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# Nutritional requirements during ageing[☆]

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**Abstract –** Ageing is a physiological condition characterized by a decline of the adaptatives capacities and associated to a decrease of the lean mass. That one is due to a decrease of the post-prandial protein synthesis. It is why protein recommended allowances must be sufficient for a quantitative aspect (0.8–1.2 g/kg/d) and adapted for a qualitative point of view. Energy requirements do not decrease with age if the physical activity is unchanged: it is why the carbohydrate and lipid intakes must be similar to those of a younger adult. The quality of the carbohydrate intake and the distribution of the fatty acids are also important in order to avoid any deficiency. Concerning non-energetic nutrients, one must be particularly cautious for the vitamin D and calcium intakes. Behind nutrients there are foods and dietary patterns who have their own effects.

**Keywords:** nutritional requirements / lean mass / protein intakes / elderly / ageing

**Résumé – Les besoins nutritionnels au cours du vieillissement.** Le vieillissement est une condition physiologique caractérisée par une perte des capacités d'adaptation et associée à une diminution de la masse maigre. Celle-ci est liée à une diminution de la synthèse protéique post-prandiale. C'est pourquoi les apports conseillés en protéines doivent être suffisants sur le plan qualitatif (0,8–1,2 g/kg/j) et satisfaisants sur le plan qualitatif. Les besoins énergétiques, quant à eux, ne diminuent pas à activité physique égale : c'est pourquoi les apports glucidiques et lipidiques doivent être maintenus à un niveau identique à ceux de l'adulte jeune. La qualité de l'apport glucidique et la répartition de l'apport lipidique sont également importants, en veillant à éviter tout déséquilibre en acides gras. En ce qui concerne l'apport en micronutriments non énergétiques, on veillera particulièrement à l'apport en vitamine D et en calcium. Au-delà des nutriments il y a les aliments, mais aussi les styles alimentaires qui ont des effets propres.

**Mots clés :** apports nutritionnels conseillés / masse maigre / apports protidiques / personnes âgées / vieillissement

## 1 Introduction

The dramatic increase of life expectancy achieving 85.4 years in women (and 79.4 years in men), instead of 37 years in 1810, two centuries ago, and instead of 25 years in 1750, associated to an increase of the baby-boom between 1945 and 1975 lead today to the papy boom and then to a very high number of subjects over 65 years. But the chronologic age do not allow to anticipate the health status, although ageing is a physiological process.

## 2 Physiology of ageing

Ageing is a decrease of the adaptive capacity in front of new situations or aggressions. For the digestive system, few

changes of digestive capacities, secretory or motricity are seen. However, it exists a lengthening of the satiety duration: that induces a spontaneous spacing of the food intakes or a reduction of the dietary intakes. Moreover, we observe a decrease of the perceived pleasure during the meals, meaning that there is a negative allesthesia which may reinforce the reduction of the amount of ingesta. Finally, it exists an increase of the detection level for smells and tastes which may also modify appetite. All that may explain a loss of the adaptive capacity after under-feeding: indeed it is not followed by an increase of the dietary intakes, and that may explain the lack of return to the initial weight, in opposition with that is observed in younger subjects (Roberts *et al.*, 1994; Moriguti *et al.*, 2000). Similarly, in the case of over-feeding there are few reductions of the dietary intakes on the next meal and that could contribute to a weight gain (Rolls *et al.*, 1995).

The main ageing metabolic characteristic is the decline of the lean mass, that is to say essentially the muscle and bone mass. Although it is physiological, and begins early in the life,

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that may lead to sarcopenia and osteopenia, sometimes called osteo-sarcopenia characterized by a progressive global loss of the muscle mass and strength, associated to a higher risk of declining physical performances, an alteration of the quality of life and to an increase of morbidity and mortality (Fielding *et al.*, 2011; Cao and Morley, 2016). Its causes are numerous. Among them the lesser capacity of the post-prandial protein synthesis linked to the age, is a major explanation (Visser and Schaap, 2011). Moreover, some circumstances require to increase the protein synthesis in order to recover the alteration of the lean mass. The reduction of the lean mass contributes to the lesser resistance to infections and aggressions. It is also responsible of the decrease of the basal metabolism and therefore of the energy expenditure; it is inversely correlated to an increase of the fat mass. It is associated to a decrease of the muscle strength with age (Lauretani *et al.*, 2003).

## 3 Energy and protein requirements

If the physical activity is unchanged the energy requirements are not diminished with age. However, the protein requirements are enhanced in order to compensate for the reduction of the muscle protein synthesis. In a three years longitudinal study (Health ABC Study) (Houston *et al.*, 2008), the reduction of the lean mass linked to the age decreases in parallel to the increase of the protein intakes in absolute value (from 57 to 91 g/d) or relative value (from 11 to 19%). Similarly, in a cross-sectional study in elderly women aged 60–90 years the muscle strength is higher and the physical performance is higher in the women eating more than 0.8 g/kg/g of proteins (Gregorio *et al.*, 2014). It is why in healthy elderly people, the recommended dietary allowances for protein is 1.1 to 1.2 g/kg/d, instead of 0.83 to 1.0 g/kg/d in younger subjects (Martin, 2018). However, in well-nourished men 65 years or older a recent study do not find difference for lean mass between 0.83 or 1.3 g/kg/d of protein; but i) the lean mass was high initially; ii) the fat mass has decreased with 1.3 g/kg/d of protein; iii) all subjects received 1260 mg calcium and 1000 vitamin D; iv) the lean mass do not reflect the strength nor the function (Bhasin *et al.*, 2018).

The decrease of the post-prandial protein synthesis is due to an elevation of the anabolic threshold in the elderly. This threshold depends from the aminoacidemia particularly from the leucinemia (Katsanos *et al.*, 2006; Paddon-Jones *et al.*, 2006). The elevation of the threshold is due to the splanchnic sequestrations of amino acids in the liver and the intestine, leading to a lesser bioavailability of the amino acids and particularly of leucine for the protein synthesis. The balance between protein anabolism and catabolism may also be influenced by other factors, physiological factors or not. The anabolism is altered by the insulin resistance, the reduction of anabolic hormones (testosterone, growth hormone, IGF1), the vitamin D deficiency, the physical inactivity, the mitochondrial dysfunction and the inflammatory process. Catabolism may be increased by aggressions and tissue losses (wounds, burns slough, ulcers, fractures, cicatrisation...), or by an excess of physical activity...

So, not only quantitative intake but also qualitative aspects are important for the protein synthesis. In order to exceed the anabolic threshold, fast proteins which increase more the aminoacidemia are specifically of interest. It is well-known that lactoserum proteins are fast proteins (Boirie *et al.*, 1997; Dangin *et al.*, 2003); they are rich in leucine and trigger more the protein synthesis than casein and are more efficiency in order to limit the muscle protein losses in the elderly (Pennings *et al.*, 2011; Bergia *et al.*, 2018). A recent cross-sectional study in women older than 65 years confirms that the animal protein intakes, and particularly the dairy protein intakes are correlated to the bone strength microstructure (Durosier-Izart *et al.*, 2017). That confirm the former data of the prospective study (Iowa Women's Health Study) (Munger *et al.*, 1999) showing that the risk of femoral neck fracture decreases while the total and animal protein intakes increase.

Energy intakes and protein metabolism are linked. It is well established that it exists a sparing nitrogen effect of carbohydrates and then of caloric intakes. It is why in overweight elderly subjects, any energy reduction is always accompanied by a lean mass loss, in absolute or relative value, even if it is associated by exercise (Weinheimer *et al.*, 2010).

Don't forget finally that there is no proven data that energy restriction increases the life expectancy in primates, in opposition with that is often said; in interventional studies the control group is overfeed or has a bad diet, and the experimental group is supplemented (Le Bourg, 2018; Moore, 2018). Classically, a caloric restriction under 1500 Kcalories without deficiencies is not possible in human. The only one interventional study with a long duration restrictive diet in human has shown a weight loss and a general health alteration (Le Bourg, 2012).

## 4 Nutritional requirements for lipids and carbohydrate

The percentage of energy from fat is similar in elderly and in younger adults (35 to 40%) (ANSES, 2011). It must not be smaller because it is necessary to maintain recommended essential fatty acid allowances. Saturated fatty acids (particularly from dairy source) intake must be sufficient in order to maintain a sufficient intake of myristic acid (Jan *et al.*, 2004; Drouin *et al.*, 2018): indeed this fatty acid increases the desaturases activity for the biotransformation of linoleic and alphalinolenic acids into long chain polyunsaturated fatty acids.

Moreover, if the saturated fatty acid intake is too low, it could facilitate alpha linolenic acid β oxidation. In reality, it is necessary to maintain simultaneously sufficient intakes of alphalinolenic acid (as a precursor of longer fatty acids) because there is a decrease of the desaturases activity with age and sufficient intakes of long chain omega 3 fatty acids (EPA and mainly DHA): indeed DHA is a major fatty acid for structural and functional retina (Souied *et al.*, 2015) and brain (Andrieu *et al.*, 2017). Overall, 1% of the total energy for alphalinolenic acid and 4% for linoleic acid are necessary. For DHA, the requirement is of 250 mg/d and for total long chain omega 3 fatty acids it is of 500 mg/d (ANSES, 2011).

There are no specific requirements for carbohydrates in comparison with younger adults. Their consumption is fundamental for the nitrogen balance. The restrictive diets are negative for maintaining the lean mass.

The quality of the carbohydrate intakes is also important to take into account. Many studies have shown an inverse relationship between glycemic index and/or glycemic load and Age Related Macular Disease incidence (Chiu *et al.*, 2006, 2007a, b; Kaushik *et al.*, 2008). A recent prospective study has shown that a high glycemic index diet and a high glycemic load are associated to a higher risk of osteoporotic fractures (García-Gavilán *et al.*, 2018). Another study has found an association between free sugars and frailty (Laclaustra *et al.*, 2018), and between sugar intakes and beta amyloid plaques accretion in the brain (Taylor *et al.*, 2017).

## 5 Micronutrient requirements

Since energy intake is often reduced due to the appetite reduction and the satiety increase, and to the lesser physical activity, many elderly people eat approximatively 1500 kcal/d or less. That implies a diet with a high nutritional density (mg of a nutrient for 100 Kcal).

Calcium and vitamin D intakes are of great importance. Many studies show that a small calcium or a small intake of dairy products is associated with a higher risk of osteopenia and fractures (Prentice, 2014; Fung *et al.*, 2017), even if the calcium intake is not very low. For instance in the Melbourne Collaborative Cohort Study (Khan *et al.*, 2015), the fracture incidence was 30% higher in the lowest quartile when compared to the highest quartile of calcium intake (641 ± 121 mg/d *versus* 1 076 ± 163 mg/d).

Although previous studies have demonstrated the efficacy of a vitamin D and calcium supplementation on the fracture incidence in home resident elderly subjects (Chapuy *et al.*, 1992; Dawson-Hughes *et al.*, 1997) a recent meta-analysis on the interventional trials with vitamin D alone (after the age of 18 years old) do not show a preventive effect on the occurrence of fracture and fall (Bolland *et al.*, 2018). The issue of the dose is raised in that paper since there is probably no benefit to high and spaced doses of vitamin D. Moreover, supplementation should be given to vitamin D deficient patients, who have a reduced muscle function and walk speed. It is well-known that this last parameter is a good survival marker in the elderly (Studenski *et al.*, 2011).

## 6 Weight and body composition

All these data show that the continuation of a physical activity is the best way for maintaining sufficient energy intake in order to allow the achievement and the coverage of the non-energetic requirements (micronutrients) mainly if the nutritional density is not so high. Moreover, this allows to keep a stable weight and a good lean body mass.

Many studies have shown that in the elderly a moderate overweight is associated with a lesser mortality (Stevens *et al.*, 1998). Other studies have shown a higher post-surgery mortality for a small body mass index (BMI) compared to a higher BMI (Koster *et al.*, 2008; Mullen *et al.*, 2009; Valentijn *et al.*, 2013). A prospective study has demonstrated that a weight loss in elderly subjects with metabolic abnormalities was associated with an increase of mortality (Dong *et al.*, 2018). Similarly, a low muscle strength increases mortality, whatever the weight confirming the major role of the muscle

mass. The negative role of sarcopenia in obesity has been proven on mortality as soon as 2008 (Prado *et al.*, 2008; Zamboni *et al.*, 2008). Obesity with sarcopenia is the most insidious form of sarcopenia with its negative consequences on physical incapacity (Baumgartner, 2000) and on functional disability Baumgartner *et al.*, 2004).

So it is fundamental to maintain stable weight in older subjects with normal weight and to obtain sufficient protein and energy intakes and then to maintain a regular physical activity. In case of obesity in the elderly, it is necessary to screen and prevent sarcopenia.

## 7 Dietary patterns

Behind the nutrient intakes, a global or holistic approach is essential. The dietary patterns reflect the dietary complexity. It includes both the matrix effect (Thorning *et al.*, 2017) linked to the food and the dietary variety. So, for example, it has been shown that a better diet quality (with high intake of vegetables, fruits, whole grains, legumes, nuts, dairy products, fish and low intake of sugar-containing beverages) is related to larger brain tissue volumes (gray matter, white matter, hippocampal volumes) (Croll *et al.*, 2018). Similarly, the Mediterranean diet is not only associated to a lesser prevalence of the age-related cognitive decline, but it has been shown in randomized controlled trials with a Mediterranean diet a lower risk of low-plasma brain derived neurotrophic factor (BDNF) which promotes connectivity between neurons (Radd-Vagenas *et al.*, 2018). Among women aged ≥ 60 years with type 2 diabetes a Mediterranean style diet pattern is associated with a reduced risk of frailty syndrome in a recent large prospective study (Lopez-Garcia *et al.*, 2018).

## 8 No nutritive needs

Eat has not only nutritive functions, and nutrient requirements are not the only one dietary needs. Non-nutritive needs are in interaction with the previous. These are hedonic and psychological functions (with the eating pleasure) and social and relational functions. They greatly contribute to sufficient dietary intakes and to the coverage of the nutrient requirements. They must be taken into account for an optimized diet.

## 9 Conclusion

The nutritional requirements during ageing are not so far different from those of younger adults. However, some cautions must be taken, particularly to avoid non-sufficient intakes in proteins and in energy. Indeed, there is a decrease of the lean mass due to the decrease of the post-prandial protein synthesis, so the protein needs must be increase in order to compensate that. Moreover, there is a potential vicious circle for the energy balance due to the decrease of the resting metabolism and of the physical activity. Since carbohydrate energy source may improve the protein balance by a nitrogen sparing, it must be also preserve. Finally, the fatty acids variety is also of consequence for health, mainly the essential fatty acids. A focus must be done on non-energetic nutrients, whose intakes depend on the diet variety and the nutritional density. No food groups must be removed, particularly fish, meat and

dairy products for omega 3 fatty acids, proteins, iron, and calcium.

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