Protein Requirements of the Elderly

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Of all the chemical constituents of the organism, the ones with the widest variety of functions are the proteins, which range from structural components to enzymes. The proteins of animals and plants are made from the same array of about 20 amino acids. These are all α amino acids that may have a polar, ionic side chain (PI), a polar, non-ionic side chain (PN), or a nonpolar side chain (N), which may be aliphatic or aromatic in nature. Table 1 lists the essential and nonessential amino acids and indicates the polarity of the side chain.

Proteins and other amino acid–containing body constituents are being synthesized and degraded continuously. The level of daily protein turnover is greater than can be accounted for by ingestion, indicating that amino acids are being reused with regularity if not total efficiency. A finite amount of nitrogenous products are excreted and lost in sweat, sloughed skin, nails, and so forth and the amino acids thus lost to the body’s metabolic economy need constantly to be replaced.

Not all protein is digested and absorbed to the same extent. Undigested protein and some metabolic detritus appear in the feces. The absorbed amino acids enter

<table>
<thead>
<tr>
<th>Essential</th>
<th>Nonessential</th>
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<tbody>
<tr>
<td>Histidine (PI)</td>
<td>Alanine (N)</td>
</tr>
<tr>
<td>Isoleucine (N)</td>
<td>Arginine (PI)</td>
</tr>
<tr>
<td>Leucine (N)</td>
<td>Asparagine (PN)</td>
</tr>
<tr>
<td>Lysine (PI)</td>
<td>Aspartic acid (PI)</td>
</tr>
<tr>
<td>Methionine (N)</td>
<td>Cysteine (PI)</td>
</tr>
<tr>
<td>Phenylalanine (N)</td>
<td>Glutamic acid (PI)</td>
</tr>
<tr>
<td>Threonine (PN)</td>
<td>Glutamine (PN)</td>
</tr>
<tr>
<td>Tryptophan (N)</td>
<td>Glycine (N)</td>
</tr>
<tr>
<td>Valine (N)</td>
<td>Hydroxyproline (N)</td>
</tr>
</tbody>
</table>

Pl, polar, ionic side chain; PN, polar, non-ionic side chain; N, neutral side chain.
the metabolic amino acid pool where they may go toward synthesis of structural or other indispensable proteins; they may be used toward maintenance of pools of cellular and circulating proteins; or they may be metabolized to CO\textsubscript{2} and urea. Except for those amino acids that are destined for excretion, there is an equilibrium between the amino acid pool derived from the diet and the various protein pools of the organism.

Different amino acids are used to provide different end-products, and equilibrium between precursor amino acid and its particular product can be used to measure rates of utilization. The interactions among amino acids and proteins and aspects of turnover studies have been discussed recently by Young and Fukagawa (1).

Measurement of amino acid metabolism or of protein turnover generally depends on tracing the metabolic pathway(s) of isotopically labeled amino acids. The labels are usually $^{15}$N or $^{13}$C, although $^{14}$C has been used. Generally these are administered intravenously or by gavage and the appearance of tracer in plasma or in end-products (urea, NH\textsubscript{3}) is measured. The data are analyzed using specific mathematical models. Another approach involves measuring the dilution by body pools of an intravenously administered labeled amino acid and using the derived data to assess protein synthesis or catabolism. The assessments can be complicated by the interactions between amino acids and the known ability of one amino acid to replace the requirement for another: tyrosine can replace 50% of the requirement for phenylalanine, for example.

Protein quality will also influence amino acid metabolism because different amounts of different proteins are absorbed. Protein quality is assessed in various ways. One is protein efficiency ratio (PER), which is determined by dividing an animal's weight gain by its protein intake. Another index, biological value (BV), is defined by the equation: (nitrogen retained/nitrogen absorbed from dietary protein) $\times$ 100. Digestibility is defined as nitrogen intake minus fecal nitrogen plus fecal metabolic nitrogen divided by nitrogen intake. Finally, net protein utilization (NPU) is defined as nitrogen retained divided by nitrogen consumed. Albanese (2) has summarized these values for some common foods. Whole egg (hen's) shows a digestibility of 99%, BV of 94%, NPU of 94%, and PER of 3.92. Beef is 99% digestible but its BV, NPU, and PER values are 74%, 73%, and 3.20, respectively. In contrast, soybeans are 90% digestible, have BV and NPU values of 73% and 66% and a PER of 2.32.

PROTEIN SYNTHESIS AND TURNOVER

Young et al. (3) studied total body protein synthesis in term and premature infants and young and old adults. They administered $^{15}$N-glycine to achieve a steady state and then determined the isotope enrichment in urinary urea. For the purposes of this discussion we need only consider the data derived from the adult subjects. The four young adults (three male, one female) were aged 20 to 23 years and the elderly groups consisted of four women aged 69 to 91 years. In the young group (body weight
71 ± 15 kg) total body protein synthesis amounted to 3.0 ± 0.2 g/kg/day or 0.11 ± 0.01 g/calorie. In the elderly women (body weight 56 ± 10 kg), total body protein synthesis was 1.9 ± 0.2 g/kg/day or 0.11 ± 0.03 g/calorie. They concluded that the efficiency of dietary nitrogen utilization was similar for the two groups and that protein needs were a function of rate of protein synthesis.

James and Lehmann (4) compared protein turnover in small groups of fit young people (age 45–51 years), fit old people (age 68–69 years), and immobile old people (age 67–93 years) (Table 2). Although there were differences among the three groups in protein turnover, synthesis, and breakdown, protein balance was not significantly different.

A number of physical, physiological, psychological, and sociological changes occur in aging subjects. Some of these, such as the loss of lean tissue mass, reduction in liver size, and loss of renal function, may be regarded as “normal” concomitants of aging. Cohn et al. (5) described age-related changes in the body composition of men. Their body weight in the second, fourth, sixth, or seventh decade of life hardly varied (80 ± 0.4 kg) and neither did nonmuscle mass (37.5 ± 0.3 kg), but muscle mass fell from 30% of body weight at 20 to 29 years to 22.5% at 70 to 79 years. In that same time interval, body fat rose from 18.8% to 30% of body weight.

Protein synthesis at age 60 years is 40% below that at 30 years and falls by another 5% and 8% at 70 and 80 years, respectively. Muscle protein breakdown is also reduced with age. Muscle protein breakdown (g/day) per kilogram of body weight is 30% lower in 70-year-old men than in 22-year-old men and 52% lower in 76-year-old women than in those who are 20 years old (6).

Overlapping the physiological changes are increases in chronic conditions associated with aging. Bidlack et al. (7) have summarized some of the increases in chronic conditions that are observed in aging. At 65+ years (compared to the national occurrence rate), arthritis is increased by 284%, hypertension by 235%, diabetes by 246%, and diseases of the urinary tract by 124%. The prevalence of digestive diseases shows a similar pattern. Compared to people who are younger than 45 years, inci-

<table>
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<tr>
<th>Number</th>
<th>6</th>
<th>9</th>
<th>13</th>
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</thead>
<tbody>
<tr>
<td>Gender</td>
<td>5M; 1F</td>
<td>6M; 3F</td>
<td>6M; 7F</td>
</tr>
<tr>
<td>Mean age (yrs)</td>
<td>47.5</td>
<td>76.1</td>
<td>81.6</td>
</tr>
<tr>
<td>Turnover</td>
<td>2.833 ± 0.16</td>
<td>2.303 ± 0.11</td>
<td>2.907 ± 0.17*</td>
</tr>
<tr>
<td>Synthesis</td>
<td>2.216 ± 0.12</td>
<td>1.703 ± 0.09</td>
<td>2.220 ± 0.18*</td>
</tr>
<tr>
<td>Breakdown</td>
<td>2.083 ± 0.16</td>
<td>1.553 ± 0.11</td>
<td>2.157 ± 0.17*</td>
</tr>
<tr>
<td>Balance</td>
<td>+0.150 ± 0.5</td>
<td>+0.150 ± 0.5</td>
<td>+0.106 ± 0.09b</td>
</tr>
</tbody>
</table>

After James OFW, Lehmann AB (4).
* p < 0.05.
b Not significant.
dence at 65+ years of ulcer is increased by 44%, constipation by 428%, gastritis by 107%, colitis and gastroenteritis by 160%, and there is a 28-fold increase in diverticular disease (8).

Other factors also impinge on nutrition. Lowenstein (9) has pointed out that nutrition of the elderly is complicated by dental problems. About two-thirds of Americans aged 75 years have lost more than half their teeth, which influences the quality as well as quantity of food intake. A rise in the threshold for taste and smell may affect eating behavior and thus influence nutritional status. Social factors such as depression and social isolation also play a role in determining nutritional quality and adequacy. Whereas nutritional requirements of the elderly for protein are logically determined in a healthy population, the values thus derived have to be modified to fit specific cases of aging-related conditions.

PROTEIN REQUIREMENTS OF ADULTS

Protein requirements of adults are determined in one of two ways. The first of these is called the factorial method and is based on measurement of losses of nitrogen (via urine, feces, skin) and then factoring in other aspects of nitrogen metabolism. The underlying principle is to measure loss of body nitrogen when the subject is ingesting an adequate, but nitrogen-free, diet. The endogenous loss of nitrogen is assumed to be the minimum nitrogen output in subjects in the healthy state. The minimum dietary protein requirement is then the amount of high quality protein needed to balance the endogenous loss.

Nitrogen loss in urine and feces is relatively easy to measure in subjects stabilized on a protein-free diet. Minor nitrogen loss (cutaneous, etc.) is more difficult to assess but has been assumed to be about 5 mg of nitrogen/kg of body weight per day in men and 3.6 mg/kg/day in women. The obligatory body losses (urine plus feces plus skin plus miscellaneous) are taken as minimum body loss and, to correct for efficiency of nitrogen utilization, the obligatory value is multiplied by a factor of 1.3. In other words, the nitrogen requirement at that point is 130% of the obligatory loss. To account for individual variation, the nitrogen requirement is multiplied again by a factor of 1.3. This figure (now 169% of the obligatory loss) is considered to be practical and represents the “safe” nitrogen allowance. In growth, pregnancy, or lactation the nitrogen requirement is increased and again multiplied by an appropriate factor. Using this method, an FAO/WHO study concluded that 0.57 g egg protein/kg ideal weight was sufficient to meet protein requirements (10).

The other method for assessing protein requirements is to measure nitrogen balance in response to graded levels of dietary protein. Both methods have been discussed in detail by Young (11) and Munro (12). Young (11) summarized studies in which the total urinary plus fecal nitrogen loss in young women, young men, and elderly women was 1.96, 3.33, and 2.13 g, respectively. When computed on the basis of body weight, the nitrogen loss in the three groups was approximately 34 ± 4 mg/kg in young women, 46 ± 6 mg/kg in young men, and 34 ± 6 mg/kg in elderly
women. He also cites data (11) suggesting that the "safe practical allowance" of milk or egg protein for elderly women is 0.42 g/kg/day.

Early reviews suggested that the protein needs of elderly people did not differ markedly from those of young people, being in the range of 0.7 to 1.0 g protein/kg/day. In the past decade or so, further studies have appeared. Cheng et al. (13) examined nitrogen balance in young and old adults at three levels of protein intake. This protein was derived from a mixture of wheat, soy, and milk. Their subjects were eight young prisoners (age 25.5 ± 0.9 years) and seven elderly volunteers (age 66.9 ± 1.9 years) from a Chilean nursing home. Protein intake was studied in 11-day periods using diets that provided 0.4, 0.8, or 1.6 g/kg/day. Energy intake was set at 40 kcal/kg/day. At each level of protein intake, digestibility was similar in the young and old groups. At 0.4 g nitrogen/kg/day all subjects were in negative nitrogen balance to the same extent. At 0.8 g nitrogen/kg/day, five of the young men and three of the old men were in negative nitrogen balance but there were no statistical differences between the groups. At 1.6 g nitrogen/kg/day all the subjects were in positive nitrogen balance and there was no difference between the groups. The conclusion was that there were no significant differences between young and old men in protein requirement or efficiency of utilization.

Uauy et al. (14) studied nitrogen balance response to graded levels of egg protein in seven elderly men and seven elderly women. The average age of the men and women was 71 and 74 years, respectively. The men were fed 0.57, 0.70, or 0.85 g protein/kg/day and the women were given 0.52, 0.65, or 0.80 g protein/kg/day. The diet periods were 10 days in duration. Of the men, four were in positive nitrogen balance on the lower levels of intake and five achieved positive nitrogen balance on the highest intake. All the women were in negative nitrogen balance at the lowest level, and five remained in negative balance at the two higher intakes. The calculated protein requirement for the women was 0.83 g/kg/day or about twice that estimated earlier by the factorial method (15). Zanni et al. (16) used the factorial method to measure protein requirements in six elderly (68 ± 5 years) men. They arrived at a "safe" level for egg protein of 0.59 g protein/kg ideal body weight.

Gersovitz et al. (17) conducted a month-long metabolic nitrogen balance study on seven elderly men (75 ± 4 years) and eight elderly women (78 ± 9 years). The subjects were ambulatory but not in the best of health. The sole protein source in the diet was 0.8 g egg protein/kg/day. About half the subjects in each group were not in nitrogen balance during the last 5 days of the study. The authors concluded that 0.8 g/kg/day of egg protein is not sufficient to confer nitrogen equilibrium in subjects older than 70 years. Their results paralleled earlier ones obtained in the same laboratory (14). The recent findings are summarized in Table 3.

Energy intake declines with aging. McGandy et al. (18) found in one cohort of men that energy intake fell by 22% (2,700–2,100 kcal) as their age rose from 30 to 80 years. Munro (19) reported that young men in Scotland ingested between 3,000 and 4,000 kcal/day (about 12% as protein), whereas retired men subsisted on 2,050 kcal/day (14% as protein). Kishi et al. (20) have shown that as energy intake of adult men fell, so did their dietary protein requirement to achieve zero nitrogen balance.
PROTEIN REQUIREMENTS

TABLE 3. Recent studies of protein requirements in the elderly

<table>
<thead>
<tr>
<th>Subjects and methods</th>
<th>Conclusion</th>
<th>Ref.</th>
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<tbody>
<tr>
<td>7 men, age = 66.9 ± 5.0 years. Three 11-day periods of 0.4, 0.8, or 1.6 g/kg protein (wheat-soy-milk). Energy intake 40 kcal/mg. 57% in nitrogen balance at 0.8 g/kg</td>
<td>0.8 g protein/kg is adequate</td>
<td>13</td>
</tr>
<tr>
<td>7 men (71.3 ± 6 years); 7 women (74.0 ± 6 years). Not all in optimum health. 10-day study. Egg protein fed at 0.57, 0.70, or 0.85 g/kg (men) or 0.52, 0.65, and 0.80 g/kg (women). Energy intake 32 kcal/g. At highest level 71% men, 29% women in positive balance</td>
<td>0.8 g protein/kg is more adequate than FAO/WHO &quot;safe level&quot;</td>
<td>14</td>
</tr>
<tr>
<td>6 men (68.2 ± 4.8 years). Factorial method. Fed 1/5–1/8 times N loss. Energy intake 32 kcal/g</td>
<td>FAO/WHO &quot;safe level&quot; (0.57 g egg protein) is adequate</td>
<td>16</td>
</tr>
<tr>
<td>7 men (75.3 ± 3.9 years); 7 women (78.1 ± 9.0 years). None of the subjects truly healthy. 0.8 g egg protein for 30 days. Energy intake 32 kcal/kg (men), 29 kcal/kg (women). After 30 days 1/2 of each group in positive balance</td>
<td>0.8 g protein/kg not adequate in the long term</td>
<td>17</td>
</tr>
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</table>

For instance, at an intake of 40 kcal/kg the mean requirement was 0.78 g protein/kg and at 57 kcal/kg the mean protein requirement was 0.42 g protein/kg.

Munro et al. (21) have recently examined the adequacy of protein intake in 691 healthy, free-living men and women. They divided the study groups by age, 60 to 75 years or >75 years. The average protein intake of the group was in the range of 1.02 to 1.06 g/kg. The authors examined the levels of a variety of plasma proteins as a function of protein intake. In the men total plasma proteins declined with increasing protein intake. Among the women there were also significant reductions in plasma transferrin, ceruloplasmin, and retinol-binding protein. The reduced levels of these proteins in aging cannot be attributed to low levels of dietary protein (Table 4).

Protein provides total nitrogen as well as essential amino acids. Are these components required in the same ratio throughout life? Munro (12) has reviewed the data and has shown that in infancy 43% of total dietary nitrogen must be in the form of essential amino acids in order to support optimal growth. At 10 to 23 years only 36% of the nitrogen need be as essential amino acids and in young adults this ratio falls to 19%. The situation in the elderly has not been resolved. Tuttle et al. (22) suggested that the requirement of some essential amino acids might be increased in the elderly. They found specifically that the requirements for methionine plus cystine and for lysine were 46 and 30 mg/kg, respectively (23), whereas Munro (12) cites his own data, which show the requirements for those specific amino acids to be 13 and 11 mg/kg in young adults. Albanese et al. (24) reported that elderly women might have an increased lysine requirement. Watts et al. (25) found that sulfur amino acid...
TABLE 4. Protein intake and plasma constituents in elderly men and women

<table>
<thead>
<tr>
<th></th>
<th>Men 60-75 years</th>
<th>&gt;75 years</th>
<th>Women 60-75 years</th>
<th>&gt;75 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Protein (g/day)</td>
<td>83</td>
<td>74</td>
<td>65</td>
<td>64</td>
</tr>
<tr>
<td>(g/kg/Bwt)</td>
<td>1.06</td>
<td>1.05</td>
<td>1.02</td>
<td>1.06</td>
</tr>
<tr>
<td>Energy (kJ/day)</td>
<td>8113</td>
<td>7432</td>
<td>6283</td>
<td>6182</td>
</tr>
<tr>
<td>Plasma (per dl)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein (g)</td>
<td>7.01*</td>
<td>7.03</td>
<td>7.00</td>
<td>6.86*</td>
</tr>
<tr>
<td>Albumin (g)</td>
<td>4.23</td>
<td>4.11</td>
<td>4.20</td>
<td>4.05</td>
</tr>
<tr>
<td>Transferrin (mg)</td>
<td>298</td>
<td>296</td>
<td>303*</td>
<td>292</td>
</tr>
<tr>
<td>Ceruloplasmin (mg)</td>
<td>32.1</td>
<td>34.8</td>
<td>26.4*</td>
<td>35.8</td>
</tr>
<tr>
<td>Urea (mg)</td>
<td>29.1*</td>
<td>23.3*</td>
<td>17.1</td>
<td>19.9</td>
</tr>
<tr>
<td>Creatinine (mg)</td>
<td>1.24*</td>
<td>1.35</td>
<td>1.01</td>
<td>1.11</td>
</tr>
</tbody>
</table>

After Munro HN, et al. (21).
* Negatively correlated with protein intake ($p \leq 0.05$).
* Positively correlated with protein intake ($p \leq 0.05$).

requirements in elderly black men were lower than those for younger men. All these studies were based on protein (or amino acid) intake necessary to achieve zero nitrogen balance.

CONCLUSION

The Recommended Daily Allowances publication (26) summarized estimates of essential amino acid requirements in infants, children, and adults. Requirements (minus histidine for which there are no data in children aged 2–12 years) fall from 714 mg/kg/day in infants, to 352 mg/kg/day in children under the age of 2, to 214 mg/kg/day in children aged 10 to 12, and down to 84 mg/kg/day in adults. Thus, the reduction in requirement between 3 months and adulthood is 88%. The foregoing discussion suggests that we need to learn more about essential amino acid requirements in the elderly.

A high protein intake may be detrimental in that it may increase calcium excretion (27) and may influence age-related loss of kidney function (28). However, other experiments have shown that the increased calcium excretion may only be transient (29), and one long-term study did not show any correlation between protein intake, aging, and kidney function (30).

The data that we have available at present suggest that health in aging (for subjects with no debilitating disease) can be maintained on an average daily intake of 1 g protein per kg body weight or less (23). The new recommended dietary allowance for men and women older than 51 years is 0.8 g/kg body weight, or an average of 63 g/day for men and 50 g/day for women (26).

In view of the increasing proportion of the elderly in the population, we could profit from further investigations into requirements for specific amino acids, and it
might also be useful to study further the influences of protein and amino acid intakes on the metabolism of specific proteins. The classification of elderly used by Munro et al. (21), namely, 60 to 75 years and 76+ years, could further focus our knowledge of protein requirements.

ACKNOWLEDGMENT

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REFERENCES


**DISCUSSION**

*Dr. Munro:* It is important to recognize that nitrogen balance is affected to a major extent by the amount of energy in the diet. You can easily turn a negative balance into a positive one and vice versa by altering the energy intake.

*Dr. Rush:* Dr. Meredith may wish to comment on data that suggest that a protein intake of 0.6 or even 0.8 g/kg is inadequate for older individuals who exercise regularly. Also, although I don’t find the data compelling, it is worth recalling that Colin Campbell believes that the high protein levels of Western diets may be more harmful for health than their high fat content. There is a considerable literature on protein toxicity from fetal life through old age.

*Dr. Meredith:* Using nitrogen balances, we have found that active men in late middle age do indeed have a higher nitrogen requirement than sedentary individuals—about 0.95 g/kg daily. Energy intakes in these men were very large compared with sedentary subjects. However, if protein is considered as a fraction of the energy intake, the protein requirement was actually lower than in sedentary subjects.

*Dr. Glick:* Is Dr. Meredith suggesting that the increased requirement for protein in active people is associated with their higher level of activity? Could it not be accounted for simply by their having a greater muscle mass?

*Dr. Meredith:* The people we were studying were runners or cyclists. Their muscle mass was not obviously different from sedentary individuals. Therefore, I don’t think the size of the muscle compartment was important in explaining the differences. I favor the hypothesis that has been put forward from England that suggests that if you have a high rate of energy expenditure, protein is burned along with other fuels at a greater rate than usual.

I should like to make a further comment that is perhaps more relevant to aging. I don’t think we have sufficiently examined protein and energy requirements in an extremely sedentary population. I wonder whether the relationships that Dr. Munro has described between
protein intake and energy intake are changed by the combination of immobilization and old age.

**Dr. Berry:** When you are looking for a cheap source of protein of high biological value for elderly people on a reduced budget, is there anything to compare with eggs?

**Dr. Kritchevsky:** Not in my view. I think eggs are the best and cheapest source of high grade protein. If you are a fanatic about cholesterol you can use the white only, but the yolk contains a lot of phospholipid and is fairly high in monounsaturates.

**Dr. Munro:** It is important to emphasize that the degree of chronic illness in elderly people is relevant to their protein requirements. In a British study population, all but one of those individuals who were identified as having some clinically or biochemically recognizable form of malnutrition had chronic wasting diseases (1). I do not think it is reasonable to legislate only for the healthy. We must legislate for people who need additional energy and protein to compensate for the ravages of chronic disease.

**Dr. Kritchevsky:** This is more or less what I said at the end of my paper. We need to start to look at different groups of elderly people ranging from the healthy to the sick. I think it is a grave error that the RDAs stop at 51 + years of age.

**Dr. Durnin:** What sort of difference would it make to the true protein requirements for people with wasting diseases? Would you add 0.2 g/kg?

**Dr. Munro:** I imagine that is the order of magnitude that would be required.

**Dr. Nestel:** What is known about protein requirements in less developed parts of the world? There are data from New Guinea collected in the early 1970s that suggested that the protein intake was less than half the FAO recommended value, yet the subjects were muscular fit old people.

**Dr. Munro:** Those studies have been criticized because of the method of nitrogen collection and other methodological problems.

**Dr. Nestel:** It is true that the measurements of nitrogen excretion were suboptimal, but the diet was very simple and readily measurable and nearly all nutritionists working in the area said that about 90% of the diet was carbohydrate. This doesn't leave much for fat and protein, however one calculates it.

**Dr. Berry:** What is considered to be the best biochemical index or test for detecting an inadequate protein intake?

**Dr. Munro:** Nitrogen balance has been the standard since about 1840, but it is not an easy technique to apply with the necessary precision. The somatomedin factors (insulin-like growth factors, or IGFs) might be helpful, although it may simply reflect the rate of protein turnover. We don't yet know whether it is really sensitive to the balance of protein, represented by the difference between intake and requirement.

**Dr. Nestel:** Data from my institution show that in the early years of life infection and nitrogen loss are associated with low plasma IGF concentrations and the IGF levels increase as the children recover from illness and nitrogen balance becomes positive.

**Dr. Heseker:** We have heard a lot about the decrease in lean body mass with age. To what degree can elderly people diminish this decrease by physical exertion?

**Dr. Meredith:** The decrease in lean mass with age does not seem to be affected by activity levels. Men who have been athletes all their lives remain extremely fit but still sustain loss of lean mass. However, we need more data on different types of exercise that might maintain or increase lean mass in the elderly.

**REFERENCE**