Managing Nutritional Requirements in an Ageing Population

The role of protein and vitamin D

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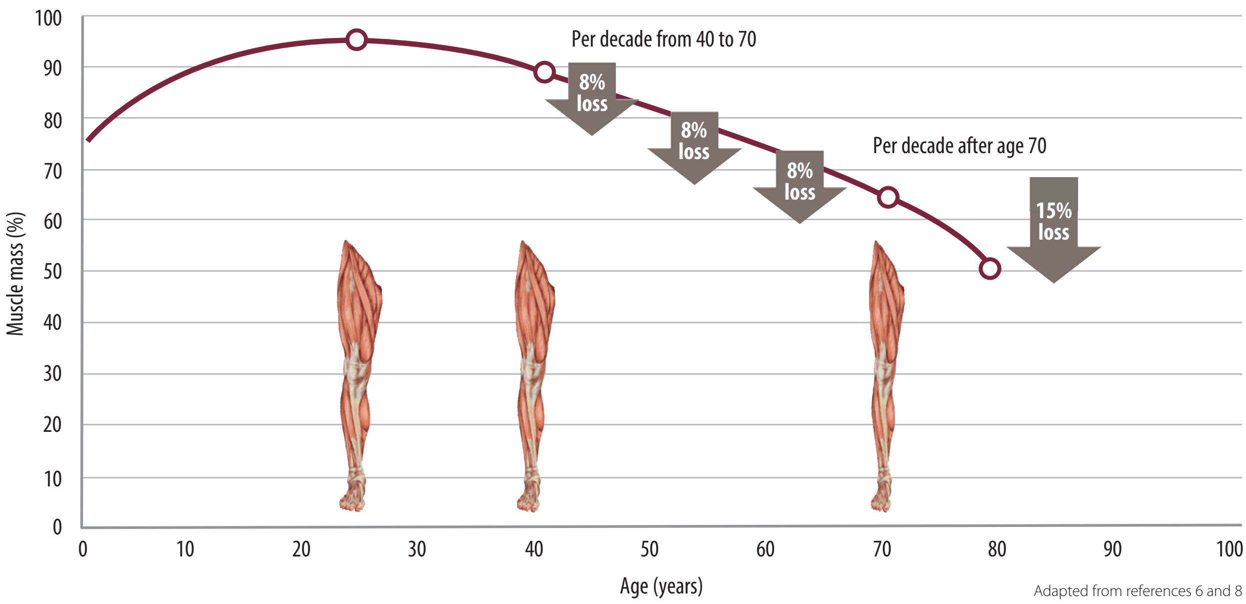
The UK has an ageing population; with the number of people of state pension age projected to increase by 28 per cent to 15.6 million by 2035.[1] This rise in the proportion of older people will place increasing demands on healthcare, with growing numbers of individuals with chronic disease and disability. The natural effects of ageing include decline in organ and system function,[2] changes in the immune system[3] and loss of muscle mass.[4]

Loss of muscle mass and malnutrition in older people

Muscle mass plays a vital role in health and is an important determinant of strength, mobility and physical endurance.[5] It is estimated that over the age of 40 years, muscle mass decreases at approximately eight per cent per decade; increasing to 15 per cent per decade over the age of 70 years (see **Figure 1**).[6] This leads to a decline in muscle strength, with reductions of 1.5 per cent per year between the ages of 50 to 60 and 3 per cent per year thereafter.[7] Decreased physical activity, hormonal changes, reduced calorie and protein intake, altered inflammatory and immune response and changes to protein synthesis may all contribute to these losses.[5]

Loss of muscle mass is frequently compounded by malnutrition.[9] Malnutrition risk prevalence rates are consistently higher in older people in both hospital and community settings.[10] Data amalgamated from the BAPEN Nutrition Screening Week surveys in the UK 2007-2011 demonstrate a 33 per cent higher risk of malnutrition (irrespective of season) in those over the age of 65 on admission to hospital (28-38% *vs* 21-28% <65 years; $p<0.001$) with risk of malnutrition in older people accounting for 62 per cent of the the total.[11]

Figure 1: Loss of Muscle Mass by Decade



Adapted from references 6 and 8

Thus, malnutrition and loss of muscle mass often co-exist and manifest clinically through a combination of decreased nutrient intake and body weight, along with reductions in strength and physical function.[12] A recent study of 800 community-living people >65 years of age in Europe and North America found that 80 per cent were malnourished, 61 per cent had at least one impaired measure of strength or physical performance, and 89 per cent of men and 69 per cent of women had a Low Skeletal Muscle Index.[13]

Malnutrition and loss of muscle mass lead to increased morbidity, with reductions in quality of life[12] and functionality, including an increased frequency of falls,[14] an inability to regain previous function after illness/surgery,[15, 16] increased dependency,[17] an increased risk of nosocomial infections[18] and adverse metabolic conditions, such as increased insulin resistance.[19] These are also associated with significant increases in mortality; a study in community patients with evidence of loss of muscle mass and strength over the age of 80 demonstrated a mortality rate of 67.4 per cent *vs* 41.2 per cent in those without losses ($p<0.001$).[20]

Malnutrition and loss of muscle mass therefore represent a considerable burden on the healthcare system and contribute to rising healthcare costs.[12] BAPEN estimate that malnutrition in the UK costs over £13 billion per year: £8 billion for healthcare, including hospital visits and primary care, and £5 billion for services associated with nursing, residential, and home care.[21] Many studies have found a direct relationship between malnutrition and increased length of hospital stay, treatment costs, return to usual life,[22, 23] and rates of readmission to hospital.[24]

Muscle mass and protein intake

Reduced intake of protein coupled with a change in muscle protein metabolism in older people can lead to protein deficiency; a recognised risk factor for loss of muscle mass and frailty.[25, 26] The Reference Nutrient Intake (RNI) in the UK for protein in the healthy adult population is 0.75 g/kg body weight/day.[27] However, the UK National Diet and Nutrition Survey showed that about one in four institutionalised older people and a similar number of free-living women >65 years of age fail to meet this RNI for protein (see **Table 1**).[28] Recent guidelines published by the European Society for Clinical Nutrition and Metabolism (ESPEN) recommended that requirements for protein in older people should be raised to meet increased needs and compensate for altered utilisation – levels between 1.0-1.2 g/protein/kg body weight/day for healthy older adults, increasing to 1.2-1.5 g/kg body weight/day for those with or at risk of malnutrition should be aimed for, with even higher levels for those with serious illness or injury.[29] This can equate to 25-30 g of high quality protein eaten per meal to provide sufficient essential amino acids (particularly leucine) to promote anabolism in those with loss of muscle mass.[30] Daily exercise/activity for as long as possible is also recommended.

Muscle protein metabolism in older people

Muscle exists in a dynamic state of equilibrium between rates of synthesis and breakdown, but with increasing age, muscle tissue appears resistant to normal amino acid stimuli and muscle synthesis is reduced (anabolic resistance). This may be a consequence of decline in physical activity with age or altered inflammatory processes, which interfere with protein turnover.[30]

Vitamin D

Vitamin D is derived largely through the action of sunlight on the skin (see **Figure 2**); only a small quantity of vitamin D is obtained from dietary intake – sources include oily fish and eggs, and fortified foods such as margarine. Poor vitamin D intake is common in community-based older people at risk of malnutrition[31, 32] and, in 2010, a UK health survey showed a high prevalence of sub-optimal vitamin D status in older people.[33] This is due to reduced dietary intake, impaired intestinal absorption and hydroxylation in the liver and kidneys,[34] diminished sunlight exposure and reduced skin thickness contributing to decreased synthesis.

In the UK, the RNI for vitamin D is 10 µg (400 IU) for those aged ≥65 years.[35] However, in recognition of the effects of poor vitamin D status on health outcomes, European experts have recommended that older adults aged ≥65 years meet a mean daily vitamin D intake of 20 µg (800 IU).[36]

Table 1: Proportion of Older People with Protein Intake below the RNI for Protein in the UK[28]

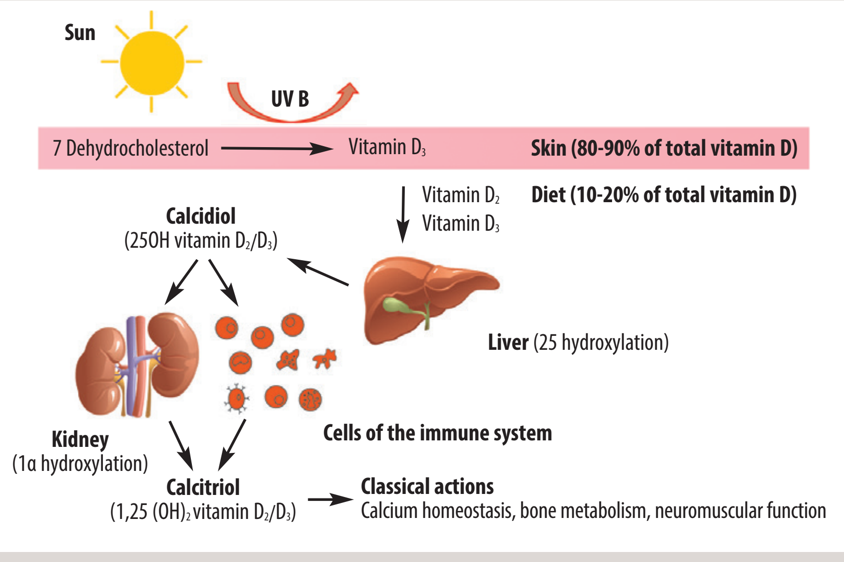
Subjects	n	% of subjects with protein intake below the RNI*
Free-living men	632	14%
Free-living women	643	25%
Institutionalised men	204	27%
Institutionalised women	208	23%

**RNI for men aged 50+ 53.3g/day, women aged 50+ 46.0g/day*

Figure 2: Vitamin D Sources and Metabolism

In the UK, from mid-October to the beginning of April there is no ambient ultraviolet sunlight of the appropriate wavelength, so the body relies on both stores from sun exposure in the summer and dietary sources to maintain vitamin D levels.[47] The effectiveness of UV-B depends on the time of day. During summer, early morning and late afternoon in the UK, UV-B radiation is not strong enough to activate vitamin D production.[36]

The circulatory system transports vitamin D to the liver where it is converted to the pro-hormone calcidiol. Calcidiol is transported to the kidneys and cells of the immune system where it is converted to calcitriol, the active form of vitamin D. Calcitriol is transported to target organs where it binds to specific receptors and once bound, controls calcium absorption in the intestine.



Adapted from references 45 and 46

Adequate levels of vitamin D are known to be important for bone health, however, vitamin D contributes a much wider role in body systems. Calcium absorption in the gut is dependent upon adequate levels of vitamin D; calcium is an important component within biochemical systems of heart, muscle, and nerve function. Accumulating evidence also suggests there are additional roles for vitamin D in brain development and neuro-protection, with a risk of cognitive decline, dementia and Alzheimer's disease in older people with low levels of serum vitamin D.[37] While the main manifestation of severe vitamin D deficiency is osteomalacia in adults and rickets in children,[38] it is now established that less severe vitamin D deficiency may lead to secondary hyperparathyroidism, bone loss, muscle weakness, falls and fragility fractures in older people.[39-44]

Supplementation with protein and vitamin D

Use of high protein oral nutritional supplements (ONS) in malnourished older adults has been shown to produce clinical and functional benefits. A systematic review and meta-analysis of high protein ONS (defined as >20% energy from protein), involving 36 randomised controlled trials with 3790 patients (83% of trials in patients >65 years) across different healthcare settings, showed supplementation resulted in improved grip strength ($p<0.014$), increased intake of protein ($p<0.001$) and energy ($p<0.001$), and improvements in weight ($p<0.001$).[48] Clinical complications reduced by an average of 19 per cent compared with controls ($p<0.001$) and the number of re-admissions to hospital by 30 per cent ($p=0.004$). In individuals with hip fractures, high protein supplements may reduce the number of long-term medical complications.[49]

In patients with proven deficiencies of micronutrients, vitamin D supplementation has been shown to reduce the incidence of hip fractures[50] and to increase muscle strength.[51] A meta-analysis of seven randomised trials has suggested that supplemental vitamin D, in a dose of 700-1000 IU a day, reduced the risk of falling among older individuals by 19 per cent.[52] The importance of dose has been highlighted in a study which looked at the effect of four vitamin D supplement doses on falls risk in older nursing home residents (n=124, average age 89 years). Participants were randomly assigned to receive 200 IU, 400 IU, 600 IU, or 800 IU vitamin D or placebo daily for five months. Participants in the 800 IU group had a 72 per cent lower adjusted-incidence rate ratio of falls than those taking placebo over the five months.[53] No significant differences were observed for the adjusted fall rates compared to placebo in any of the other supplement groups. A more recent pooled analysis of vitamin D dose requirements for fracture prevention in 31,022 individuals (mean age, 76 years; 91% women) showed a 30 per cent reduction in the risk of hip fracture and a 14 per cent reduction in the risk of any non-vertebral fracture with the highest intake level (median, 800 IU daily; range, 792 to 2000).[54]

Management of those with malnutrition with or without loss of muscle mass, may include the use of multi-component ONS with higher levels of protein and vitamin D where appropriate. A recent study in The Netherlands trialled a nutritional intervention in malnourished older adults using a combination of an energy and protein enriched diet, ONS, vitamin D and calcium supplements and dietetic counselling *vs.* usual care (n=210).[55] Body weight increased significantly more in the intervention group than in the control group in the highest body weight category and nutritional intervention significantly decreased functional limitations in those patients who had not received nutritional support and/or dietetic counselling before the start of the study. In addition, participants in the control group fell more than twice as often as participants in the intervention group.

Nutritional intervention with energy and protein-enriched diets, ONS, vitamin D and calcium has also been shown to be cost neutral while reducing functional limitations in older malnourished patients when compared with usual care.[56] Additionally, nutritional intervention with ONS, vitamin D and calcium, compared with vitamin D and calcium alone, has been shown to reduce the length of hospital stay and clinical complications in older post-surgical fracture patients.[57] Results from this recent study showed in the ONS group, length of stay was shortened by 3.8 days ($p=0.04$) and the total number of infective episodes reduced significantly ($p=0.019$).

Conclusion

Ageing, even in healthy older people, is accompanied by a reduction in muscle mass and strength. In the presence of malnutrition, this loss of strength and increasing frailty can lead to functional impairment, reduced independence and an increased risk of falling, fractures and death. In hospital settings the situation can be compounded and recovery delayed. These factors have significant personal and economic burdens and make the preservation of muscle mass and strength in older people an important goal. Supplementation to increase protein and vitamin D intake has been found to be beneficial in improving clinical and functional outcomes in those who are malnourished.

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