction. The initial insult leads to local and generalized inflammation and to the activation of an abnormal hormonal response, characterized by a marked increase in catecholamines and other stress hormones. This response produces a hypermetabolic-catabolic state (Figure 2). The degree of hypermetabolism and catabolism is dependent on both the degree of injury and the host response to injury. The hormonally induced metabolic response produces a marked increase in energy demands and change in nutrient use, with 50% coming from fat, 30% from carbohydrates, and 20% (or more) from protein. An energy deficit is common. The increased use of protein for fuel is counter to normal nutrient partitioning principles and rapidly depletes lean body mass.[5,6]

**Figure 2.** Necrotizing fasciitis. Due to the massive wound and infection, the stress response is activated and catabolism and lean mass loss result.

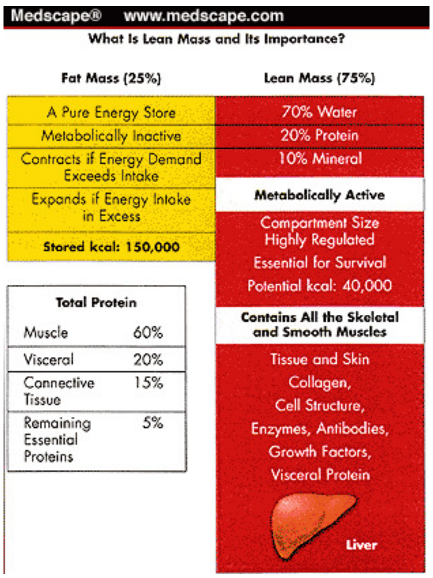


### What Is Normal Body Composition: Effects of Lost Lean Mass

I n order to better understand the impact of erosion of lean mass and the normal and abnormal use of protein and fat for fuel, a general understanding of normal body composition is required.[11,12] The body is composed of a fat and a lean (fat-free) body mass component.

**Lean mass.** The body's protein is contained in lean body mass, mostly as skeletal muscle.[11-15] Lean body mass is 50% to 60% muscle mass by weight and the rest is bone and tendon. Protein makes up the critical cell structure in muscle, viscera, red cells, and connective tissue. Enzymes that direct metabolism and antibodies that maintain immune functions are also proteins. It is the loss of body protein, not fat loss, that produces the complications of malnutrition; protein synthesis is essential for any tissue repair. Skin is composed primarily of the protein collagen.[13-16] Table 4 summarizes the definition of lean mass and its importance.

## Table 4. What Is Lean Mass and Its Importance?



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What Is Lean Mass and Its Importance?

| Fat Mass (25%) | Lean Mass (75%) |
|---|---|
| A Pure Energy Store | 70% Water |
| Metabolically Inactive | 20% Protein |
| Contracts if Energy Demand Exceeds Intake | 10% Mineral |
| Expands if Energy Intake in Excess | **Metabolically Active** |
| **Stored kcal: 150,000** | Compartment Size Highly Regulated |
| | Essential for Survival |
| | Potential kcal: 40,000 |
| | **Contains All the Skeletal and Smooth Muscles** |
| | Tissue and Skin Collagen, Cell Structure, Enzymes, Antibodies, Growth Factors, Visceral Protein |
| | Liver |

| Total Protein | |
|---|---|
| Muscle | 60% |
| Visceral | 20% |
| Connective Tissue | 15% |
| Remaining Essential Proteins | 5% |

**Fat mass.** Stored body fat is used primarily as a reservoir for energy. The size of the fat depot is controlled by both genetic and environmental stimuli, such as diet. Excess nutrients, especially carbohydrates, will expand the depot, while inadequate intake will decrease depot size.[16-18] One of the biggest health problems in this country is excess fat due to overeating and decreased physical activity.

There are 5 types of lipids (Table 5). The metabolic activity that fat undergoes is conversion to fatty acids for energy use and back to fat for storage. A component of the essential lipids is used for all membrane phospholipid content. Cholesterol is the lipid used for many hormones and other essential molecules.[18] There are other essential lipids used in normal metabolic activity, but they make up only a very small proportion of the total fat mass.[18] Table 6 summarizes the differences between essential fat and storage fat.

## Table 5. Types of Lipids

- Free fatty acids (fat)
- Phospholipids

- Lecithin
- Cholesterol
- Lipoproteins

### Table 6. Essential Vs Storage Fat

- Some essential fat is needed for normal physiologic function.
- This essential storage is greater in women than in men likely due to a biologically established range to provide energy for childbearing.
- Storage fat makes up the majority of fat in the average individual.

**Genetic drive.** Body composition is genetically determined -- especially the lean mass component. There are a number of genetic adaptations the body makes to maintain normal lean body mass or body protein, as any net loss of body protein or lean mass is deleterious.[14-17]

**Anabolic hormones.** Endogenous levels of anabolic hormones, human growth hormone (HGH), testosterone, and, to some degree, insulin are maintained at a level sufficient to increase net anabolism when needed to maintain body protein content. This process is most evident during periods of decreased intake where efficiency of protein synthesis increases and any protein used for fuel is decreased to avoid a net loss. (This process is overridden with the stress or fright-flight response).[5,6]

**Resistance exercise.** Resistance exercise, which is muscle activity against a force (eg, lifting objects, weight-bearing activity, a weight-lifting program), leads to an anabolic stimulus that increases the protein synthesis of muscle.[19,20]

**Protein intake.** Protein intake must be sufficient to allow for the necessary new protein synthesis. The recommended daily allowance (RDA) in the United States is 0.8 g/kg body weight/day. This amount increases with age, body stress, and wounds when more protein synthesis is needed. [9,10,21]

Table 7 summarizes how the human body maintains lean body mass.

### Table 7. Maintenance of Lean Body Mass

- Intense genetic drive to maintain essential protein stores
- Anabolic hormones that stimulate protein synthesis to preserve protein stores

- Resistance exercise
- Adequate protein intake

**Body compositional changes.** Compositional changes occur secondarily to lost lean mass, resulting in complications.[14-20] If pre-existing loss is added to a body insult, the result is more severe complications. A 40% loss of total lean mass is fatal (Table 8).

### Table 8. Relationship Between Loss of Lean Mass and Degree of Mortality



Complications Relative to Loss of Lean Body Mass*

| Lean Body Mass (% loss of total) | Complications (related to lost lean mass) | Associated Mortality (%) |
|---|---|---|
| 10 | Impaired immunity, increased infection | 10 |
| 20 | Decreased healing, weakness, infection | 30 |
| 30 | Too weak to sit, pressure sores, pneumonia, no healing | 50 |
| 40 | Death, usually from pneumonia | 100 |

*Assuming no preexisting loss.

### Methods of Measuring Body Composition

O nly body composition evaluations will determine how much of the weight loss is lean body mass. The complications (eg, weakness seen in the patient), are often the best markers and should raise concern. But the extent of body composition changes due to an insult or poor nutrition (or both) is not easily determined after an injury. Restoration of body composition can be more precisely defined, and the amount of weight that is lean mass and the amount that is fat can be more accurately measured using currently available techniques.[11-14]. If lean mass loss is the major problem, the anticipated weight gained should be mainly lean mass.

There are a variety of methods to measure and monitor body composition changes. The easiest (but least accurate) are anthropometric measurements.[11-14] These measurements can determine the progression or correction of involuntary weight loss and PEM. However, the key value is the starting point in the once-healthy state. An initial measurement, once PEM is present, will assist with trends, but restoration of normal is the goal. The usual approach is to measure either lean mass or fat mass and subtract that from total mass to obtain the final composition.

**Body mass index.**[13,14] The measurement of body mass index (BMI) determines the body mass according to the relationship of weight to height and compares it to a normal range. The formula for BMI is weight in kilograms divided by height in square meters ($kg/m^2$).

An estimate of fat mass is made, which can then be used to calculate lean mass. Accuracy depends on how close the individual is to the "normal" population. The BMI of a muscular individual (who maybe outside the norm) would underestimate lean mass. A very obese individual would have a BMI that overestimates lean body mass.

**Skinfold thickness.**[12-14] This measurement estimates fat mass based on the thickness of a skin fold at a number of precisely defined areas on the body. The values are then used in a formula that includes other variables, such as age. The value of contained fat assumes a homogenous fat distribution. Fat mass is calculated and lean mass is derived by subtracting the fat mass from the total mass.

**Circumference measurements.** Circumference measurements are taken for specific body areas (Table 9) and then added to the skinfold measure. Again the assumption is that the fat and muscle mass in these areas can be compared