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Course handout for the subject

"NUTRITION AND FOOD"

Intended for 3rd-year students in the Professional Bachelor's Degree program (LMD system)

Food Science and Quality Control (semester 6)

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Preface

The subject title comprises two parts:

- Nutrition: This is the science that represents the transformation and use of food in the human body. Physiologically speaking, it encompasses all the processes (assimilation, excretion, and respiration) that occur in a living organism, enabling the production of energy.

- Food: This refers to the act of eating or the manner of eating.

- Food: This is a digested substance, provided by food, that serves to nourish a living being (human) to ensure its growth, development, and good health.

It was therefore necessary to learn how to "eat well" because it is vital for ensuring a healthy and active life. Most people know very well that they need to eat to have the strength to work; however, the world doesn't have a clear idea of what eating well means.

The wise choice of a healthy diet, and therefore ensuring ideal nutrition, relies on nutritional education. This concept is essential from a young age and plays a crucial role in promoting good nutrition, especially in developing countries where nutritional knowledge is insufficient to meet the numerous rapid and profound economic and social challenges.

This educational course covers the basics of human nutrition and serves as an indispensable guide for third-year undergraduate students (L3) in Food Science, providing them with a significant and lasting nutritional foundation from both a theoretical and practical perspective.

The main objective of this educational document is to enable students in their final year of undergraduate studies in Food Science – Bachelor's degree in Agri-food and Quality Control – to acquire fundamental concepts in Nutrition and Food and their application to

their daily lives, both individually and in society. This means consolidating the key foundations of human health through proper nutrition and diet. Students will put the fundamental concepts covered in this course into practice, understanding the roles of different nutrients in the human body. They will evaluate their actual nutritional intake and then deduce the adequacy of their intake according to their needs, taking into account factors such as age, sex, weight, height, level of physical activity, climate, physiological state, and other factors that define their normal or pathological nutritional status. This will also explain how to address various nutritional problems or diseases such as malnutrition, diabetes, and other issues related to metabolic syndrome.

This course is an introduction to the methodology of Human Dietetics. It will provide students with fundamental knowledge of metabolic biochemistry, nutrition science, and, to a lesser extent, physio-nutrition. This foundational knowledge will enable them to propose balanced diets to healthy individuals for preventative purposes or to patients for therapeutic purposes, taking into account various metabolic situations.

The course's main objectives are:

• To acquire certain skills in nutrition and dietetics;

• To understand the different types of nutritional needs;

• To become familiar with the different food groups;

• To understand the roles of each nutrient (macro and micronutrients);

• To learn how to perform energy and nutritional calculations using food composition tables;

• To determine the daily intake of different nutrients;

• To explore nutrition and the various possible physiological states (including at-risk populations);

• To understand artificial nutrition;

• To assess nutritional status, fat mass, and lean mass;

• Recognize the different nutritional diseases;

• Learn about the main diseases of malnutrition.

Upon completion of this course, students will be able to:

- Understand the differences between nutrition and diet; between food and nutrients;

- Use recommended daily intakes and food composition tables to calculate daily nutrient intakes;

- Accurately compare intakes with requirements and identify necessary recommendations;

- Understand the various factors influencing basal metabolism and therefore the needs of each at-risk population;

- Define the causes, symptoms, and solutions of some metabolic nutritional diseases or malnutrition;

- Calculate observed daily intakes, basal metabolism, and certain nutritional indices such as Body Mass Index (BMI).

This handout is divided into:

I would like to express my sincere gratitude to the colleagues who kindly reviewed the manuscript of this teaching course and helped me improve it further.

This first version may contain some imperfections, and I would be grateful to anyone who shares their corrections, comments, and suggestions. Thank you very much.

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INTRODUCTION

1- Concept and General Information

- Food: The act of eating or drinking; the way we eat or drink.

- Nutrition: The transformation and use of food in the body. Physiologically speaking: all the processes (assimilation, excretion, respiration) that take place in a living organism to produce energy.

- Food: A substance that can be digested and used to nourish a living being (growth and good health). A single food is not sufficient, except for breast milk for the first six months (due to technological evolution and the development of knowledge).

- **Nutrition:** Substances provided by food that ensure the development and maintenance of the body.

Eating well is vital for a healthy and active life. Most people know that food is essential for the body's energy and energy needs to work. However, the world doesn't have a clear understanding of what "eating well" means. Nutritional education plays a crucial role in promoting good nutrition, especially in developing countries where nutritional knowledge is insufficient to meet the rapidly evolving and profound economic and social challenges.

- Food Groups:

Group 1: Beverages; where water is the most essential beverage (2 liters/day);

Group 2: Milk and dairy products; rich in calcium, essential amino acids, and vitamins A, D, and B;

Group 3: Meat, fish, and eggs; rich in essential amino acids, iron, and various fats;

Group 4: Fruits and vegetables; rich in fiber (cellulose), pectin, hemicellulose, vitamins C and A, antioxidants, and carbohydrates.

Group 5: Legumes; Rich in fiber and protein (methionine, cysteines),

Group 06: Starchy products; rich in starch, vitamin B and trace elements.

Group 7: Fats; rich in lipids, fatty acids (FA), and fat-soluble vitamins A, D, E, and K.

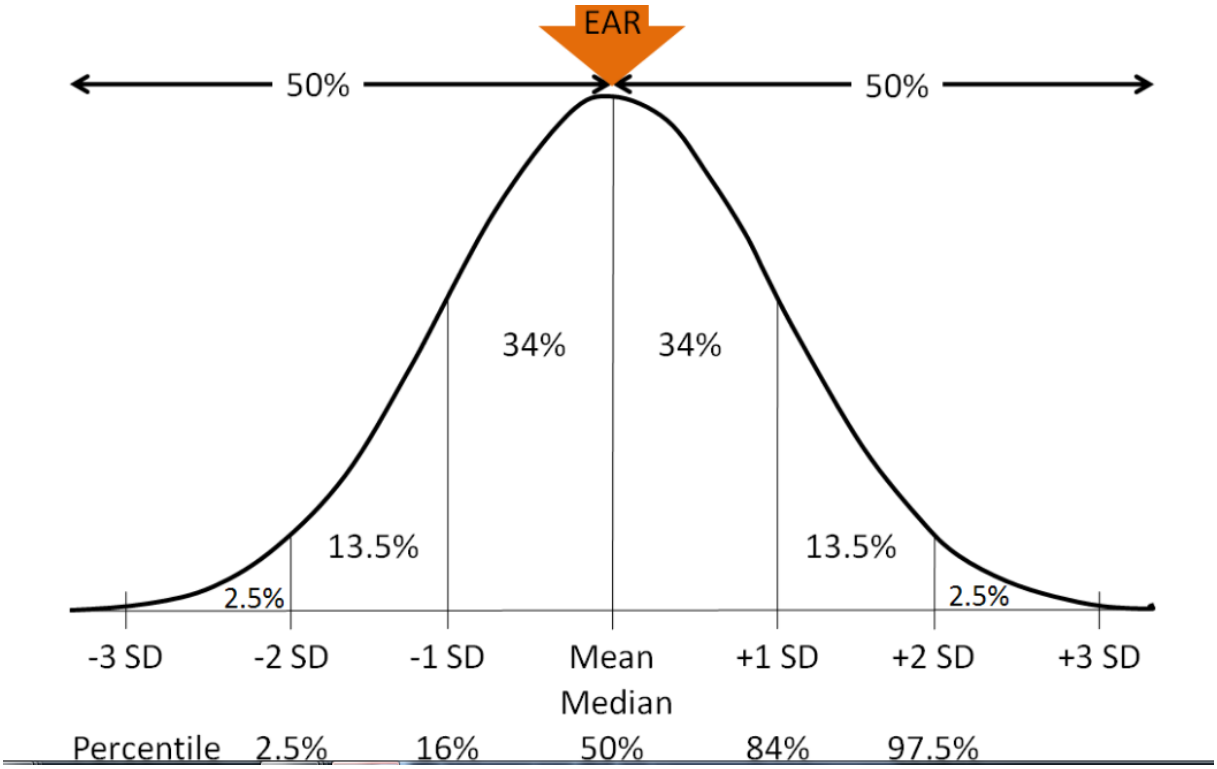
Group 8: Sugary products (monosaccharides, disaccharides) and fat (pastries).

2- Concept of Nutritional Needs

Minimum nutritional needs: This is the smallest amount of a nutrient required to maintain vital functions and a normal state of health. If these needs are not met, clinical signs of severe deficiency will appear in both the short and long term.

Optimal (average) nutritional needs: This represents the reference intake resulting from observing the consumption of a group of subjects assumed to be healthy (average/mean nutrient requirement). It is the average of individual needs within an experimental group composed of a limited number of individuals.

Recommended Dietary Intake (RDI): This is equal to the average nutritional need, measured in a group of individuals, plus 2TE (Total Equivalent) to cover the needs of 97.5% of the reference population.



Estimated Average Requirement (EAR)
The EAR meets the need of 50% of the population as depicted in this normal distribution. SD- standard deviation.
If an EAR is set, the formula for setting the RDA is:
EAR + 2 Standard Deviations = RDI

Fig. 01: Recommended nutritional intake

Net requirement: This expresses the amount of nutrient used by the tissues after intestinal absorption. It also includes the concept of reserve.

Reserve: A nutrient that allows the body to cope with physiological or pathological conditions.

This is why it is difficult to define an optimal reserve level a priori. The ideal reserve should be easily mobilized and not have adverse effects on the body.

Nutritional requirement: This expresses the amount of nutrient or energy that must be ingested to meet the net requirement, taking into account the amount actually absorbed. This absorption varies greatly from person to person, depending on the nutrient, and depending on the type of diet followed.

3- Determining Needs: Methods and Markers

3-1- Cellular and Animal Models

- Exploration using cultured cells;
- Animal models that provide important metabolic and physiological data;
- Human application, which must be approached with caution.

3-2- Physiological Approaches in Humans

Determining an individual's nutrient and energy requirements. These approaches are technically complex and limited to certain subjects only. (The representativeness, exploration, and generalization of the results obtained remain points of discussion).

3-2-1- Factorial Method

Evaluates the different needs of the body separately and takes into account the average absorbability of the food (actual absorption coefficient).

- Maintenance requirement (M): losses via endogenous routes (feces, urinary, and cutaneous);
- Net growth requirement (GR): weight gain (change in body composition);
- Gestation requirement (G): fetus, placenta, amniotic sac, uterus, and its blood volume;
- Lactation requirement (L): quantity of milk exported;
- Actual Absorption Coefficient (AAC):
- Fractionated Actual Absorption Coefficient: measures endogenous fecal (isotopic) losses.

3-2-2- Balance Method

Studying the equilibrium between intake and output. Retention of a nutrient by the body (risk of overestimating intake or underestimating losses). This will require careful attention.

3-3- Depletion-Repletion Method

Administering a diet deficient in vitamin C (scurvy), after which it is reintroduced at different levels; kinetic evolution using markers.

4- Nutritional Surveys

Assessing the nutritional status of a population by measuring intake (dietary indicators) and relevant biological markers.

4-1- Dietary Indicators

Estimating nutritional intake in a given population (observed intake). This method has certain limitations, especially for nutrients not studied by previous methods. There are three levels of limitation: data collection (omissions, inaccuracies), conversion of food quantities into nutrient quantities (errors in volume accuracy, due to the use of the Rigal and Ripert food composition tables), and the actual bioavailability of nutrients.

3-4- Isotopic Techniques

Isotopic tracers; stable isotopes*; in-depth metabolic studies, mathematical models to measure the synthesis, storage, oxidation, and elimination of a labeled nutrient (absorption and loss, basal metabolic rate (BMR) dependent on this nutrient).

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4-2- Biological Markers

4-2-1- Direct Markers

These measure the concentrations of the nutrient being studied in the different compartments of the body (plasma, serum, circulating, or tissue concentration) and in excreta (urine, feces, sweat), skin, and skin appendages (nails, hair, body hair).

4-2-2- Functional Markers

These measure the nutrient's role in a biological function (enzymatic activity) or its structure within a blood component (hemoglobin iron).

5- Clinical Approaches

These are used in cases of hospitalization of patients requiring prolonged intravenous or parental nutrition (where the quantity of nutrient strictly necessary for the treatment or prevention of a deficiency is required).

6- Epidemiological approaches

If they include a nutritional survey, they allow us to establish a link between nutrition and health.

6-1- Observational studies (descriptive epidemiology)

Allow us to establish a statistical correlation between nutrition and disease.

6-1-1- Cross-sectional/case-control studies

At a given time, the nutritional status of sick individuals is compared to that of a number of healthy individuals.

6-1-2- Longitudinal/cohort studies

These are prospective studies where dietary/biological indicators are monitored (over a longer period of time to observe the onset of diseases).

6-2- Intervention studies

Demonstrate the causal link between a nutrient and a disease (pathology). They are based on a comparison between a treated group and another control group: such as the double-blind approach (micronutrient) in the form of a capsule, softgel or incorporated into a food for the objective: nutritional, biological and clinical monitoring (SU.VI.MAX) (Supplémentatyion and Vitamins and Minerals AntioXydants) at nutritional doses.

7- Energy of a Food

The gross energy (enthalpy) of a food is the amount of heat produced by the combustion of 1g of that food in a calorimeter under oxygen pressure.

It is expressed in calories (the unit of heat)/joules per gram of food. As a reminder: one calorie is the amount of heat required to raise the temperature of 1g of water from 14.5°C to 15.5°C by 1°C.

The kilocalorie is preferred: 1 kcal = 1000 kJ = Calorie.

In the International System of Units (SI), the energy value of foods is expressed in joules.

1 kcal = 4.185 kJ

1 kJ = 0.239 kcal

1 MJ = 1000 kJ = 239 kcal

CHAPTER I: NEEDS OF A HEALTHY INDIVIDUAL

1- Physiological Needs and Energy Intake

1-1- Concepts of Physiological Needs

Food is composed of nutrients. Nutrients are substances that provide:

- Energy for activity, growth, and all bodily functions such as respiration and digestion…
- Materials for growth and repair of the body, and for maintaining the immune system
- A healthy system.

There are many nutrients. We divide them into:

Macro (large) nutrients: which we need in large quantities. These are carbohydrates (starches, sugars, and dietary fiber), lipids, and proteins.

Micro (small) nutrients: which we need in small quantities. These include minerals (iron, iodine, zinc…) and vitamins (vitamin A, B vitamins, and vitamin C…).

The physiological nutrient requirement is the smallest amount of a nutrient, in its most suitable chemical form, necessary for the body to maintain normal development and health, without disrupting the metabolism of other nutrients. The most appropriate dietary intake would therefore be that which is just sufficient, given bioavailability, to meet the physiological need for that nutrient, avoiding excessive strain on regulatory mechanisms and leading to depletion or overload of reserves.

It is currently impossible to routinely assess the physiological nutrient requirement for a given individual. This difficulty stems from the fact that its value differs from one person to another, and we lack sufficiently precise and reliable markers to predict these variations. Consequently, it is not possible to define the most appropriate dietary intake for each individual.

In practice, the goal is to determine the amount of nutrients needed to meet the needs of almost all individuals in a given population in order to protect the population as a whole from the risk of deficiency. This value is called the "safety intake" or "Recommended Nutrient Intake" (RNI). By definition, RNIs are therefore higher than the needs of most members of the target population, without specifying the extent of the difference for any given individual. Under no circumstances should they be equated with the amount of nutrients each individual should consume, even though the term "recommended" intake has been misleading in the past. These values also do not allow us to judge how well an individual's diet meets their needs. RNIs are therefore only a useful guide for feeding communities.

1-1-1-Concept of Energy Intake

An individual's energy requirements (Tables 01 and 02) depend on several factors, including sex, age, weight, height, and physical activity. The energy contained in food is expressed in kilocalories (kcal) and comes from proteins, carbohydrates, and fats, which are called macronutrients. Proteins and carbohydrates each provide 4 kcal/gram, while fats provide 9 kcal/gram.

Table 01: Daily energy intake and distribution

Energy	1 900- 2200 kcalories on average for women*
	2 400-2700 kcalories on average for men *
Proteins	11-15 % Total Energy Intake (TEI)
	Animal proteins (PA 1/2)/Plant proteins (PV 1/2) = 1
Lipids	30 à 35% of TEI
	Saturated FA≤8-10% (1/3)
	Polyinsaturated FA (2/3)
	Mono-insaturated FA≥10-15 % 1/3
	Poly-insaturrated FA ≥5-10 % 1/3
	(linoleic FA (18 :2 n-6) /alphalinolenic FA (18 : n-3) = 5)
Carbohydrates	50 à 55 % OF TEI
	Sugar and sugary products ≤ 10 % (1/5)
	Complex sugar = 40-45% (4/5)
Plant fibers	30-40 g per day
Drinking water	2600 mL per 24h

*average for inactive and active people, adult woman of 60 kg and man of 70 kg.

Table 02: Average recommended energy intake by age group in kcal*

Children 1-3 years old	1 250	Adult men	2 200 à 2 700
Children 4-9 years old	1 750	Adult women	1 800 à 2 200
Boys 10-12 years old	2 200	Pregnant women	2 150 à 2 250
Girls 10-12 years old	2 000	Breastfeeding women	2 500
Teenagers 13-19 years old	2 650	Able-bodied seniors	1 800 à 2 100
Teenage girls 13-19 years old	2 150		

*depends on body size, level of physical activity, and lifestyle.

An adult's energy requirement varies considerably from one individual to another, even at rest (Basal Metabolic Rate or BMR). This is primarily due to differences in body composition, as variations in lean mass account for 60 to 80% of the interindividual variance in BMR (in a normal population, lean mass is closely correlated with height). Sex and fat mass account for only about 2% of these differences. BMR represents the energy required to maintain electrochemical gradients, renew cellular components, and support integrative functions (ventilation, circulation, nervous system, etc.) in a fasting state and before any activity. Physical activity is the other major source of interindividual variation in energy expenditure.

The maintenance requirement corresponds to the energy intake at which weight remains constant, that is, an energy intake equal to energy expenditure. In adults, the energy requirement represents the average maintenance requirement of the reference group. In children, it is the average maintenance requirement plus the average growth requirement of the reference group.

1-1-2- Protein intake

Proteins, defined by the chemical formula NH_2-RCH-COOH, represent 15% of total body mass, or slightly more than 10 kg in a 70 kg individual. They are constantly renewed, and their synthesis can only occur through a daily intake of amino acids. Those that cannot be produced by the body are called essential amino acids. There are proteins composed solely of amino acids and others containing a non-protein component: these are called heteroproteins. These can be lipids (lipoproteins), carbohydrates (glycoproteins), nucleic acids (nucleoproteins), but also other elements such as a metal ion or a pigment. There are eight essential amino acids (Figure 02), also called indispensable amino acids.

- Alanine
- Arginine
- Asparagine
- Aspartate
- Cystéine
- Glutamate
- Glutamine
- Glycine
- Histidine
- Isoleucine*
- Leucine*
- Lysine*
- Méthionine*
- Phénylalanine*
- Sérine
- Taurine
- Thréonine*
- Tryptophane*
- Tyrosine
- Valine*

*Acides aminés essentiels

Fig. 02: Main amino acids

Animal proteins have a higher nutritional value than plant proteins because they contain all the essential amino acids. Cereal proteins are relatively low in lysine, while legume proteins are generally low in sulfur-containing amino acids (cysteine, methionine). Plant-based food combinations allow populations with limited access to animal proteins to meet their protein needs by combining cereals and legumes in their daily diet. Animal proteins have high digestibility, between 94% and 98%, while that of plant proteins is more variable, with many reaching around 75%.

Proteins perform several functions:

• Structural proteins. They are involved in the formation of cell membranes and intracellular organelles;

• Motility proteins. Represented by actin and myosin, they enable muscle contraction;

• Regulatory proteins. They have various roles:

• Enzymatic (all enzymes are protein substances);

Proteins are essential for the body's active metabolism and play both intracellular and extracellular roles. The body does not store amino acids. However, when needed, the body can mobilize amino acids primarily through increased protein catabolism, which occurs at the expense of lean mass, that is, mainly muscle.

In 1973, the FAO and WHO proposed a safe protein intake of 0.57 g/kg/day. This remains a minimum intake, but one that includes safety margins, ensuring that almost the entire adult population can maintain nitrogen balance. Actual protein intake ranges from 10 to 15% of total calories consumed: between 10 and 12% in physically active populations with high energy intake; and around 14-15% in urban populations in the Western world. Thus, the average French person consumes approximately 2,200 kcal, of which 330 kcal come from protein (80 g of protein, or 1.3 to 1.4 g/kg/day of body weight). In practice, protein intake should be greater than or equal to 55 g of protein for women, and greater than or equal to 70 g of protein for men. Table 03 shows the protein recommendations.

Table 03: Recommendations from the United Nations (1985 FAO / WHO / UNU) and the Institute of Medicine (2002/2005) regarding selected protein intake for certain age groups and physiological states

Group	Age (years)	Protein safety level (g/kg/day) UNU
Infants	0.3-0.5	1.47
	0.75-1	1.15
Children	3-4	1.09
	9-10	0.99
Teenagers	13-14 (Girles)	0.94
	13-14 (Boys)	0.97
Young adult	19+	0.75
Elderly		0.75
Women: pregnant	2nd trimester	+ 6 g per day
	3rd trimester	+ 11 g per day
Breastfeeding Women	0-6 months	~+ 16 g per day
	6-12 months	12 g per day

The values correspond to proteins such as those of equal quality found in a chicken egg, cow's milk, meat or fish.

There are two sources of protein: animal and plant (Table 04). In a balanced diet, the ratio of Animal Protein (AP) to Plant Protein (PP) should be 1.

Table 04: Animal and Plant Proteins

Animal source proteins	Characteristics
Meat, deli meats 130 g = 25 g of proteins on average	All amino acids are present Proteins represent 20% of the total mass
Fish 150 g = 25 g (on average)	Protein composition roughly similar to meat
Egg Whit Yellow 1 egg = 13 g (on average)	– 90 % of proteins (essentially ovalbumin) – 30 % of proteins (essentially ovovitellin)
Milk, dairy products 200 mL of milk = 2 yogurts = 100 g of white cheese = 7 g of protein (on average)	There are 35g of protein per liter of milk (80 % of casein and whey)
Plant-based proteins	**Characteristics**
Cereals (Wheat, rice, corn, rye …) 50 g = 5 g of protein (on average)	They contain 10% protein on average They are rich in sulfur amino acids (methionine cysteine), low in lysine and isoleucine
Legumes (Lentils, white beans, peas, chickpeas, broad beans…) 50 g = 5 g of protein (on average)	They contain 20% lysine-rich proteins and low in sulfur amino acids and valine
Oilseeds (Peanut, walnut, almond …)	The proteins are low in lysine
Tubers and roots (Potatoes, beets, carrots …)	Less than 10% of protein

1-1-3- Lipid Intake

Lipids are organic molecules insoluble in water and soluble in nonpolar organic solvents such as benzene, chloroform, ether, etc. They are fats composed primarily of fatty acids (FAs) esterified with glycerol (Table 05). The most important classes of lipids in animal nutrition are triaglycerols or triglycerides (nonpolar lipids) and phospholipids (polar lipids). Phospholipids are composed of esters of two fatty acids and a phosphoric acid linked to an alcohol. Unlike terrestrial animals, lipids of aquatic origin contain a significant proportion of long-chain polyunsaturated fatty acids of the n-3 series. The main dietary lipids are triglycerides: they consist of glycerol and three fatty acids.

Table 05: Classification of Lipids

Simple lipids (fatty acids esterified with alcohols)	Fats (fatty acids esterified with glycerol) Waxes (true waxes, sterol esters, vitamin A and D esters)
Complex lipids (fatty acids esterified with alcohols and other groups)	Phospholipids (contain phosphoric acid and usually a nitrogenous base) Glycolipids (lipids containing a carbohydrate and nitrogen but no phosphate or glycerol) Sulfolipids (lipids containing a sulfur group) Lipoproteins (lipids bound to plasma or other proteins) Lipopolysaccharides (lipids bound to polysaccharides)
Lipid derivatives (obtained by hydrolysis of simple or complex lipids)	Fatty acids (saturated, monounsaturated, or polyunsaturated) Monoacylglycerols and diacylglycerols Alcohols (include sterols, steroids, vitamin D and vitamin A)
Various lipids	Straight-chain hydrocarbons, Carotenoids, Squalene, Vitamins E and K

Modern diets contain 40% of calories in the form of lipids, and dietary lipid intake is essential because lipids are carriers of essential fatty acids and fat-soluble vitamins such as vitamins A, D, E, and K. Lipids are a significant source of energy and ensure the transport of carotenoid pigments. Among macronutrients, lipids are the most efficient energy source. Indeed, lipids provide 38 kJ per gram. The fatty acids provided by food are primarily in the form of triglycerides (50-140 g/day) and much smaller amounts of phospholipids (2-4 g/day).

The most abundant saturated fatty acids in nature are palmitic (C16) and stearic (C18) acids, and to a lesser extent myristic (C14) and lauric (C12) acids. The most abundant monounsaturated fatty acids are palmitoleic acid (C16) and, above all, oleic acid (C18), the main constituent of vegetable oils, but also found in abundance in fluid animal fats (goose and human fats). Oleic acid alone represents 30% of the fatty acids provided by food. Two essential fatty acids are fundamental from a nutritional standpoint because they cannot be synthesized by the body. They are called essential and must therefore be obtained from food:

- **Linoleic acid:** It belongs to the Omega 6 or n-6 family, meaning a family of fatty acids with two double bonds. The first double bond is located between the 6th carbon atom (C6) and the 7th carbon atom (C7), starting from the CH3 group (linoleic acid = C18:2, n-6). It is found primarily in vegetable oils such as sunflower, grapeseed, and corn oil (Table 6).
- **Alpha-linolenic acid:** It belongs to the Omega 3 or n-3 family. The first double bond is between C3 and C4 (alpha-linolenic acid = C18:3, n-3). It is found in oily fish and vegetable oils such as rapeseed, soybean, and walnut oil.

The essential or indispensable nature of these fatty acids is linked to several of their biological functions, such as:

- Their integration into membrane phospholipids, which, due to their physicochemical nature, gives membranes to all cells their functionality. This is particularly true of the nervous system and the retina, whose phospholipids are very rich in docosahexaenoic acid;
- Their role as precursors (especially arachidonic acid) for the synthesis of eicosanoid mediators such as prostaglandins, thromboxanes, and leukotrienes;
- Blood triglycerides, nervous system development, platelet function, reproductive function, epidermal function, the immune system, and the inflammatory response;

- Their specific functions in regulating gene expression in relation to nutritional intake and/or critical stages of cell maturation and differentiation.

It should also be noted that n-3 fatty acids, and to a lesser extent n-6 fatty acids, can reduce the risk of thrombosis and moderately lower blood pressure.

Table 06: Lipid composition of some common food products

Designation	Monounsaturated fatty acids	Polyunsaturated fatty acids		Saturated FA
		Series n6	Series n3	
Sunflower oil	●●	●●●		●
Grapeseed oil	●	●●●		●
Walnut oil	●	●●●	●●	●
Soybean oil	●●	●●	●●	●
Corn oil	●●	●●		●
Rapeseed oil	●●●	●	●●	●
Virgin olive oil	●●●	●		●
Peanut oil	●●●	●		●
Goose fat	●●	●		●●
Butter	●			●●●
Dry and salty cheeses:				
– Goat cheese,	●			●●
– Roquefort,	●			●●
– Comté,	●			●●
– Cammembert,	●			●●
Chocolate				●●
Quiches	●			●●
Various pastries, croissant	●			●●

Dietary fats are a macronutrient that is also an essential source of energy and helps the body absorb other nutrients. It has been found that their consumption is largely excessive among college-aged students. It is often the first macronutrient to be restricted during periods of calorie restriction.

due to its high calorie density. To promote good health, the recommendation for total oil and fat intake is 27 grams per day, or 20 to 35% of total daily energy intake. At least 70% of this intake should come from unsaturated fatty acids, and the number of calories from saturated

fats should not exceed 10% of total daily calories. Diets containing up to 35% of calories from fat can be compatible with good health if energy intake is reasonable and saturated fat intake is low. However, fats and oils containing less than 20% of caloric intake increase the risk of insufficient intake of essential fatty acids.

Lipids have several roles, which are as follows:

The oxidation of one gram of lipid releases 9 kcal. It is the most energy-dense nutrient. Daily lipid requirements in a balanced diet are estimated at 30-35% of total energy intake. Adipose tissue represents the majority of body fat. In adults, it typically corresponds to 8 to 10 kg of body weight. Women have an average of 20 to 25% body fat, and men 15 to 20%. There are, of course, significant individual variations related to diet, level of physical activity, age, and genetic factors.

The distribution of this fat mass is crucial for health. When it is predominantly abdominal and infiltrates the internal organs (android), the cardiovascular risk is significant; when it is located in the gynoid region, the risk is lower.

- *Reserve role*

Adipose tissue has a well-defined energy reserve function, primarily in the form of triglycerides contained within adipocytes.

- *Insulating Role*

Adipose tissue is a thermal insulator, and humans are homeothermic only thanks to its subcutaneous presence. They do not experience external temperature variations like cold-blooded animals.

- *Endocrine Role*

Adipose tissue is not just an inert storage tissue; it has an endocrine role. Adipocytes secrete various substances, including leptin, which influences food intake. Their enzymatic machinery also allows them to transform certain molecules; an excessive reduction in adipose tissue, with fat mass below 10% of total body weight, induces infertility in women. Conversely, an excess of fat mass, especially android fat, increases insulin resistance, notably through adiponectin (a hormone secreted by adipose tissue). Adipose tissue, although all its functions are not yet fully understood, plays a hormonal role whose importance is becoming increasingly essential.

- *Structural Role*

Lipids, particularly through the various phospholipids largely composed of polyunsaturated fatty acids, participate in the formation of the membrane of every cell in the body. Their role is absolutely crucial in maintaining cellular integrity, the degree of rigidity, and in the various exchanges between the intracellular and extracellular environments.

Through their position and composition, glycolipids on the cell membrane, as well as phospholipids, play a role in signal transduction (functioning as receptors).

- *Roles as Molecular Precursors*

Lipids are the precursors of numerous molecules such as cholesterol (steroid hormones, bile acids, vitamin D synthesized by the skin under the influence of ultraviolet rays), polyunsaturated fatty acids (prostanoids [prostaglandin, thromboxane, leukotriene]), and phospholipids (pulmonary surfactant).

- *Transport Role of Fat-Soluble Vitamins*

Vitamins A, D, E, and K are fat-soluble and are absorbed with dietary fats, unlike water-soluble vitamins such as vitamin C and the B vitamins.

Numerous epidemiological studies attest to the importance of environmental factors, including diet, on the incidence of various cancers. For example, a high incidence of breast cancer in women is associated with diets rich in lipids, particularly saturated or unsaturated fatty acids. Furthermore, findings suggest that the risk of breast cancer metastasis is significantly higher in patients with low levels of linolenic acid measured in their tissues. In prostate cancer, positive correlations have been found between cancer incidence and diets rich in lipids, but not in the case of diets rich in linoleic acid or long-chain polyunsaturated fatty acids. In the case of colon cancer, numerous epidemiological data establish a positive correlation between the frequency of this cancer and the amount of lipids ingested per day in different countries.

However, comparative case-control studies or cohort studies do not show such a relationship with diets providing 30 to 40% of energy intake from fats.

Furthermore, the risk of developing non-communicable diseases decreases by adopting the following behaviors:

- Reducing saturated fats to less than 10% of total energy intake;
- Reducing saturated fatty acids to less than 1% of total energy intake;

- Replacing saturated fats and trans fatty acids with unsaturated fats, particularly polyunsaturated fats.

It is possible to reduce fat intake, especially industrial trans fatty acids, by following these steps:

- Steam or boil food instead of frying;
- Replace butter, lard, and clarified butter with oils rich in polyunsaturated fats, such as soybean, rapeseed, corn, safflower, or sunflower oil;
- Eat low-fat dairy products and lean meat, or trim visible fat from meat; and
- Limit consumption of baked and fried foods, as well as pre-packaged foods (e.g., doughnuts, cakes, pies, cookies, biscuits, and waffles) that contain industrially produced trans fats.

1-1-4- Carbohydrate Intake

Carbohydrates are the primary source of dietary energy among macronutrients, accounting for between 40 and 80% of total energy intake. There are two main categories of carbohydrates: simple sugars and complex carbohydrates. Simple sugars include monosaccharides (glucose, fructose) and disaccharides (sucrose, lactose, maltose, etc.) and provide energy more quickly. Simple sugars are often added to foods such as sweets and sugary drinks, including soft drinks, syrups, etc. They are also naturally present in foods, such as fructose in fruits or lactose in dairy products. Complex carbohydrates, or polysaccharides, are slowly absorbed by the body and produce energy over a longer period of time. Sources of complex carbohydrates include starch and fiber from whole grains, fruits, vegetables, and legumes. It is recommended to consume foods rich in complex carbohydrates and fiber for better energy balance, which also contributes to better body weight control.

The most metabolically important monosaccharides are glucose, fructose, and galactose, and they possess fundamental properties:

- They are not broken down by hydrolysis into simpler substances;
- They are rapidly emptied from the gastric cavity;
- They are absorbed through the intestinal mucosa.

Carbohydrates in the form of glucose are an energy substrate usable by all cells and essential for some. However, the body's stores are very small: a few minutes as glucose, a few hours as liver and muscle glycogen. In the body, carbohydrates are either obtained directly from food after transformation or through metabolic processes (gluconeogenesis from amino acids).

Glucose is transported into the intestinal epithelium by specific sodium-dependent transporters (known as SGLT-1, for Sodium Glucose coTransporter-1), and this active transport requires energy. Enterocyte transport of fructose relies on a different facilitated diffusion process, involving a GLUT5-type molecular transport system, which does not require energy. These different mechanisms mean that simple sugars appear rapidly in the bloodstream after ingestion. They are therefore called fast-acting sugars.

Oligosaccharides are composed of a small number of molecules; most are disaccharides, the most important of which are sucrose (made up of glucose and fructose), lactose (glucose and galactose), and maltose (two glucose molecules). Disaccharides are C12 sugars. To be absorbed in the digestive tract, they must undergo hydrolysis by salivary and pancreatic enzymes, which transform them into two monosaccharide molecules. Consequently, their intestinal absorption is slower than that of simple sugars. Heterosides, derived from complex molecules containing non-carbohydrate elements (proteins, phosphorus, etc.) associated with carbohydrate elements, are present in various connective tissues such as cartilage, certain membrane receptors, and mucus.

The FAO/WHO report proposes a classification of the main categories of dietary carbohydrates based on their degree of polymerization (Table 07). This approach represents a compromise between a chemical classification and a physiological classification.

Table 07: Main dietary carbohydrates

Class (DP)	Sub-group	Components
Sugar (1-2)	Monosaccharides	Glucose, galactose, fructose
	Disaccharides	Sucrose, lactose, trehalose
	Polyols	Sorbitol, mannitol
Oligosaccharides (3-9)	Malto-oligosaccharides	Maltodextrines
	Other oligosaccharides	Raffinose, stachyose, fructo-oligosaccharides
Polysaccharides (>9)	Amidon	Amylose, amylopectine, modified starches
	Non-starch Polysaccharides	Cellulose, hemicellulose, pectins, hydrocolloïds

DP: Degree of polymerization

Carbohydrate-rich foods are less energy-dense than fat-rich foods because carbohydrates provide only 4 kcal per gram, compared to 9 kcal per gram for fats. The implication is that, based on an equal weight of food consumed, a carbohydrate-rich food provides less dietary energy than a fat-rich food, thus reducing the risk of overeating. Carbohydrates should make up 50 to 55% of total energy intake as part of a balanced diet. Furthermore, only 10% of total energy intake (TEI) should come from sugary foods with a high glycemic index, which is far from being the case currently, particularly among adolescents.

Total carbohydrate requirements are estimated at 5 to 8 g/kg/day. Slow-release carbohydrates from lentils, white beans, peas, broad beans, chickpeas, cereals, etc., should provide at least 40 to 45% of total energy intake. While requirements vary depending on the level of physical activity, the brain is always the primary source of glucose. It requires 150 to 180 g per day, with the remainder distributed to the muscles and organs. The following table provides an overview of the sucrose content in foods. Table 08 presents sucrose (glucose and fructose content in different food.

Table 08: Sucrose content in g/100 g of different foods

Milks	
Woman	0
Cow	0
Goat	0
Fruits	
Apricot	3.6
Pineapple	7,5
Banana	6 to 9
Orange	4.2
Peach	4.2
Pear	1
Apple	2
Plum	2
Grape	0
Cherry	0
Dried fruit	
Dates	45 to 48
Oilseeds	
Almond	2.3
Peanut	4.5
Hazelnut	0
Walnut	0
Olive	0
Drinks	
Lemonade	10 to 12
Beer	0
Wine	0
Sugar-based preparations	
Honey	2.6 to 3
Candy	93
Chocolate	20 to 60
Jam	50 to 55
Sugar	99.5
Fresh vegetables	
Beetroot	9 to 15
Carrot	1,7
Cabbage	1 to 2
Melon	3,3 to 6,2
Onion	2 to3
Potato	0 to 1
and other vegetables	
Dried vegetables	
Dried peas	6.7
Lentille	2.1
Beans	1.6
Farinaceous products	
Biscotte	1
Croissant	2
No animal content	
Meat	0
Deli meats	0
Shellfish	0
Eggs	0
Dairy products, cheese	0

A key index that has become accepted as an indicator of carbohydrates' ability to prevent lifestyle-related diseases and help reduce the incidence of obesity is the glycemic index (GI).

This measures the glycemic response (an indication of how quickly blood glucose rises and how long it remains elevated) after consuming carbohydrate-containing foods.

There is evidence that the GI is relevant to sports nutrition (and this concept can be extended to any sustained physical activity, a common working condition in developing countries) as well as to appetite regulation, with low-GI foods (Table 9) being the best choice in both cases.

An important point to consider is that glycemic index (GI) values can also be determined for mixed meals and complete diets. Nutritional advice will therefore focus on consuming foods with the lowest glycemic index. Numerous studies have shown that a diet with a high glycemic load (glycemic index x carbohydrate intake) is associated with an increased risk of cardiometabolic disorders (diabetes, ischemic heart disease), as well as oculoneurodegenerative diseases, because a high glycemic index induces oxidative stress and increases systemic low-grade inflammation and neuroinflammation. The glycemic index depends on factors specific to the individual (physical activity, insulin sensitivity) and specific to the food (particle size, density) and the diet (acidity, matrix, nutritional complexity). Cooking food also increases its glycemic index and the method of culinary preparation plays a role: for potatoes, for example, the glycemic index is 52% for those boiled in water and 85% when they are prepared as puree.

Consuming free sugars increases the risk of tooth decay. Excess calories from foods and beverages high in free sugars also contribute to unhealthy weight gain, potentially leading to overweight or obesity. Recent evidence also shows that free sugars affect blood pressure and serum lipids, suggesting that reducing free sugar consumption lowers risk factors for cardiovascular disease.

Sugar consumption can be limited by adopting the following strategies:

- Limit the consumption of foods and drinks high in sugar, for example sugary snacks, sweets and sugary drinks (i.e. all types of drinks containing free sugars, namely sodas, non-carbonated drinks, fruit or vegetable juices, liquid or powder concentrates, flavored waters, energy and sports drinks, ready-to-drink tea and coffee).
- Snack on fresh fruit and raw vegetables rather than sugary snacks.

Table 09 presents glycemic index (GI) of different foods.

Table 09: Glycemic index (GI) of common foods

.Glucose .Honey .Sweet ned soda, .Chocolat bar* .Novelt ycandy*, .White bread .Sweetened refined cereals (corn flakes)* .Biscuits, pastries, viennoiseries*	**IG < 70**
White rice "Sugar" or sucrose Dried fruit Potatoes cooked in their skins (mashed, GI > 70) Beets Banana, pineapple, mango, grapes Cooked cabbage, cooked celery Cooked pasta Whole wheat bread or bran bread Brown rice Semolina Whole rye bread	**40 < IG > 70**
Dairy products Raw carrots (cooked, glycemic index > 70) Dried vegetables, lentils, dried beans, chickpeas Fresh fruit (high in fructose) Soybeans Green vegetables Mushrooms	**IG < 40**

Plant-based dietary fiber consists of plant cell membranes and is found primarily in grains, vegetables, and fruits. It comprises fibrous residues not hydrolyzed by digestive enzymes, but partially broken down by the gut microbiota (polysaccharide components). Four main

constituents are recognized: cellulose, hemicellulose, pectin, and lignin, along with a large number of other fibers.

The overall fiber content of plants varies with their age, origin, and degree of ripeness:

- Lignin, found mainly in the hard parts of plants, is not metabolized; it is irritating to the intestines;
- Cellulose, abundant in green vegetables, is partially broken down by the intestinal flora (15%); it is very hydrophilic;
- Hemicelluloses A and B are found in young plants; they are 60 to 85% broken down in the colon; they have a very high affinity for water;
- Pectins (galacturonic acid polymers) are found mainly in berries and pome fruits; by absorbing large quantities of water, they transform into a viscous gel that spreads in a thin layer on the intestinal mucosa and slows the absorption of certain nutrients.
- Due to their high hydrophilic capacity, fibers increase stool weight and volume; they accelerate intestinal transit, sequester bile salts and cholesterol; they slow carbohydrate absorption; and they can be recommended as an adjunct in diabetes and hyperlipoproteinemia;
- One drawback: they reduce the absorption of minerals and B vitamins; the presence of phytic acid in the bran of cereals exacerbates this effect.

Since then, following numerous observational studies and interventions, fibers have acquired an image as a "functional compound," or even a "health compound." The beneficial preventive and therapeutic action of certain fibers on increasing stool production, stimulating colonic fermentation, reducing total cholesterol and/or LDL cholesterol levels in the fasting period, and decreasing postprandial blood glucose and/or insulin levels are now recognized with a reasonable level of evidence.

Dietary fiber slows gastric emptying and creates a feeling of fullness. Its consumption helps control food intake (by influencing GLP-1 secretion). Soluble fiber dilutes various ingested toxins, increasing the speed of intestinal transit and thus reducing their contact with the digestive mucosa, thereby decreasing their absorption.

Dietary fiber intake is considered an important determinant of health. However, the intrinsic beneficial effect of fiber is rather difficult to define precisely because it is consumed alongside other potentially beneficial nutrients with which it is associated within the food matrix: vitamins, minerals, and other plant micronutrients. The table 10 below shows the fiber content of foods.

Table 10: Fiber content of common foods

Foods	Dietary fiber (g/100g of food)	Foods	Dietary fiber (g/100g of food)
Cereals		**Vegetables**	
Wheat		Carrots	03.7
Bran	47.5	Potatoes	03.5
Wholemeal bread	08.5	Green cabbage	03.4
White bread	02.7	Lettuce	01.5
Rice		Tomatoes	01.4
Wholemeal	09.1	**Fruits**	
White	03.0	Almonds	14.3
Oats, flakes	07.2	Walnuts	05.2
Legumes		Bananas	03.4
White beans	25.5	Pears	02.4
Chickpeas	15.0	Strawberries	02.1
Lentils	11.7	Apples	01.4
Green peas	06.3		

1-1-5- Non-nutritional Contribution

Over the past two decades, oxidative stress, caused by reactive oxygen species (ROS), has been proposed as a key factor in the development of insulin resistance, diabetes, cardiovascular disease, neurodegenerative disorders, and other chronic non-communicable diseases. Prolonged exposure of β-cells to oxidizing agents (e.g., H_2O_2) leads to their dysfunction and induced insulin resistance, as well as the utilization of antioxidants that enhance insulin sensitivity, as demonstrated by in vitro studies and animal models. The role of ROS in the initiation, progression, and clinical consequences of cardiovascular diseases is already well established and has been described in several research articles proposing various mechanisms of antioxidant action in the prevention of cardiovascular disease.

Although lifestyle and dietary changes are still considered crucial, many authors suggest that increasing dietary antioxidant intake is one of the most important factors in preventing non-communicable diseases, especially when these antioxidants are obtained through a normal diet rather than dietary supplements. The human diet contains numerous antioxidants, including vitamins (C, E, beta-carotene), trace elements (copper, iron, zinc, selenium), and

plant metabolites (polyphenols, carotenoids). While phytochemicals are often considered antinutrients or non-nutritive elements, several discoveries over the past 15 years have led to a better understanding of their positive impact on the human body, particularly their important role in preventing chronic diseases. Plant foods contain a wide range of secondary metabolites, among which polyphenols (Table 11) are one of the most abundant and nutritionally important phytochemicals.

There are currently over 8,000 known phenolic structures, and more than 500 are found in plant-based foods and are considered dietary polyphenols. Polyphenols are synthesized from the combination of derivatives formed from phenylalanine and acetic acid via two biochemical pathways: the shikimate pathway and the acetate pathway. Polyphenols constitute the largest group of non-nutritive compounds, given their diversity, dietary occurrence, and biological properties.

The main classes of polyphenols include simple phenols, phenolic acids, acetophenones, phenylacetic acids, coumarins, anthraquinones, xanthones, stilbenes, lignans, and flavonoids. The latter are the most complex and widespread in plants. Flavonoids represent about two-thirds of dietary polyphenols and the remaining third are phenolic acids, constituting the second largest group of phenolic compounds present in food.

Flavonoids are an integral part of the diets of both animals and humans, and plants are their only source, as they cannot be synthesized by animals. The most frequently found flavonoids in food are flavonols, which predominate in fruits in the form of various glycosides. In vegetables, quercetin derivatives are the most abundant flavonoids.

It is difficult to accurately estimate the daily intake of flavonoids in the diet, given their complex distribution in plants, the diversity of classes, the techniques used (analytical or calculation methods), and dietary habits.

Global consumption of polyphenols varies by country. For example, the average daily polyphenol intake for an adult is approximately 283 to 1,000 mg of total polyphenols in France, 500 to 1,100 mg in Spain, approximately 700 mg in Italy, 890 mg in Finland, 534 mg in Brazil, and approximately 1,500 mg in Japan, while the total flavonoid intake is approximately 190 mg in the United Kingdom and Ireland, approximately 240 to 350 mg in the United States, approximately 450 mg in Australia, between 50 and 500 mg in China, and approximately 320 mg in Korea.

Table 11: Main dietary sources of polyphenols

Food groups	Polyphenols
Wine	Phenolic acid, stilbenes, flavonols, dihydroflavonols, anthocyanins, flavanol monomers (catechins) and flavanol polymer (proanthocyanidins)
Beer	Prenatal flavonoids, phenolic acid, simple phenols, flavanols, hydroxycoumarins, flavonols and flavones
Cofee	Phenolic acid
Tea	Catechins, phenolic acids, flavonols and proanthocyanidins
Cacao	Flavanols (catechines and proanthocyanidins), phenolic acids, flavonols, some stilbenes, simple phenols, and isocoumarins
Vegetables	Flavonols (kaempferol and quercetin derivatives) and hydroxycinnamic acids (cabbage) Hydroxycinnamic acids, flavonols and flavanones (tomatoes) Flavonoids, phenolic acids and capsaicinoids (pepper) Hydroxycinnamic acids and anthocyanins (eggplants) Hydroxycinnamic acids, flavones and flavonols (leafy greens) Flavonols such as quercetin (onions) Phenolic acids (roots)
Fruits	Anthocyanins, ellagitannins and proanthocyanidins (berries) Flavanone glycosides, polymethoxylated flavones and traces of flavonols and hydroxycinnamic acids (citrus fruits) Chlorogenic acids, anthocyanins, flavonols, catechins and proanthocyanidins (apples and drupes)
Hazelnuts	Catechins, proanthocyanidins, ellagitannins and ellagic acid
Legumes	Proanthocyanidins, flavonols, flavanones and hydroxycinnamic acids
Soy	Isofavonoids
Virgin or extra virgin olive oil	Tyrosols
Sesame oil	Lignans and phenolic acid
Aromatic plants	Phenolic acids, flavones, phenolic diterpenes and flavanones
Spices	Phenylpropenes, phenolic acids, flavones and flavonols

1-1-6- Water Intake

Water is essential for life. It comprises 75% of body weight in infants and 55% in the elderly, and is crucial for cellular homeostasis and life itself. The water content of a 70 kg adult is approximately 42 kg, or 60% of total body weight.

Water is the most indispensable of all nutrients: in a moderately warm environment, deprivation leads to death within 2 to 3 days. Humans may drink for various reasons, particularly for pleasure, but most consumption is due to water deficiency, which triggers what is known as regulatory or physiological thirst. Water is essential for metabolism, substrate transport across membranes, cellular homeostasis, temperature regulation, and circulatory function. Water intake has three main sources:

- Drinking water: on average 1 to 1.5 liters per 24 hours;
- Water contained in food: between 0.5 and 1 liter per 24 hours;
- Metabolic water or synthetic water: the oxidation of 1 g of carbohydrates produces 0.6 ml of water, that of 1 g of protein 0.4 ml, that of 1 g of lipids 1.07 ml. In total, approximately 120 ml per 1,000 calories metabolized, or 200 to 300 ml per 24 hours.

In fact, the proportion of water in body weight varies. It increases with the proportion of cell mass, which is 72% hydrated, and whose most variable sub-compartment is muscle mass; the amount of body water is therefore greater the more muscle a person has. It decreases with the proportion of adipose tissue, which is 10% hydrated. Therefore, the amount of body water is lower the more fat a person has. Adequate water intake values for different developmental stage groups (Table 12) were calculated based on three factors:

The observed intakes of European population groups, desirable urinary osmolality values, and desirable total water intake volumes per unit of dietary energy (kcal) consumed are shown. The water content of various foods is shown in Table 13. Water elimination via feces is approximately 100 ml per 24 h (except in cases of diarrhea), which represents only about 1% of the daily water flow through the digestive tract. During diarrhea, the water content of stool can reach 95%, and water losses can thus reach several liters. Urine output constitutes the most variable component of water loss.

Table 12: Comparison of recommended water intakes according to European and American health organizations

Life stages and sex	Age	European Food Safety Authority, Parma, Italy 2010 (ml/day)	National Academy of Medicine, United States 2004a (ml/day)
Infants	0-6 months	680 ml via milk	700
	6-12 months	800-1000	800
Children	1-2 years old	1100-1200	1300
	2-3 years old	1300	
	4-8 years old	1600	1700
	9-13 years old boys	2100	2400
	9-13 years old girls	1900	2100
	14-18 years old boys	2500	3300
	14-18 years old girls	2000	2300
Adults			
Men	≥ 19 years old	2500	3700
Woumen		2000	2700
Pregnant women	≥ 19 years old	2300	3000
Breastfeeding women		2600-2700	3800
Elderly people		Like adults	Like adults

[a] the values relate to total water consumption (pure water + drinks + moisture from food)

Table 13: Water content of different foods

Fruits		**Others**	
Avocado, banana, olive	70 à 75 %	Bread	35%
Apricot	75 à 80 %	Jam	33%
Lemon and melon	90 %	Rusk	6%
All other fruits	80 à 85 %	Chocolate	2%
Vegetables		Oil	0%
Potatoes, peas	75 %		
All other vegetables	between 90 and 95 %		
Meat	Approximately 60%		
Dairy products and eggs			
Cow's milk	87%		
Eggs	75%		
Camembert cheese	51%		
Emmental, Roquefort cheese	35%		
Butter	15%		

The water permeability of the collecting duct depends on the antidiuretic hormone. Urinary water excretion is partially independent of electrolyte excretion; the osmotic pressure of the final urine is, depending on the needs of the fluid balance, lower or higher than that of the plasma. Exhaled air is always saturated with water vapor at 37°C, resulting in an output of 0.05 g of water per liter of exhaled air. Therefore, thermoregulatory water losses can reach several liters per 24 hours.

Preventing dehydration requires ensuring a balance between fluid intake and losses. "Warning signs" should alert caregivers to the risk of dehydration: decreased fluid intake (altered mental status, difficulty swallowing, anorexia, or fear of incontinence) or increased losses (diarrhea, vomiting, hyperthermia, dyspnea). Three main types of dehydration are distinguished. Global dehydration, where the loss of water and sodium is proportional, is often caused by losses of digestive origin: diarrhea, vomiting, fistulas. In this type of dehydration, serum sodium levels are often only slightly affected.

Extracellular dehydration, where sodium loss is predominant and often caused by renal losses, can be induced by diuretics. It is often accompanied by hyponatremia. Intracellular dehydration, where water loss exceeds sodium loss, occurs in burns, heatstroke, and diabetes insipidus, if it is not compensated by sufficient oral hydration.

The diagnosis of dehydration is primarily clinical, based on several signs such as thirst and weight loss, which is a key indicator. Blood and urine electrolyte levels are valuable in diagnosing the type of dehydration and monitoring treatment. Dehydration is considered severe when it results in a weight loss of 10% or more of the initial weight. It constantly leads to a series of often severe disorders, including neuropsychiatric ones, which can lead to coma, and kidney failure which is initially functional but which, if the pathological state continues, can become organic.

It is at the extremes of age, in infants and the elderly, that dehydration most easily occurs and presents the most serious complications, particularly in infants, where there is a risk of neuropsychological sequelae if treatment is not administered quickly enough. Treatment is based on rehydration, most often administered intravenously. The quantities and proportions of water and sodium chloride to be given depend on the precise diagnosis of the type of dehydration and the estimated extent of fluid loss.

1-1-8- Micronutrients

Micronutrients, so named because the body only needs minute amounts of them, play a vital role in the production of enzymes, hormones, and other substances that help regulate growth, activity, development, and the function of the immune and reproductive systems. Adequate intake is especially important during early childhood and other periods of rapid growth, as well as during pregnancy and breastfeeding.

Micronutrients—also known as vitamins and minerals—are essential components of a quality diet and have profound effects on health. Although they are only needed in very small quantities, micronutrients are the building blocks indispensable for good brain, bone, and overall health. There are two main groups of vitamins: water-soluble vitamins, which are the B vitamins, and vitamin C.

The fat-soluble vitamins are vitamins A, D, E, and K. Regarding minerals and trace elements (Tables 14 and 15), only their daily quantitative requirements differentiate them. Minerals include calcium, sodium, magnesium, phosphorus, and potassium (requires several tens of milligrams). Trace elements include copper, zinc, fluorine, iodine, manganese, and selenium (requires less than 10-20 mg and measured in micrograms). Iron occupies an intermediate position (requires from a few milligrams up to 30 mg for pregnant women).

Micronutrient deficiencies are often referred to as "invisible hunger" because they develop gradually over time, their devastating impact only becoming apparent once irreversible damage has occurred. Although a child may sleep through the night with a full stomach, micronutrient deficiencies mean their body is constantly hungry for proper nutrition.

For pregnant women, a lack of essential vitamins and minerals can have catastrophic results, increasing the risk of low birth weight, congenital malformations, stillbirth, or even death. Deficiencies in calcium, vitamin D, and folic acid are particularly concerning during pregnancy and can lead to a number of complications for both the mother and the developing baby. Iron deficiency can cause anemia, with an increased risk of hemorrhage and bacterial infection during childbirth, and is linked to maternal deaths. Babies may be born prematurely and suffer from infections, learning disabilities, and developmental delays. Zinc deficiency weakens immune function and is associated with an increased risk of gastrointestinal infections. It is also a contributing factor in infant deaths from diarrhea.

Table 14: Minerals and Trace Elements: Roles and Common Dietary Sources

	Main roles	Sources
Calcium	– Bone metabolism – Nerve conduction – Neuromuscular excitability – Blood clotting	– Dairy products – Fruits, dried vegetables – Mineral waters
Copper	- Enzyme cofactor, immunity	– Dried vegetables – Crustaceans
Iron	– Hemoglobin and myoglobin – Component of cytochrome enzymes	- Meats, fish (heme iron - Fe++) – Dried vegetables, green vegetables (spinach, parsley) (non-heme iron - Fe+++)
Fluorine	Tooth decay prevention	– Mineral water – Tap water (in France) – Tea
Iodine	Thyroid hormones	– Seafood – Dried vegetables (beans, soybeans)
Magnesium	- Participates in metabolic reactions, energy production (stabilizes ATP) – Adaptation to stress – Neuromuscular excitability	–Vegetables and dried fruit – Cereals – Cocoa – Mineral water
Manganese	– Carbohydrate and lipid metabolism – Antioxidants	– Fruits and vegetables (depending on soil composition) – Tea
Phosphorus	– Bone metabolism	– Cheese, dairy products – Meat, eggs – Legumes – Oilseeds
Potassium	–Neuromuscular excitability – Protein and glycogen metabolism	– Dried fruits and vegetables – Fresh fruits and vegetables – Fish
Selenium	– Antioxidant (promotes the action of glutathione peroxidase and vitamin E)	– Meats, fish – Milk – Whole grains (concentration varies depending on soil content)
Zinc	– Metabolism of various nutrients and nucleic acids	– Seafood (especially oysters) – Meats (poultry, pork) – Whole grains

Table 15: Recommended intake of minerals and trace elements *(Chevallier, 2009)*

	Ca mg	P mg	Mg mg	Fe mg	Zn mg	Fe mg	F mg	I µg	Se µg	Cr µg
Children 1-3 years old	500	360	80	7	6	0,8	0.5	80	20	25
4-6 years old	700	450	130	7	7	1.0	0.8	90	30	35
7-9 years old	900	600	200	8	9	1.2	1.2	120	40	40
10-12 years old	1200	830	280	10	12	1.5	1.5	150	45	45
Teenagers 13-15 ans	1200	830	410	13	13	1.5	2	150	50	50
Teenage girls 13-15 ans	1200	800	370	16	10	1.5	2	150	50	50
Teenagers 16-19 ans	1200	830	410	13	13	1.5	2	150	50	50
Teenage girls 16-19 ans	1200	800	370	16	10	1.5	2	150	50	50
Men adults	900	750	420	9	12	2	2.5	150	60	65
Women adults	900	750	360	16	10	1.55	2	150	50	55
Men > 65 ans	1200	750	420	9	11	1.5	2.5	150	70	70
Woumen > 65 ans	1200	800	360	9	11	1.5	2	150	60	60
Pregnant Woumen 3rd trimestre	1000	800	400	30	14	2	2	200	60	60
Breastfeeding women	1000	850	390	10	19	2	2	200	60	55
Elderly people > 75 years old	1200	800	400	10	12	1.5	2	150	80	_

1-1-9- Vitamins

Vitamins are organic substances with no intrinsic energy value, acting in small doses. They are essential to the body because humans cannot synthesize them in sufficient quantities. Their absence in the diet leads, in the medium to long term, to the development of deficiency diseases. Vitamins constitute a very heterogeneous group of molecules in terms of their physicochemical characteristics, metabolism, and mode of action. While plants and auxotrophic microorganisms can produce all the vitamins they need, this is not the case for humans and animals, for whom the diet must provide these essential elements.

Vitamins are generally divided into two groups: fat-soluble vitamins and water-soluble vitamins. Fat-soluble vitamins are absorbed along with fats and, like fats, are stored in the body. Conversely, water-soluble vitamins (with the exception of vitamin B12) are not stored, and excess intake is eliminated in the urine. Vitamins can be identified by either a letter or their chemical name. The water-soluble vitamins are the B vitamins and vitamin C, while the fat-soluble vitamins are vitamins A, D, E, and K. Their role and main dietary sources are summarized in Table 16.

In 1981 and again in 1992, a group of French experts defined the optimal nutritional values for the French population. These were updated in 2001. If the recommended nutrient intakes (RNIs) were met, it could be considered that the needs for nutrients (carbohydrates, lipids, proteins) and micronutrients (vitamins, minerals, trace elements) would be covered for 97.5% of the population. Indeed, intake varies according to age: it is not the same for children and the elderly, for pregnant women and those who are not pregnant, etc. It is also adjusted according to physical activity: whether people are sedentary or participate in sports, occasionally or regularly, and according to social and medical contexts. The 2001 RNIs take these factors into account. Thus, recommended intakes were defined and are reproduced in Table 17.

Table 16: Vitamins: roles and common food sources

	Main roles	Essential sources
Vitamin A	Vitamin A (retinol) – Vision – Protection of epithelial cells – Growth, immunity Provitamin A (beta-carotene) – Antioxidants	– Butter, cheese – Eggs – Colorful fruits (melons, apricots, peaches, oranges…) – Colorful vegetables (carrots, tomatoes…) – Green vegetables (spinach, parsley…)
Vitamin B1 (Thiamine)	– Carbohydrate assimilation – Amino acid metabolism	– Meat (especially pork), fish, eggs – Legumes (lentils, beans, etc.) – Whole grains
Vitamin B2 (Riboflavin)	– Link in the respiratory chain – Energy metabolism – Purine and amino acid metabolism	– Dairy products (yogurt, cheese, milk) – Eggs – Meat, fish – Whole grains, legumes
Vitamin B3 (Niacin)	– Carbohydrate, lipid and protein metabolism	– Meats (especially poultry, rabbit) and fish (tuna, salmon) – Legumes (lentils, soybeans, peas, broad beans…) – Oilseeds (peanuts, hazelnuts, almonds…)
Vitamin B5 (Pantothenic acid)	– Essential component of coenzyme A – Cellular metabolism – Fatty acid metabolism, ketogenesis	– Meat and fish – Eggs – Whole grains, legumes – Fruits and vegetables
Vitamin B6 (Pyridoxine)	– Amino acid metabolism – Synthesis of neurotransmitters	– Cereals, legumes – Meats, fish – Eggs
Vitamin B8 (Biotin)	– Coenzyme of enzymes – Amino acid and fat metabolism – Gluconeogenesis	– Meats (poultry) – Fresh vegetables (cauliflower, etc.) – Legumes, mushrooms – Eggs
Vitamin B9 (Folic acid)	– Nucleotide synthesis – Protein synthesis – Erythrocyte maturation – Decrease in homocysteine levels	-Leafy green vegetables (salad, spinach, watercress, lamb's lettuce…)

Vitamin B12 (Cobalamin)	– Immunity – Erythrocyte synthesis – Decrease in homocysteinemia	-Fish -Meat - Eggs, dairy products (cheese, milk)
Vitamine C (ascorbic acid)	– Antioxidants – Collagen synthesis – Improved iron absorption – Immunity – Reduced sensitivity to certain allergens	– Red berries (blackcurrants, strawberries, redcurrants) –Citrus fruits (oranges, lemons, grapefruits…) –Kiwis, exotic fruits –Vegetables (cauliflower, cabbage…) –Green vegetables, parsley…
Vitamin D	– Increased calcium absorption – Bone mineralization – Growth	– Oily fish (sardines, mackerel, tuna, etc.) – Egg yolk – Dairy products (whole milk, butter, cheese) – (+ endogenous cutaneous synthesis)
Vitamin E	-Antioxydant : protects cell membranes	– Vegetable oils (sunflower, olive, soybean, rapeseed, peanut, corn)
Vitamin K	-Blood clotting	- - Cabbage (green cabbage, red cabbage, Brussels sprouts, cauliflower) - Broccoli - Leafy green vegetables (parsley, spinach, etc.) - (+ gut flora synthesis)

Two compounds generally considered vitamins can be synthesized in the body in sufficient quantities to meet your needs: vitamin D, synthesized from 7-dehydrocholesterol in the skin upon sun exposure, and niacin, synthesized from tryptophan, an essential amino acid. However, both were discovered following studies of deficiency diseases that constituted significant public health problems at the beginning of the 20th century: rickets (due to vitamin D deficiency and insufficient sun exposure) and pellagra (due to a deficiency in tryptophan and preformed niacin).

Etiological factors of deficiency: While a mismatch between needs and losses is a possible cause of subclinical and/or mild deficiency in the general population, micronutrient deficiencies are often the result of increased losses secondary to digestive disease leading to malabsorption. From a pathophysiological perspective, chronic gastritis with hypochlorhydria particularly affects the absorption of iron, calcium, vitamin B12, and folate. Pancreatic

insufficiency, in the case of overall malabsorption, can affect the absorption of fat-soluble vitamins.

Table 17: Recommended intake of vitamins

	C mg	**B1 mg**	**B2 mg**	**B3 mg**	**B5 mg**	**B6 mg**	**B8 µg**	**B9 µg**	**B12 µg**	**A µg**	**E mg**	**D µg**	**K µg**
Infants	50	0.2	0.4	3	3	0.3	6	70	0.5	350	4	20-25	5-10
Children													
1-3 years old	60	0.4	0.8	6	2.5	0.6	12	100	0,8	400	6	10	15
4-6 years old	75	6.5	1	8	3	0.8	20	150	1.1	450	7.5	5	20
7- 9 a years old	90	0.8	1.3	9	3.5	1	25	200	1.4	500	9	5	30
10-12 years old	100	1		10	4	1.3	35	250	1.9	550	11	5	40
Boys			1.4										
Girls			1.3										
Teenagers 13-15 years old	110	1.3	1.6	13	4.5	1.6	45	300	2.3	700	12	5	41
Teenage girls 13- 15 years old	110	1.3	1.6	14	5	1.5	50	300	2.4	500	12	5	45
Teenagers 16- 19 ans	110	1.3	1.6	14	5	1.8	50	330	2.4	800	12	5	65
Teenage girls 16- 19 ans	110	1.1	1.5	11	5	1.5	50	300	2.4	600	12	5	65
Adult Men	110	1.3	1.6	14	5	1.8	50	330	2.4	800	12	5	45
Adult Woumen	110	1.1	1.5	11	5	3.5	50	300	2.4	600	12	5	45
Pregnant Woumen 3rd trimester	120	1.8	1.6	16	5	2	50	400	2.6	700	12	10	45
Breastfeeding Woumen	130	1.8	1.6	16	5	2	50	400	2.6	700	12	10	45
Elderly people > 75 years old	120	1.2	1.6		5	2.2	60		2.3		20-50	10-15	30
H				14				330		700			
F				11				400		600			

Hepatobiliary and pancreatic diseases can, by disrupting enterohepatic circulation, cause a loss of micronutrients such as vitamin A, vitamin D, folate, and vitamin B12, which are excreted in bile. Villous atrophy, enterocolitis, and also the sequelae of medical and surgical treatments (inflammatory bowel disease, short bowel syndrome, blind loop syndrome,

radiation-induced small bowel disease) can also be responsible for a deficiency syndrome due to often multiple malabsorption of micronutrients.

Finally, one last element must be considered in the development of a deficiency. Tissue stores of micronutrients vary considerably depending on the type of micronutrients recommended, and these stores can be depleted in certain diseases. The liver is a predominant storage site for a large number of micronutrients, including vitamin A, B coenzymes, and iron. Thus, chronic liver diseases, particularly those caused by alcoholism, can be a contributing factor to deficiency due to reduced storage capacity. The time between the development of an intake/requirement deficit and the appearance of a clinical deficiency varies according to these tissue stores. It is generally accepted that deficiencies in water-soluble vitamins appear earlier than deficiencies in fat-soluble vitamins because their tissue stores are smaller.

The main deficiencies: Iodine deficiency is the leading cause of preventable brain damage in children. Its most devastating effects occur during fetal development and in the first few years of a child's life. Vitamin A deficiency affects approximately one-third of children living in low- and middle-income regions, primarily in sub-Saharan Africa and South Asia. Vitamin A deficiency weakens the immune system and increases the risk of a child contracting infections such as measles and diarrheal diseases, and of dying from them.

A folate deficiency leads to a slowing of mitosis, with, among other things, damage to blood cell lines, inducing macrocytic anemia, leukopenia, and thrombocytopenia. Folate plays a key role in organogenesis. Folate deficiency in pregnant women is thought to be linked to Neural Tube Defects (NTDs), which include:

- Encephalocele: protrusion of part of the brain from the skull.
- Anencephaly: absence of the skull and brain (cerebrum, cerebellum, and brainstem).
- Spina bifida: malformation of the spine, characterized by the failure of fusion of the posterior arches and spinous processes of one or more vertebrae, most often in the lumbosacral region.

An alteration in vitamin C status has been suggested in several pathologies such as cardiovascular diseases, cataracts, and cancers of the upper digestive tract and rectum, but remains controversial. Vitamin C is attributed with numerous pharmacological-type actions on immunity and plasma and cellular antioxidant status. It is thought to have a protective effect against lipids and an overall anti-stress effect. It has been proposed as an adjunctive

treatment for acne, psoriasis and smoker's bronchial metaplasia, although formal proof of its effectiveness in these indications has not been validated.

2- Food Composition Tables

Printed food composition tables were a traditional source of information on food composition; they are now being replaced by computerized databases from which the printed versions are usually produced. This information is widely used in the health, agriculture, and trade sectors. Food composition databases provide values for energy and nutrients (e.g., protein, vitamins, and minerals) and other important dietary components (e.g., fiber) for each of the listed foods. These values are based on chemical analyses performed in analytical laboratories or are estimated from other appropriate data.

Food composition data are essential for various purposes in many fields, such as assessing energy and nutrient intake in individuals or groups. They are also necessary to assess the effects of diet on health and disease progression and are therefore an essential prerequisite for epidemiological research. Ultimately, they contribute to the development of dietary guidelines for population groups and to menu planning for schools, hospitals, prisons, and the armed forces. They have even been used to plan food ration requirements for polar expeditions. The wide range of applications in a variety of other sectors includes clinical dietetics, sports nutrition, the food industry (product development and food labeling, for example), government food and health services (target setting), nutrition education, and health promotion. Knowledge of food composition is often a commercial advantage, as importing countries with regulated nutrition labeling prefer (and may require) that imported foodstuffs meet the standards set for local products.

Computerized databases offer several substantial advantages over paper-based composition tables: they can hold more information, and the data can be used much more easily for calculations. Information can also be presented quite readily in various formats to meet the needs of different users. This ease of calculation is particularly important for

nutritional epidemiologists, as they frequently work with very large numbers of subjects and numerous and varied records of food consumption.

CHAPTER II: MODIFICATIONS TO NUTRITIONAL INTAKE

1- Nutrition and Physical Activity

Nutrition, along with physical training, is a key factor in athletic performance. If the physical training load is significant, dietary modifications, based on recommended nutritional intakes, may sometimes be considered. These modifications have two main objectives: firstly, to ensure the replacement of macronutrients and micronutrients used during exercise (quantitative and qualitative compensation of energy expenditure), and secondly, to provide the necessary energy supplements (in the form of substrates) before, during, and after competition to optimize performance.

2- Energy Intake

The energy expenditure associated with sports activity depends on the nature and duration of the activity. Since the human body has virtually no energy reserves, the biochemical energy required for muscle contraction is produced on demand, particularly for efforts lasting more than two to three minutes, primarily through aerobic oxidation of substrates. For shorter periods of exertion, energy comes either from the mobilization of intramuscular energy reserves stored as ATP and phosphocreatine (depleted in 30 to 45 seconds), or from anaerobic lactic glycolysis for efforts lasting from 30 seconds to 2–3 minutes. In both cases, ATP is produced from the anaerobic or aerobic oxidation of glucose (Figure 03). Sports can thus be classified according to their duration and, indirectly, the energy systems that are utilized.

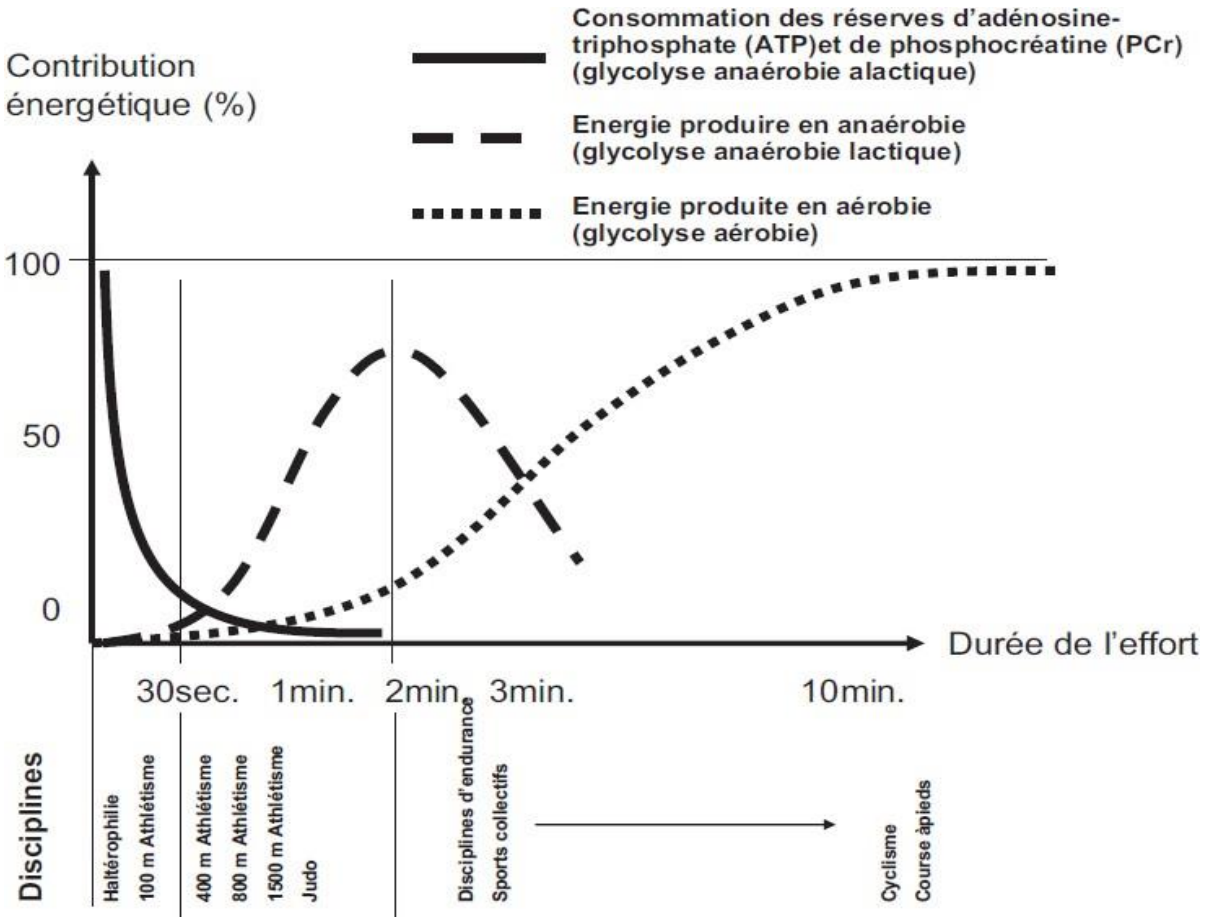

Fig. 03: Main energy sources as a function of the duration of the effort

When exertion lasts for several minutes, aerobic energy processes are primarily used. Numerous publications have assessed this energy expenditure according to the sport practiced. Figure 04 shows the approximate amounts of this energy expenditure according to the type of sport and its intensity (the data are expressed as maximum and minimum values for recreational and competitive activities, respectively). For a young man, this exercise-related expenditure adds to his daily energy expenditure, which is around 2500 kcal (35 to 40 kcal/kg/day) and can reach an additional 800–1200 kcal per hour of exercise. Training level also influences this energy expenditure; this is expressed as the energy cost of the activity, which is lower in athletes who have acquired good technical mastery of the sporting movement.

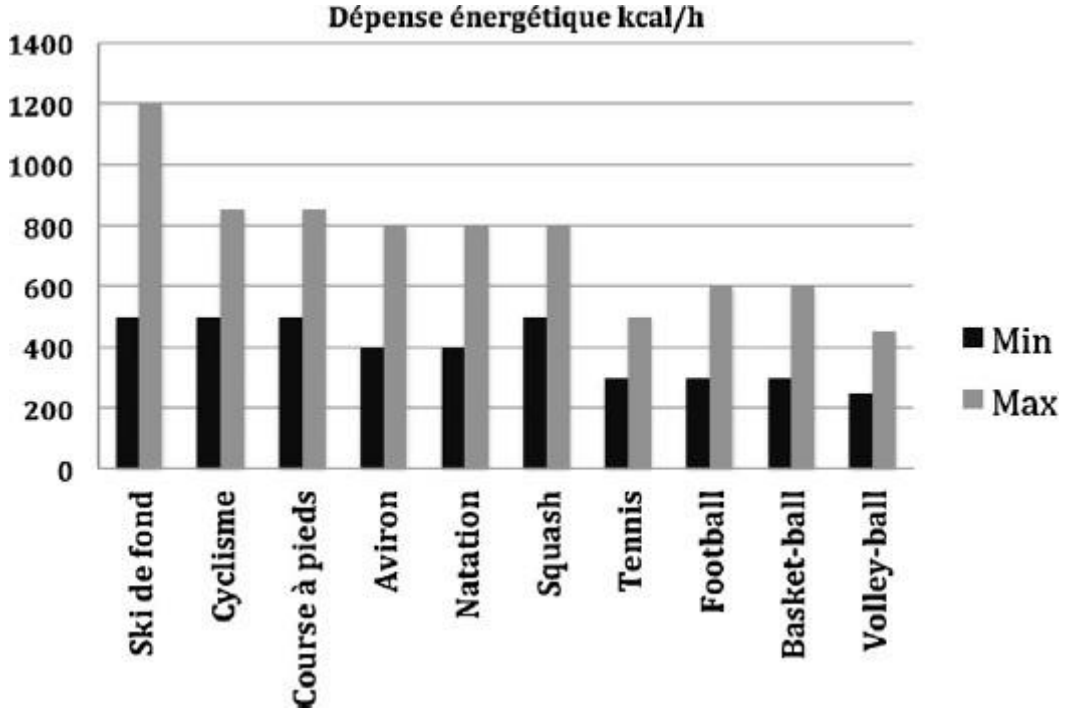

Fig. 04: Energy expenditure (in kcal/h) observed in different sports

The daily duration of training will increase this daily energy expenditure, which can reach up to 5,000–6,000 kcal for a professional cyclist during a typical Tour de France stage, and 3,000 to 5,000 kcal during a marathon, depending on the running speed. Finally, adverse environmental conditions can increase this energy expenditure (for example, exposure to cold can increase hourly expenditure by 100 to 200 kcal).

Overall, energy intake adapted to the level of expenditure is provided by a balanced and varied diet in the form of meals and snacks, with an increased carbohydrate intake. The needs for protein, vitamins, and minerals are met by increasing energy intake. Recommended intakes can therefore vary from 50 to 80 kcal/kg/day for men and from 40 to 60 kcal/kg/day for women. A runner with a training program of four to five sessions per week should consume at least 50 to 60 kcal/kg/day. Weight monitoring is a simple way to track this, with a maximum of one weigh-in per week, ideally done well away from training sessions and competitions, which can temporarily cause post-exercise inflammatory edema (fluid retention).

3- Carbohydrate Intake

Carbohydrates are the energy substrate for exercise. They replace muscle glycogen and maintain normal blood glucose levels, which are stored as glycogen. They constitute at least 55% of the energy intake and up to 70% in endurance sports. Muscle glycogen is used locally and cannot be resynthesized during exercise. Its depletion leads to local fatigue. Liver glycogen, which is fully usable, maintains blood glucose levels. Its depletion causes hypoglycemia. Total glycogen stores provide enough energy for 3 hours of exercise at 70% of maximum oxygen consumption. It is common practice to increase carbohydrate intake during the 3 days preceding a competition to achieve maximum muscle glycogen levels during the event. These are carbohydrates with a low or intermediate glycemic index, except during long-duration events where high-index carbohydrates are used (glucose, sucrose, maltodextrin, polyglucose or fructose solutions).

On a daily basis, an increase in carbohydrate intake is recommended, proportional to the training load, in the range of 5 to 11 g/kg/day (compared to the 4.5 g/kg/day recommended for sedentary individuals). This carbohydrate overload is offset by a slight decrease in the percentage of fat intake.

4- Proteins

Sustained physical activity leads to protein loss due to muscle micro-tears and oxidation during prolonged training or competition. It is therefore necessary to promote muscle protein synthesis (accretion) to achieve a positive protein balance after exercise. While the recommended protein intake meets the needs of recreational or occasional physical activity, it is advisable to prioritize high-biological-value proteins and increase the recommended intake (by 1.5 to 2 times) for elite athletes or bodybuilders by using dietary protein or protein powders. These proteins can be administered in spaced doses when dealing with "slow" proteins (by analogy with slow and fast carbohydrates) such as casein, or in close succession for "fast" proteins such as whey.

An elite endurance athlete requires a higher protein intake, closer to the upper limit of the aforementioned range (1.0 to 1.6 g/kg/day).

Strength/power training is thought to increase protein requirements more than endurance training, particularly at the beginning of training and/or when volume increases significantly. Recommendations for strength/power training typically range from 1.6 to 2.0 g/kg/day.

5- Lipid Intake

Fats play important physiological roles in the body. They are used to build phospholipids and glycolipids, which make up biological membranes; they are involved in the synthesis of hormones and intracellular messengers; and they represent energy molecules stored as triglycerides. Fat supplementation in athletes' diets has not shown any benefits on physical performance, unlike carbohydrates. However, many athletes tend to adopt diets low in fat (less than 25% of total energy intake), which limits the intake of essential fatty acids. To meet the needs for essential fatty acids, as well as fat-soluble vitamins, it has been recommended that athletes have a minimum lipid intake of between 1 and 1.2 g per kilogram of body weight per day, and their consumption is discouraged just before, during, and after competition.

Supplementing the diet with antioxidant nutrients has been proposed as a possible way to further reduce the harmful effects of exercise. Some studies suggest that high-dose vitamin A, C, and E supplementation may reduce the severity of muscle damage, measured by circulating concentrations of specific muscle proteins, but the evidence is not entirely conclusive, and more information is needed before any use.

Adding NaCl to the drink limits the decrease in plasma volume during exercise and prevents the onset of hyponatremia in endurance events. Sodium is the most important electrolyte due to its excretion in sweat (NaCl 20 to 60 mmol/L). A supplement of 1 to 1.5 g of NaCl per liter of drink is recommended, especially during the recovery phase, while avoiding the intake of salt in the form of tablets or capsules.

6- Hydration

Hydration is essential. Since muscles are composed of approximately 75% water, a 2% weight loss during exercise reduces physical performance by nearly 20%. Water is the best drink. Replenishing lost fluids during exercise helps maintain performance. Thirst is a poor indicator of dehydration and often occurs too late. Proper hydration helps maintain a near-constant weight during athletic activity. It prevents heatstroke and reduces the risk of muscle cramps. Before an event, it is advisable to drink fluids in small sips (300–500 ml over 2 hours), especially if weather conditions are conducive to sweating. During the event, the amount of water is adjusted to the anticipated fluid loss and can reach up to 1.5 liters per hour when the activity lasts longer than one hour. Beyond a duration of 3 hours, the needs are in the order of 0.5 to 1 l/h. After exercise, it is necessary to quickly restore the fluid deficit by providing an amount of drink compensating for 150% of the weight loss observed during the event.

CHAPTER III: NUTRITION AND PHYSIOLOGICAL STATES

Nutrition is the science of the exchange of matter and energy between the organism and its environment. Nutrition focuses on nutritional needs, which underlie this exchange, the conditions that these needs create, and the dietary process by which this exchange takes place. This is considered not only from the biological perspective of the human organism but also from the cultural perspective of the group, since human beings are generally immersed in the cultural framework of a given group. Nutritional needs depend on determining factors of expenditure, which are classified as follows:

– Basal energy expenditure;

– The thermic effect of food consumption or specific dynamic action;

– Energy expenditure from muscular activity;

– Energy expenditure from thermogenesis;

– Energy expenditure for growth, repair, and production.

Basal metabolism obviously involves energy consumption, like a car idling at rest. Basal metabolism represents the energy and chemical transformations that keep the organism alive at rest and maintain thermal comfort. It includes:

– Osmotic work to maintain chemical gradients, and the electrochemical work of the nervous system;

– The mechanical work of the heart, lungs, digestive tract, and resting muscle tension;

– The chemical work of the liver and kidneys, and the ongoing breakdown and synthesis of cellular and tissue compounds.

Within a species in general, basal metabolism depends primarily on the organism's mass, but also on age and sex.

1- Age

There is a decline in resting energy expenditure with age in men. This decrease is estimated at approximately 1 to 2% per decade, or 150 kcal between the second and ninth decades. This represents a loss of approximately 13 to 20% between the ages of 30 and 80. The most likely hypothesis is that the decline in resting energy expenditure is due to the loss of lean mass.

Given that reference intakes are intended for healthy individuals and considering the limited data available regarding specific needs related to aging, the nutrient recommendations for older adults are the same as for adults aged 19 to 50, with the exception of vitamins D, B6, B12, calcium, and iron.

Recommended dietary allowances (RDAs) do not differ for protein in older adults (0.8 g protein/kg body weight), although some suggest that intakes of up to 1.2 g protein/kg may protect against age-related sarcopenia. At a minimum, current RDAs should include high-quality meat or plant-based protein, as well as daily protein intake distributed as evenly as possible across meals.

Vitamin D requirements (a nutrient that plays a key role in maintaining calcium-phosphate balance and bone mineralization) increase to 800 IU per day (20 mg/day) in men and women over 70 years of age.

This is partly based on the fact that exposure to sunlight tends to decrease with age, vitamin D synthesis in the skin declines, as does its conversion into the active hormone form in the kidneys. The recommended intake of vitamin B6 (a coenzyme involved in the metabolism of amino acids, glycogen, and sphingoid bases) increases slightly at age 51 and older (men: 1.7 mg/day; women: 1.5 mg/day), as higher intakes are needed to maintain normal plasma levels. Recommendations for vitamin B_{12}, a nutrient essential for normal blood formation and neurological function, are the same for older men and women (i.e., 2.4 mg/day). However, since older people may have difficulty absorbing food-bound vitamin B_{12} due to decreased stomach acid (e.g., atrophic gastritis), adults aged 51 are advised to consume foods fortified with vitamin B or to take vitamin B_{12} supplements.

As mentioned previously, calcium is less efficiently absorbed with age. Therefore, the recommended daily intake is increased to 1,200 mg for women aged 51 and over and for men over 70. Finally, considering that menstruation ceases at menopause, the iron recommendation decreases to 8 mg/day for women aged 51 and over.

2- Sex

Per unit of body weight, adult men have a basal metabolic rate 12 to 20% higher than that of women. This is partly due to the fact that women have a greater proportion of adipose tissue than men. There is no satisfactory explanation for this.

3- Breastfeeding

Breast milk production varies considerably from woman to woman. Commonly cited values range from 750 to 850 ml/day. The energy value of breast milk varies widely depending on the ethnicity of the women studied. It also varies with the duration of breastfeeding. Nutritional composition tables provide values ranging from 67 kcal (280 kJ) to 75 kcal (313 kJ) per 100 ml. The cost of synthesis is calculated using a minimum synthesis efficiency factor of 80%. For example, if a woman produces 800 ml of milk per day, the energy value of the milk will represent at least 80% of the synthesis cost, from 536 kcal (2,240 kJ) to 600 kcal (2,508 kJ); the maximum synthesis cost will be from 670 kcal (2,800 kJ) to 750 kcal (3,135 kJ). Beyond any calculated assessment, it is known that breast milk production will cost at least the energy value contained in the milk itself.

The amount and quality of breast milk a woman produces do not depend on her weight, height, or nutritional status, although obese women sometimes have more difficulty breastfeeding. Macronutrient intake does not influence the composition of breast milk, but the mother's intake of fatty acids does affect its fatty acid content. The calcium, phosphorus, magnesium, sodium, and potassium content of breast milk is not determined by the mother's diet, but the content of several vitamins (A, D, thiamine, riboflavin, pyridoxine, and cobalamin), iodine, and selenium is linked to the mother's nutritional status and dietary intake. Breast milk must contain sufficient iodine to allow the newborn to build up optimal reserves of thyroid hormones and to prevent neurological developmental delays in breastfed infants.

4- Pregnancy

Pregnancy includes the growth of the fetus and placenta, as well as the growth and modification of maternal tissues, which obviously requires energy. It is generally accepted that a normal pregnancy involves an average weight gain of around 10 ± 2 kg, as well as an increase of approximately 20% in basal metabolic rate during the last trimester. Conventional estimates place the overall cost of pregnancy at 80,000 kcal (335,000 kJ), of which 36,000 kcal (151,000 kJ) represent the storage of approximately 4 kg of adipose tissue. It could be

deduced that during her pregnancy, a woman should increase her average daily intake by 300 kcal (1,250 kJ).

Many women have a deficiency in micronutrients (iron and vitamin A, for example); It is estimated that nearly half of all pregnant women worldwide suffer from anemia, and 9.8 million pregnant women suffer from night blindness.

An estimated 19.1 million pregnant women (with the highest proportion in Africa and Southeast Asia) have low serum retinol levels. Maternal micronutrient deficiencies can decrease birth weight and compromise the child's development and survival: maternal iodine deficiency is associated with birth defects and intellectual disability in children, and in India, a link has been established between vitamin B12 deficiency and an increased risk of diabetes. Insufficient intake of certain fatty acids, such as docosahexaenoic acid (DHA), can also hinder the child's development.

The risk of pregnancy complications, such as birth defects or preeclampsia, is higher in obese women. They have higher plasma glucose levels than women with a normal body mass index, and fetal insulin levels are also higher. Excessive weight gain during pregnancy is often observed in these women. Maternal nutrition is a fundamental determinant of fetal growth, birth weight and infant morbidity; poor nutrition often leads to irreversible long-term consequences for the fetus.

5-Weight

It has long been known that energy expenditure is proportional to weight. Thus, numerous equations have been established to calculate resting energy expenditure from weight. Lean mass determines energy expenditure much more accurately than weight. This is true for both 24-hour energy expenditure and basal metabolic rate. Despite this, most equations used to calculate basal metabolic rate or total energy expenditure are based on weight. There is still no satisfactory equation for estimating basal metabolic rate from lean mass.

In the latest version of the recommended nutrient intakes for the French population (2001), two equations are proposed to estimate basal metabolic rate from weight. These two equations have been validated:

Harris and Benedict equations:

Women's MB = 2.741 + 0.0402 P + 0.711 T – 0.0197 A

Men's MB = 0.276 + 0.0573 P + 2.073 T – 0.0285 A

Black's equations:

Women's MB = $0.963 \times P^{0.48} \times T^{0.50} \times A^{0.13}$

Men's MB = $1.083 \times P^{0.48} \times T^{0.50} \times A^{0.13}$

with MB in MJ/d, P = weight in kg, T = height in m, and A = age in years

6-Climats

The human body tries to maintain its temperature at around 37°C. Like other homeothermic organisms, it can find itself in a warmer or colder environment and will spontaneously transfer heat to the cooler environment. Furthermore, the body can overheat during physical exercise or infections, which necessitates cooling. Heat exchange occurs through the skin, by radiation (infrared radiation), conduction (transmission by contact), convection (exchange related to air movement), and vaporization (evaporation of water through perspiration).

When the body overheats or is in an environment warmer than itself, cooling it does not involve an energy cost but rather losses of water and minerals. Conversely, cooling the body in contact with a colder environment requires an energy expenditure of thermogenesis to maintain core body temperature. Thermogenesis, implemented by muscular exercise, shivering or the burning of brown adipose tissue, begins from a "lower critical temperature" of the environment.

In a healthy, naked, fasting adult male, the lower critical temperature is approximately 28°C. After a substantial meal, it drops to around 22°C, and if he dresses lightly, it falls further to around 18°C. Infants have a proportionally much larger body surface area than adults. They therefore lose heat much more rapidly, and their lower critical temperature is 33°C. Furthermore, young children are much less mobile than adults and cannot shiver until they are 18 to 24 months old; therefore, cold poses a very serious danger to them.

From a quantitative perspective, the energy cost of thermogenesis can be enormous, representing up to 3 to 4 times the basal metabolic rate. For example, a 65 kg man, lightly dressed and motionless, placed in a 15°C environment free from drafts, must expend approximately 750 kcal (3,135 kJ) per day to maintain his temperature, which corresponds to a 45% increase in his basal metabolic rate. Furthermore, the cost is even greater when

conduction is high: sleeping on the bare ground or in contact with water (clothing wet from inclement weather, shipwreck). Generally speaking, it is estimated that, in the range between 20°C and 28°C, the basal metabolic rate increases by 30 kcal (125 kJ) per day for every 1°C decrease in ambient temperature below the lower critical temperature.

7- Other Physiological States

Repair occurs when an individual has lost part of their body mass due to illness, injury, or insufficient food intake to maintain a normal weight.

"Nutritional recovery" or "catch-up growth" are the terms usually used to describe the repair process that follows malnutrition. The cost of catch-up growth varies depending on the composition of the synthesized tissue and the efficiency of synthesis. On average, the energy cost of nutritional recovery is around 5 kcal/g (21 kJ/g) of synthesized tissue. This cost is very significant and will considerably increase the daily energy requirement for satisfactory nutritional recovery.

Catch-up rates exceeding 20 g/kg of body mass per day are observed, representing a cost of at least 100 kcal (418 kJ)/kg/day. Given that the maintenance requirement is 100 kcal (418 kJ)/kg for a malnourished 3-year-old girl weighing 11 kg, this maintenance intake would need to be doubled for her to reach the catch-up rate of 20 g/kg/day. In a malnourished adult, the cost is proportionally even greater. The maintenance intake would need to be tripled to reach this catch-up rate.

The maintenance requirement corresponds to the minimum energy needed to stay alive when one is not doing anything special. This is the downtime between sleep and work, leisure activities, or household chores. The maintenance requirement is directly and primarily linked to the basal metabolic rate. The estimate is 1.5 times the basal metabolic rate. A FAO/WHO/UNU expert committee speaks of residual energy requirement, which corresponds roughly to the idea of maintenance energy requirement, and estimates it at 1.4 x the basal metabolic rate.

CHAPTER IV: ARTIFICIAL NUTRITION

1- Definition

Artificial nutrition is indicated when a patient cannot or will not eat enough to meet their energy and protein needs, and after other methods (fortified diets, oral supplementation) have failed. If the digestive tract is functional and accessible, it is logical to use it, and enteral nutrition (EN) is preferred. If the digestive tract is non-functional and/or inaccessible, parenteral nutrition (PN) will be chosen. EN is necessary, particularly for hospitalized patients. The first condition for offering EN to a patient requiring nutritional support is that their digestive tract be healthy and accessible. In reality, EN is increasingly used in extreme situations where the digestive tract is already impaired but still capable of absorbing the delivered nutrients. In practice, only severe anatomical (short bowel) or functional (severe villous atrophy) malabsorption and intestinal obstructions are contraindications to EN. Parenteral nutrition (PN) should be used in cases of severe malabsorption, chronic intestinal obstruction and/or failure of enteral nutrition.

2- An Approach to Malnutrition

Malnutrition is a pernicious and very common disease. Its pernicious nature stems from the fact that it is often considered a symptom accompanying a pre-existing acute or chronic condition. Its high prevalence has been evident for several decades, and there is no indication that it is decreasing. Thirty to forty percent of hospitalized patients in Europe are malnourished.

The definition that could be adopted is that of "the state of an organism in nutritional imbalance," the imbalance being characterized by a negative energy and/or protein balance. This definition therefore implies that there are three pathophysiological mechanisms that can lead to malnutrition: an isolated deficit in intake, an increase in daily energy expenditure, and an increase in losses (glycosuria is a good example), with, of course, the possible combination of two or three of these mechanisms. The imbalance inherent in undernutrition leads to deleterious effects on tissues and/or the entire organism, with measurable changes in bodily functions and/or body composition, associated with a worsening of disease prognosis.

3- Body Fat Assessment

Body Mass Index: The Quetelet index, also known as the body mass index (BMI), is calculated by dividing weight (in kilograms) by the square of height (in meters): BMI = W(kg)/H(m)². Adopted by the WHO to define nutritional status (obesity and malnutrition), it remains the most widely used index. BMI is well correlated with body fat at the population group level. However, at the individual level, there are significant variations in body fat for a given BMI value. It is therefore crucial to emphasize that BMI is insufficient for estimating body composition at the individual level, particularly in very muscular individuals (strength athletes), in cases of fluid retention, or in cases of significant weight loss with a lean mass deficit in obese individuals.

The table 18 below shows the classification of overweight and obesity based on BMI. Obesity is defined as a BMI ≥ 30.0. This classification is consistent with that recommended by the WHO, but includes an additional subdivision for BMIs between 35.0 and 39.9, to account for the fact that the management options for obesity are not the same for a BMI over 35. The WHO classification is primarily based on the association between BMI and mortality.

Table 18: Classification of adults based on BMI

Classification	BMI	Associated morbidity risk
Underweight	<18.50	Low (but increased risk of other clinical problems)
Normal fan	18.50–24.99	Average
Overweight:	≥25,00	
Preobese	25.00–29.99	Increased
Obese, Classe I	30.00–34.99	Moderate
Obese, Class II	35.00–39.99	Important
Obese, Class III	≥40.00	Very important

Waist circumference: Waist circumference is the second most commonly used anthropometric indicator. It is measured with a tape measure at the midline between the lower costal margin and the anterior superior iliac spine on the midaxillary line, at the end of a normal exhalation and without applying pressure to the skin. Waist circumference is well correlated with visceral adiposity, the role of which in the development of cardiovascular events, type 2 diabetes, and, more recently, certain cancers is now well established. Threshold values have

been used to assess the proportion of people with excessively large waist circumferences. In European adults, waist circumferences greater than 80 cm and 94 cm, respectively for women and men, are associated with a moderate risk of metabolic complications related to abdominal obesity.

Values above 88 cm and 102 cm, respectively for women and men, indicate a high risk of metabolic complications. In children and adolescents, there is currently no consensus regarding the threshold values to use to identify individuals at risk of metabolic complications related to abdominal obesity.

Waist-to-height ratio: The ratio between an individual's waist circumference and height has the advantage of minimizing errors in risk assessment for individuals with the same waist circumference but different heights; it thus allows for consideration of differences in age and sex, as these two factors influence height. From a practical standpoint, this ratio offers the advantage of using a single threshold value regardless of age, sex, and ethnic group. A threshold value of 0.5 has therefore been identified as indicating an initial level of risk associated with abdominal obesity.

The skinfold method: The skinfold method is based on the assumption that the sites chosen for this measurement represent the average thickness of subcutaneous adipose tissue and that this reflects a constant proportion of total fat mass. The measurement is performed with a special caliper (Harpenden-type skinfold caliper) that applies a standardized pressure (10 g/mm²) regardless of the thickness of the pinched skin. Four skinfolds are frequently measured: the triceps skinfold (mid-arm at the level of the triceps bulge), the biceps skinfold (mid-arm at the level of the biceps bulge), the subscapular skinfold (1 cm below the inferior angle of the scapula), and the suprailiac skinfold (1 cm above the iliac crest). From the sum of these four skin folds, tables allow us to determine the subject's fat mass, taking into account age and sex.

Densitometry by plethysmography: This technique, much more recently developed than the previous one, is based on Boyle's Law, according to which the product of pressure × volume is a constant. When an object (body) is introduced into a chamber (cabin) of known volume, the pressure regime of this chamber is modified in proportion to the volume introduced. Knowing the body volume, we deduce the body density as above, and knowing the body density, we calculate the subject's percentage of body fat (two-compartment model). The method can be performed using either measured or predicted respiratory volumes. Indeed,

body volume is calculated by taking into account the subject's lung volume, temperature changes in the chamber, and the subject's body surface area according to the equation:

volume corporel = volume total mesuré (L) + 0,4 volume gazeux thoracique (L) – SAA

(SAA : formule de prédiction de la surface corporelle dans des conditions isothermiques, tenant compte du poids et de la taille du sujet).

This is an interesting technique when predicted lung volumes are used: body volume can be measured in a few minutes non-invasively and with limited cooperation.

However, the cost of the equipment and the need to maintain stable environmental conditions (room temperature) can limit its use.

Hydrostatic densitometry: Hydrostatic densitometry (or weighing in water), used for over 40 years in nutritional physiology, relies on Archimedes' principle to estimate body density. The subject is briefly fully immersed in a tank of water, and body volume is determined from the volume of water displaced. Body density corresponds to body mass (weight) divided by body volume.

Residual lung volume (measured using a dilution technique, e.g., helium) and intestinal gas volume (most often arbitrarily estimated at 100 mL) are also taken into account. Various equations then allow the calculation of fat mass as a percentage of body weight, and by subtraction, lean mass (two-compartment model), based on body density.

4- Lean Mass Assessment

Dual-energy X-ray absorptiometry (DEXA): Initially used to quantify bone density, particularly in relation to menopause, this radiological technique has also been used since the late 1980s to assess body composition. It is currently considered one of the gold standard techniques, especially in obese individuals. The method involves scanning the entire body with a two-energy X-ray beam.

As the beam passes through tissues, its attenuation depends on the composition of the material it traverses. The scan of the area to be examined is performed point by point, and measuring the attenuation of the two beams allows for the creation of a digital image in which each elementary surface (pixel) carries information. The use of two different energy levels first allows for the separation of bone calcium mass from soft tissues, and then for the differentiation of fat mass and lean mass within the soft tissues. Patient cooperation is limited to remaining lying on an examination table for five to ten minutes. The accuracy of DEXA is

recognized as excellent, and this method allows for segmental analysis of body composition (trunk, limbs). Lean mass in the lower limbs, in particular, is considered to reflect total skeletal muscle mass.

Bioelectrical impedance analysis: This is a rapidly expanding method for analyzing body composition, with new models regularly appearing on the market. Impedance corresponds to the resistance offered by a tissue (biological conductor) to the passage of a low-intensity alternating current. A body's impedance is a function of its water content. In the human body, lean body mass, due to the electrolytes dissolved in water, is a good conductor of electricity compared to fat mass. The principle is therefore to measure body water and deduce the amount of lean mass, assuming a constant hydration factor (generally 73%, hence:
lean mass = total body water / 0.73). Fat mass is obtained by subtracting it from weight.
In practice, a low-intensity current at an average frequency of 50 kHz, designed to penetrate the entire body water, is most often applied via superficial ECG-type electrodes attached to the skin (for example, on one hand and the opposite foot) or via metal insoles onto which the subject's feet are placed (bioelectrical impedance analysis or foot-to-foot bioelectrical impedance analysis).

Dilution methods: Based on the estimation of total body water, lean mass is assessed according to assumptions about the constancy of body hydration. Urine, saliva, or plasma samples are collected within hours of administering a known dose of a tracer (deuterium- or oxygen-18-labeled water for total body water measurement, bromine for extracellular water).

The reliability and accuracy of this method allow it to be used for calibrating other methods, particularly bioelectrical impedance analysis (BIA). However, the cost of tracers is often high. This limits the application of these methods to studies with small numbers of subjects. It should also be noted that there is no tracer available to measure intracellular water.

Imaging methods: Computed tomography (CT) and magnetic resonance imaging (MRI) refer to the anatomical model (Table 19). Cross-sectional images allow differentiation between deep and superficial adipose tissue, particularly in the abdominal area (visceral abdominal fat). Spiral CT scans allow reconstruction of the volume of adipose tissue throughout the body or in specific compartments. MRI offers the same type of approach without radiation.

The precision, the ability to distinguish between subcutaneous and visceral adipose tissue, and the capacity to analyze tissue composition (e.g., muscle lipid content) make these techniques

particularly valuable. These methods require minimal cooperation from the subject. However, the radiation exposure for CT scans, the slow image acquisition time, the greater scarcity and cost of MRI equipment, and certain difficulties in accessing these two types of equipment in hospitals for body composition measurements are the major limitations of these methods.

Table 19: Advantages and disadvantages of the main methods of measuring body composition

Method	Initial evaluation criterion	Advantages	Disadvantages
Anthropometric measurements	Weight, height, circumferences and folds	Simple, quick, reproducible, very inexpensive	Difficulties in performing the measurement in obese subjects and in the presence of edema; interobserver variability in measurement (for skin folds)
Hydrostatic densitometry	Total body volume, density, fat mass	Reliable, reproducible	Heavy and bulky equipment, difficult examination in obese patients, children, elderly subjects
Densitometry by plethysmography	Total body volume, density, fat mass	Fast, precise	Unproven reliability in severely obese patients
Dual-energy X-ray absorptiometry (DEXA)	Fat mass, lean mass, bone calcium mass (measurements globales et régionales)	Simple, reliable, precise	Expensive equipment, specialized technicians, Irradiation
Bioelectrical impedance analysis	Total body water, intracellular and extracellular water, lean mass	Inexpensive, portable, simple, non-invasive and fast	Reliability not proven in severely obese patients and during weight changes
Dilution methods	Total body water, lean mass	Reliability, precision	Costly, complex analyses
Imaging methods (CT scan, MRI)	Fat mass, muscle mass, muscle and liver lipid content (global and regional measurements)	Reliability, precision	Expensive, difficult access to facilities

CHAPTER V: DISEASES OF MALNUTRITION

1-Definition

Malnutrition encompasses deficiency malnutrition (most often leading to weight loss), excess malnutrition (overweight and obesity), and malnutrition characterized by specific deficiencies. Malnutrition plays a role in at least half of all child deaths worldwide, more than any infectious disease, yet it is not an infection.

Malnutrition is not simply a matter of satisfying appetite: a child who eats enough to satisfy their immediate hunger can still be malnourished. Furthermore, malnutrition is a largely invisible emergency. Three-quarters of children who die from malnutrition-related causes suffer from moderate or mild forms, which are not accompanied by any outward signs.

Child malnutrition is not confined to the developing world. In some industrialized countries, widening income disparities and the accompanying decline in social benefits are having alarming effects on children's nutritional well-being.

Malnutrition can manifest in various forms that interact and interact, such as protein-energy malnutrition and micronutrient deficiencies. These micronutrients are so named because these elements (such as iodine, iron, and vitamin A) are essential to the body, but only in minute quantities. Fundamentally, malnutrition is a consequence of illness and inadequate food intake, but many other factors also play a role. Discrimination and violence against women are major causes of malnutrition.

Protein-energy malnutrition (PEM), also known as protein-calorie malnutrition, is the most serious nutritional problem facing Africa and other developing regions. Its two main clinical forms are kwashiorkor and marasmus. In the first case, it is primarily a protein deficiency, and in the second, an energy (calorie) deficiency.

2- Marasmus

This is another serious form of protein-energy malnutrition. While kwashiorkor is primarily caused by a protein deficiency, marasmus is mainly due to a lack of food and, consequently, energy. It can occur at any age up to about three and a half years old, but unlike kwashiorkor, it is most common during the first year. It is, in fact, a form of starvation that can have many causes. For one reason or another, the child is not receiving sufficient amounts of breast milk or other suitable food. However, the most common cause is the early cessation of

breastfeeding, sometimes due to the mother's death, the cessation of milk production, separation of mother and infant (due to family problems, the mother's work, etc.), or the mother's desire to bottle-feed rather than breastfeed.

The illness: Growth arrest is always observed. If the child's age is known, their weight will be significantly below average (less than 60%). In severe cases, weight loss is evident, the ribs are prominent, the abdomen is sometimes protruding, the face has a characteristic simian appearance, and the limbs are very emaciated. The child is "skin and bones." The muscles are always extremely atrophied.

The most significant causes of marasmus are childhood infectious and parasitic diseases, including measles, whooping cough, diarrhea, malaria, and other parasitic infections. Chronic infections such as tuberculosis can also cause marasmus. Other common causes of marasmus include prematurity, mental deficiency, and digestive disorders (malabsorption, vomiting, etc...).

If a little subcutaneous fat remains, it is very thin. If you pinch the sagging, wrinkled skin between your thumb and forefinger (especially around the buttocks and thighs), you will notice the absence of the normal layer of adipose tissue. Most children with marasmus are not lethargic like those with kwashiorkor. On the contrary, their deep-set eyes appear quite alert. Similarly, the child is less irritable and less sad. The child generally has a good appetite. In fact, like any hungry creature, they can be voracious.

Treatment: It is similar to that for kwashiorkor. However, it is essential to ensure the patient receives adequate calories. Determining the underlying cause of the illness is crucial. If it is infectious diarrhea, dehydration may require specialized treatment with intravenous fluids or via a gastric tube, but using a much more diluted solution than in the case of kwashiorkor. If a vein cannot be accessed, fluids can be injected into the peritoneal cavity. Simultaneously, sulfonamides or tetracycline should be administered orally.

Once the diarrhea has stopped, a high-energy diet is necessary. The use of vegetable oil with skimmed milk powder is even more important here than in cases of kwashiorkor, as it ensures a high energy intake. It is advisable to test for tuberculosis. If there is any doubt, a tuberculin skin test should be performed, and if the result is positive, a chest X-ray should be taken.

Prognosis: The cause and severity of the illness determine the prognosis. A child with severe marasmus and lungs heavily affected by tuberculosis obviously has a low chance of survival. On the other hand, a child without an infectious disease and with only mild marasmus has a better outlook. In all cases, the response to treatment will likely be slower than in kwashiorkor. Once the child has recovered, it is often difficult to know what to do next, especially if they are under one year old. They may no longer have a mother, or she may be ill, and her milk will undoubtedly be insufficient. It is essential that their diet provides adequate calories and protein. Generally, 120 calories and 3 grams of protein per kilogram of body weight per day are sufficient for long-term treatment. Thus, a child weighing 10 kg would receive 1200 calories and 30 grams of protein per day. It should be noted that a child who has suffered from marasmus may be able, at the beginning of their recovery, to consume and utilize 150 to 200 calories and 4 to 5 grams of protein per kilogram of body weight.

3- Kwashiorkor

In the severe form of protein-energy malnutrition known as kwashiorkor, the diet may be sufficient to satisfy hunger, but it is generally very deficient in protein and energy. It therefore almost always consists primarily of carbohydrates, and in quantities too small to meet the child's needs. This condition is often also linked to an infectious disease. Kwashiorkor most often affects children between one and three years of age, after weaning. As long as they receive adequate amounts of breast milk, they usually benefit from a good quality protein intake that contains all the essential amino acids for health and growth.

Other diseases can also play a significant role in precipitating the onset of overt kwashiorkor in already malnourished children. The most important are gastrointestinal infections that cause diarrhea, which can impair normal absorption, and sometimes also vomiting, leading to food loss.

Intestinal worms and other parasites can be significant agents, and measles, pertussis (whooping cough), and various other infectious diseases are also known to be frequent immediate causes of kwashiorkor. Almost all infectious diseases result in increased nitrogen loss, which can only be compensated for by increasing protein intake.

The disease: Growth arrest is a constant feature. If the child's exact age is known, their height will be below normal. Muscle atrophy is also typical, but it can be masked by edema. Edema, which causes swelling due to fluid retention in the tissues, is a consistent sign. Usually, it is the feet that start to swell, then the legs, and eventually the hands, scrotum and face.

To detect the presence of edema, the doctor presses the skin above the ankle with their index finger or thumb. If edema is present, the resulting depression disappears only after a few seconds. The hair also loses its shine, becoming dull and brittle, and its color turns brown or reddish-brown. Small clumps can be easily pulled out with virtually no pain. If one of these hairs is examined under a microscope, the root is found to be damaged and the diameter smaller than that of a normal hair. The child's skin, particularly on the face, may be lighter in color than that of their parents. Sometimes, a dermatosis occurs in areas of pressure or friction, for example, in the groin, on the backs of the knees, and on the elbows.

Darker patches appear that may peel or flake off, much like old, sun-baked paint. Stools are often soft and contain particles of undigested food. They are sometimes foul-smelling, liquid, or bloody. Anemia may be aggravated by iron deficiency, malaria, hookworm, etc. The cheeks are swollen, either from fatty tissue or fluid from edema, and have the characteristic appearance known as a "moon face." This sign occurs in children who are quite emaciated and have mild edema. The cause is unknown. Serum protein levels are low, with the albumin fraction being more affected than the globulin fraction. Serum amylase is decreased. Analysis of duodenal juice reveals reduced pancreatic enzyme activity.

Treatment:

Hospitalization: All severely ill children should, if possible, be admitted to the hospital with their mother and carefully examined for any possible infection. A complete clinical examination will be performed, with particular attention paid to respiratory infections such as pneumonia or tuberculosis. Stool, urine, and blood samples (hemoglobin levels, malaria parasites) will be analyzed, and the child will be weighed and measured.

Diet: Skimmed milk powder often forms the basis of treatment. The simplest way to prepare this milk in the hospital is to mix one teaspoon of powder with 25 ml of boiled water. The child should receive 150 ml of this preparation per kg of body weight daily, divided into six meals approximately four hours apart. If the child has a good appetite, can cooperate, and feels well enough, this mixture can be given by bowl or spoon. Otherwise, it is best administered via a feeding tube. A good, easy-to-remember formula for the sugar-casein-oil-milk preparation is: 1 part sugar, 1 part casein, 1 part oil, and 1 part skimmed milk powder, to which water is added to make 20 parts.

Examples of therapeutic diets:

Child weighing 5 kg, on a skimmed milk powder diet:

5 x 150 ml/day = 750 ml/day.

Preparation administered in six meals (one every four hours) = 125 ml/meal.

The liquid mixture is made by adding 5 teaspoons of skimmed milk powder to 125 ml of water.

Child weighing 5 kg, on a sugar-casein-oil-milk diet:

5 x 150 ml/day = 750 ml/day = 125 ml/meal.

The liquid mixture is obtained by adding 5 teaspoons of the dry mix to 125 ml of boiled water.

- **Medication**

In all severe cases of kwashiorkor, it is important to administer penicillin or another antibiotic (e.g., penicillin benetamine) by intramuscular injection, at a dose of 500,000 units per day for five days. In malaria-endemic areas, it is advisable to administer a synthetic antimalarial, for example, half a tablet (125 mg) of chloroquine daily for three days, then half a tablet per week. In severe cases, and when vomiting is present, administer chloroquine by injection. It is beneficial to administer potassium in cases of dehydration, as it helps correct electrolyte imbalances; for example, 0.5 g of potassium chloride diluted in water (approximately three teaspoons), three times a day.

If the anemia is very severe, it will be treated with blood transfusions and iron preparations administered intramuscularly at a dose of 1 ml daily for five days. If a stool examination reveals the presence of hookworms, roundworms, or other intestinal parasites, an anthelmintic will be given as soon as the child's general condition begins to improve. If vomiting persists, smaller, more frequent feedings will be necessary. With the above regimen, a severe case of kwashiorkor should, between the third and seventh day, begin to lose its edema.

4- Vitamin Deficiencies

In developing countries, the most common causes of vitamin deficiencies are states of malnutrition, where deficiencies are generally multiple. A deficiency is defined as the absence or insufficiency of a substance necessary for the growth and balance of an organism.

Specific Vitamin Deficiency Syndromes:

- Vitamin A Deficiency:

Vitamin A plays a crucial role in maintaining epithelial integrity and in cell differentiation. Vitamin A deficiency manifests primarily through ocular symptoms: night blindness (diminished or lost vision in the dark) and xerophthalmia (decreased corneal transparency), and sometimes keratomalacia and blindness. In cases of xerophthalmia, rapid administration of large amounts of vitamin A is essential. Oral administration is preferred because it is safe, inexpensive, and highly effective. One 110 mg dose of retinyl palmitate or 66 mg of retinyl acetate (200,000 IU of vitamin A) is administered orally immediately. The diagnosis and dose are repeated the following day. A further dose is usually given 1 to 4 weeks later, in the hope of replenishing hepatic stores.

Indeed, children with severe protein-energy deficiency do not tolerate a massive dose well; therefore, it is essential that they be closely monitored and receive additional doses as needed, generally every 4 weeks, until their protein status improves. In the rare cases where children are unable to swallow (as sometimes occurs in stomatitis accompanying severe measles), in cases of persistent vomiting, or in malabsorption syndromes (e.g., cystic fibrosis), which prevent adequate absorption of vitamin A, an intramuscular injection of 55 mg (100,000 IU) of water-miscible retinyl palmitate should be substituted for the first oral dose.

For children aged 6 to 11 months, intramuscular and oral doses should be halved; infants under 6 months should receive one-quarter of the normal dose. Very high doses of vitamin A can be teratogenic, particularly in early pregnancy, and therefore the treatment of xerophthalmia in women of childbearing age requires a modification of the standard dose. For the treatment of night blindness or Bitot's spots, 55 mg of retinyl palmitate (10,000 IU of vitamin A) should be administered daily for at least two weeks.

- Vitamin D deficiency:

Vitamin D deficiency results in rickets in children, osteomalacia (a condition characterized by bone softening) in adults, and, at any age and under certain circumstances, tetany. Osteomalacia causes bone pain in the pelvis, thorax, and spine, of a mechanical nature. It

appears on X-rays as increased bone transparency. A risk has also been suggested by some of developing a number of pathologies in the presence of a vitamin D deficiency, such as cancer, multiple sclerosis, rheumatoid arthritis, osteoarthritis, type 1 diabetes in children, high blood pressure, schizophrenia, and depression.

- Vitamin B1:

Deficiency is primarily manifested as beriberi. In "dry" beriberi, neurological involvement is predominant. It is both peripheral and central, reflecting the presence of neuronal metabolic abnormalities and neurotransmission disorders. Central neurological involvement is observed in severe cases and manifests as memory impairment, irritability, sleep disturbances, Wernicke's encephalopathy, or Korsakoff's syndrome. Symptom improvement usually occurs without sequelae after supplementation, except in Korsakoff's syndrome, which can be irreversible. "Wet" beriberi is characterized by a predominantly non-obstructive cardiomyopathy with progressive worsening. Tachycardia, chest pain, and hypotension dominate the initial presentation. In the final stages, congestive heart failure develops, which can progress to collapse and death.

- Vitamin B2:

Deficiency, or ariboflavinosis, causes eye problems (decreased visual acuity, photophobia due to abnormal sensitivity to light) and mucocutaneous lesions (chapped lips).

- Vitamin B3:

Deficiency, or PP deficiency, causes pellagra. Gastrointestinal symptoms are prominent and reflect diffuse mucosal atrophy. Patients typically present with gastritis and achlorhydria, an increasingly severe malabsorption syndrome leading to cachexia and watery diarrhea, sometimes with blood and mucus in the stool. Dermatitis usually appears later. It is a bullous erythroedema that can progress to septation, rupture, ulceration, or drying out with the formation of hemorrhagic crusts and fissures after about three weeks.

The lesions can affect the entire body but are selectively located in areas exposed to the sun and heat, such as the backs of the hands, the face and neck, as well as areas of friction and pressure.

- Vitamin B9

Deficiency: Folate (folic acid) is a B vitamin involved in the formation of red blood cells. It also regulates the development of nerve cells during the embryonic and fetal stages and helps prevent the development of serious spinal cord and brain abnormalities. Folate deficiency causes birth defects in the fetus from the first weeks of pregnancy—often even before women know they are pregnant.

It is also associated with a high risk of prematurity and low birth weight. It is a risk factor for anemia, particularly in pregnant or breastfeeding women, and may be associated with an increased risk of maternal morbidity and mortality.

- Vitamin B12

Deficiency does not exist as a distinct condition, but a disorder called pernicious anemia (Biermer's disease) is characterized by the inability to absorb vitamin B12 due to damage to the gastric mucosa.

Confirmed vitamin C deficiency leads to scurvy and, in infants, Barlow's disease. Scurvy manifests with a multitude of clinical signs, dominated by the following:

i) Arthralgia of the large joints, osteoarthritis, and/or myalgia, occurring in a context of asthenia and weight loss;

ii) A hemorrhagic syndrome with purpura centered on the hair follicles and hematomas.

Hemorrhages can cause paralysis due to nerve sheath involvement, compartment syndrome due to muscle involvement, hemarthrosis, or osteolysis. Visceral hemorrhages are also possible;

iii) Hypertrophic and hemorrhagic gingivitis with possible secondary periodontal disease. This is a characteristic but inconsistent finding;

iiii) Mucocutaneous involvement such as ichthyosis, edema, alopecia, and/or dry mouth, the association of which with purpura and joint involvement can mimic connective tissue disease or vasculitis. Anemia can occur during vitamin C deficiency, especially when there is associated bleeding. The course of scurvy can be unfavorable or even fatal if the deficiency is not corrected, following a worsening of the hemorrhagic syndrome, cardiac involvement, or severe infection due to secondary immunodeficiency.

Treatment: Curative treatment (Table 20) comprises three main essential and inseparable components; clinical assessment of the degree of urgency and initial management of visceral consequences, replacement therapy and etiological treatment.

Table 20: Curative therapeutic schemes for vitamin deficiencies *(Serraj et al., 2007)*

Vitamin deficiency	Modality of curative treatment
A	100 000 UI/day for 3 days then 50 000UI/day for 2 weeks
D	50 000 UI of vitamin D_2 per week for 8 weeks then every 2 to 4 months
E	50-2 000 UI/day PO
K	
B_1	Neuropathy: 10-30 mg/day IM every 2 to several weeks Heart disease: 100 mg IV every 1 week then 50-100 mg/day IV or IM then 10-20 mg/day IM until the signs disappear
B_2	6-30 mg PO until improvement
B_3	400 to 1 000 mg/day PO several days then 100 to 150 mg/day PO until the skin signs disappear
B_6	Dosage according to indication: cirrhosis: 50 mg/day ; hemodialysis : 50mg/day Chronic kidney failure: 2,5 to 5 mg/day, hyperhomocysteinemia : 100 to 500 mg/day PO
B_8	10-40 mg/day PO, IV or IM until the signs disappear
B_9	1 to 5 mg/day for 3 to 6 months
B_{12}	PO : 1 000 to 2 000 µg/day then 125 to 1 000 µg/day IM : 1 000 µg/day then 1 000 µg/months
C	1 000 mg/day PO for 15 days

PO: person hospitalized IM : intramuscular IV: intravenous

CHAPTER VI: MAIN METABOLIC DISEASES

1- Type 1 Diabetes

Diabetes is characterized by a prolonged elevation of glucose levels in the blood: this is called hyperglycemia. In the case of type 1 diabetes, this imbalance is due to a deficiency of insulin, a hormone that regulates blood sugar. Potentially very serious if left uncontrolled, type 1 diabetes is now very well managed (but not cured) thanks to exogenous insulin therapy. Patients receiving insulin therapy thus have a life expectancy equivalent to the rest of the population.

In people with type 1 diabetes, insufficient or no insulin production leads to a prolonged elevation of blood glucose (or blood sugar) levels. Insulin, a hormone essential for regulating blood sugar, is normally produced by specialized cells in the pancreas: the beta cells of the islets of Langerhans.

Type 1 diabetes (T1D) is caused by the dysfunction of T lymphocytes (immune system cells) which begin to identify pancreatic beta cells as foreign to the patient's body and eliminate them. It is therefore an autoimmune disease, detectable by the presence of autoantibodies.

Symptoms appear several months, or even several years, after the onset of these events, when most of these insulin-producing cells have been destroyed. Long considered "childhood diabetes," type 1 diabetes (T1D) can occur at any age.

The consequences of insulin deficiency: Insulin facilitates the entry of glucose into several types of cells, including muscle cells, adipocytes (fat cells), and hepatocytes (liver cells). The absence of this hormone prevents the body from storing sugar. This leads to a major risk of hyperglycemia (hyperglycemia) when eating. For patients on insulin therapy, there is also a risk of hypoglycemia (hypoglycemia) between meals if an excessive dose of insulin is injected. These hypoglycemic episodes can be serious if sugar is not quickly consumed, with a risk of coma.

In the absence of glucose to fuel the organs, particularly the brain and heart, the body resorts to an alternative solution: it uses stored fat to produce alternative energy substances called ketone bodies. However, the accumulation of ketone bodies in the blood proves toxic to the body: beyond a certain level, it is called diabetic ketoacidosis. This manifests itself through various symptoms, including abdominal pain, and can also lead to a coma.

Warning signs and detection: The main method for detecting diabetes at an early stage is measuring fasting blood glucose. Normal blood glucose is approximately 1 gram of glucose per liter of blood plasma, when fasting. It varies throughout the day, increasing particularly for several hours after meals, hence the need to perform this measurement in the morning while fasting, but sometimes also after meals to detect more subtle abnormalities.

- With a blood glucose level of 1.10 to 1.26 g/L, the patient is considered prediabetic.
- If the blood glucose level exceeds 1.26 g/L on two consecutive tests, diabetes is diagnosed.

Other criteria, such as postprandial blood glucose, oral glucose tolerance test, and glycated hemoglobin (HbA1c) levels (hemoglobin to which glucose has bound), can confirm or refine the diagnosis.

However, patients generally consult later, when the blood glucose imbalance has already caused clinical signs: episodes of hyperglycemia, associated with fatigue, intense thirst, increased urinary frequency and volume, and/or weight loss despite a good appetite, are early indicators of the disease. These signs are shared by both types of diabetes. But the presence of circulating autoantibodies in the blood allows for the diagnosis of type 1 diabetes and the adjustment of treatment accordingly.

The three stages of the disease: Specialists now consider type 1 diabetes as a continuum composed of three stages:

- Stage 1: The presence of autoantibodies in the blood reveals activation of the immune system against the pancreatic beta cells, but the patient is asymptomatic because most of the insulin-producing beta cells are still present and functional.
- Stage 2: The patient is still asymptomatic, but detailed metabolic tests may reveal impaired pancreatic function (a delay in insulin secretion).
- Stage 3: Symptoms of hyperglycemia lead the patient to seek medical attention: at this stage, a critical number of beta cells have already been destroyed.

Risk of major complications: Insufficient blood sugar control leads to serious long-term complications, occurring several years after the onset of the imbalance (often up to 10 to 20 years later). These complications primarily affect the heart and blood vessels, which are the first to be damaged by an excessive and persistent concentration of glucose in the blood. Diabetes thus causes vascular damage, increasing the risk of atherosclerosis, myocardial

infarction, stroke, and peripheral artery disease. Diabetes also affects the small arteries that supply the kidneys, the nerves of the lower limbs, and the retina—these are known as microvascular complications.

Diabetes (types 1 and 2 combined) increases the risk of myocardial infarction three to five times. The disease also increases the risk of kidney failure (requiring dialysis or even a transplant), lower limb amputation due to peripheral artery disease, and blindness.

Insulin therapy: Treatment for type 1 diabetes relies on subcutaneous insulin injections, several times a day, to compensate for the body's inability to produce insulin. Human insulin analogs, produced by genetically modified bacteria, are now used:

- Rapid-acting insulin

Analogs have an almost immediate and short-lived effect, useful for quickly lowering blood glucose levels after eating.

- Ultra-slow-acting insulin analogs (basal insulins)

They are active for approximately 24 hours and ensure a continuous presence of insulin in the blood throughout the day, as in a non-diabetic individual. These two types of analogs are complementary. Properly followed treatment usually results in blood glucose levels approaching normal, thus preventing the development of long-term macro- and microvascular complications. However, insulin therapy is a demanding and lifelong treatment: the patient must measure their blood glucose several times a day by pricking their finger and adjust their insulin injections accordingly. Patient education is essential, particularly to limit the risk of hypoglycemia. Glucose monitoring devices now allow patients to check their blood glucose levels at any time, without pricking their finger, thanks to a small sensor placed on the skin that takes measurements approximately every 10 minutes. Insulin pumps are also useful for some patients: about the size of a mobile phone and attached to a belt, they deliver insulin directly via a catheter. The patient must still monitor their blood glucose levels regularly to adjust the injection doses accordingly.

2- Type 2 Diabetes

Type 2 diabetes is characterized by fasting or postprandial blood glucose levels, or by an oral glucose tolerance test (OGTT), exceeding the thresholds defined by the WHO (Table 21). It is a disorder of pancreatic insulin secretion (insulin resistance, hyperinsulinism, then relative or

absolute insulin deficiency) leading to chronic hyperglycemia. The main risk factors are heredity, a sedentary lifestyle, modern dietary habits, and being overweight.

Table 21: Definition of type 2 diabetes

Criteria	Standards
Blood sugar (non-diabetic)	Fasting blood glucose: between 0.70 and 1.10 g/L Blood glucose 1 hour 30 minutes after a meal:
Fasting blood glucose (diabétique)	Blood glucose > 1.26 g/L after an eight-hour fast, verified twice Or presence of symptoms of diabetes (polyuria, polydipsia, weight loss) associated with a blood glucose level (on venous plasma) ≥ 2 g/L or a blood glucose level (on venous plasma) ≥ 2 g/L two hours after an oral glucose load of 75 g.
Recommended glycated hemoglobin (HbA1c) level (diabetic)	≤ 7%: general case of type 2 diabetics ≤ 6.5%: subjects with newly diagnosed diabetes, no history of cardiovascular disease, and a life expectancy greater than 15 years ≤ 8%: patients with type 2 diabetes with a life expectancy of less than five years, or with advanced macrovascular complications, or poorly controlled diabetes for more than ten years, and frail elderly individuals Between 8 and 9%: dependent elderly individuals (75 years or older)

Obesity, along with age, is the leading risk factor for diabetes. The disease arises from insufficient insulin production to meet the body's increased demand, itself caused by increased insulin resistance in target tissues such as the liver, muscles, and adipose tissue. This insulinopenia is primarily a consequence of the beta cells' inability to secrete insulin in response to glucose. In the course of the disease, the relative or absolute loss of insulin sensitivity precedes the dysfunction of pancreatic beta cells. This functional defect is then accompanied by a reduction in the total mass of beta cells, which contributes to the development of the disease. Indeed, a 65% reduction in the total mass of pancreatic beta cells is associated with type 2 diabetes.

An increase in beta cell death by apoptosis, possibly associated with non- and/or dedifferentiation of beta cells, is one of the main causes of the decrease in this mass. A decrease in proliferation and neogenesis could also contribute to the

loss of pancreatic beta cell mass. This dysfunction of pancreatic beta cells could be promoted by genetic factors.

Excess lipid intake and systemic insulin resistance, associated with obesity, play a key role in the decline of beta cell mass and function. Chronic low-grade inflammation, induced by hyperlipidemia, contributes to worsening insulin resistance and the diabetogenic role of obesity. Indeed, chronic exposure of insulin-sensitive tissues to pro-inflammatory cytokines leads to insulin resistance.

Similarly, pancreatic beta cells exposed to pro-inflammatory cytokines for extended periods are unable to secrete insulin in response to glucose and eventually die by apoptosis. This chronic inflammation could also be induced by increased intestinal permeability and a change in the composition of the microbiota, also observed in obese individuals with type 2 diabetes. According to the French National Authority for Health (HAS), it is not recommended to continue treatment in a non-responding patient, nor to use two drugs from the same class. Therefore, it is advisable to try another therapeutic class. The following table 22 explains the treatments for type 2 diabetes.

Table 22 : Treatments for type 2 diabetes

Drug class (DCI)	Mechanism of action	Administrative route	Main side effects of the class	Main contraindications of the class
Biguanides (metformin)	Reduced hepatic glucose production, increased insulin sensitivity of cells, delayed intestinal glucose absorption	Oral	Digestive problems, few cases of hypoglycemia but rare cases of lactic or metabolic acidosis are possible	Moderate to severe renal insufficiency (acute or chronic), hepatocellular insufficiency, alcoholism, iodinated contrast agents
Hypoglycemic sulfonamides (gliclazide, glimepiride...)	Insulin secretion, improved sensitivity of peripheral tissues to insulin and decreased uptake by the liver	Oral	Hypoglycemia is more frequent	Severe renal or hepatic insufficiency
Glinides (repaglinide)	Insulin secretion dependent on the proper functioning of pancreatic cells	Oral	Hypoglycemia	Severe hepatic insufficiency; treatment with gemfibrozil

Alpha-glucosidase (acarbose) inhibitors	Slowing of the absorption of complex dietary carbohydrates	Oral	Digestive effects (diarrhea, intestinal discomfort...)	Severe renal or hepatic insufficiency
DPP-4 inhibitors (sitagliptin, vildagliptin…)	Potentiation of insulin secretion by inhibition of the DPP-4 enzyme, amplifying GLP-1 hormone levels.	Oral	Dizziness, headaches, constipation	Pancreatitis
GLP-1 analogues (exenatide, liraglutide...)	Endogenous hormone that glucose-dependently potentiates insulin secretion	Subcutaneous	Digestive problems, injection site reactions, headaches	Pancreatitis
Insulins and insulin analogues	They replace endogenous insulin by being released either rapidly or slowly	Subcutaneous	More frequent hypoglycemic episodes and possible weight gain	Hypersensitivity

DCI : dénomination commune internationale ; DPP-4 : dipeptidyl peptidase 4 ; GLP-1 : glucagon-like peptide 1

3- Hypercholesterolemia

Cholesterol is a waxy substance produced by the liver of animals and also obtained through diet from animal products such as meat, poultry, fish, and dairy. The body needs cholesterol to insulate nerves, build cell membranes, and produce certain hormones. It is an important lipid in some membranes. Cholesterol is one of the main risk factors for cardiovascular disease, along with diabetes, high blood pressure, and smoking. Excess cholesterol in the blood accumulates daily in the arteries (especially those of the heart) and gradually forms fatty deposits (cholesterol plaques) on their walls. These deposits thicken, creating a predisposition to thrombosis, myocardial infarction, stroke, or peripheral artery disease.

Cholesterol is transported in the blood by lipoproteins: LDL (low-density lipoprotein) and HDL (high-density lipoprotein). The normal value for total cholesterol in the blood should ideally be less than 2 g/L, while also considering associated risk factors (age, sex, family history, smoking, high blood pressure, diabetes, etc.). "Bad" cholesterol, or LDL cholesterol, is atherogenic when present in excess. It transports cholesterol from the liver to the cells and tends to clog the arteries where it is deposited. Ideally, the LDL cholesterol level should be less than 1.6 g/L (< 1.3 g/L if more than two risk factors are present). "Good" cholesterol, or HDL cholesterol, is a cardiovascular protector. It removes excess cholesterol from the artery walls and returns it to the liver where it is then eliminated. Ideally, the HDL cholesterol level should be greater than 0.4 g/L.

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As we age, cholesterol levels increase. Before menopause, women generally have lower total cholesterol levels than men of the same age. After menopause, however, LDL levels in women tend to rise. Your genes partly determine how much cholesterol your body produces. High blood cholesterol can run in families. Sometimes, an illness can cause elevated blood cholesterol levels. These include hypothyroidism (an underactive thyroid gland), liver disease, and kidney disease. Conversely, some medications, such as steroids and progestins, can raise "bad" cholesterol and lower "good" cholesterol. A suitable diet can lower cholesterol levels, improve the health of arteries, and reduce cardiovascular risks. A Mediterranean-style diet, rich in fruits, vegetables, and fish, containing unsaturated fats, and lower in meat and dairy products, can lead to, among other things, a significant reduction in coronary events. It is recommended:

- To reduce the consumption of animal fats (processed meats, fatty meats, butter, cream, whole milk and dairy products, cheeses, etc.) and to avoid foods highest in cholesterol, such as offal. The consumption of lean meats, poultry, skimmed or partially skimmed milk and dairy products, as well as fish rich in long-chain n-3 fatty acids, should be encouraged. As for egg yolks, it is generally advised to limit consumption to two to three per week, but the important thing is not to cook eggs with fat;
- To favor the consumption of vegetable fats low in saturated fatty acids: olive and peanut oils, rich in monounsaturated fatty acids; sunflower, corn, or grapeseed oils, rich in linoleic acid; rapeseed, soybean, or wheat germ oils, rich in alpha-linolenic acid. It should be noted that palm and coconut oils or margarines, rich in saturated fatty acids, should be avoided. Reduced-fat or n-3 polyunsaturated fatty acid (PUFA) margarines are not recommended for children;
- Be vigilant regarding hidden fats in processed foods, which are often high in saturated and trans fats (pastries, cakes, cookies, ready-made meals, chocolate bars, etc.);
- Cook foods without added fat, including oils and margarines. These are added raw to food at the time of serving;
- Offer foods enriched with phytosterols from the age of three, which can further reduce plasma LDL cholesterol. However, the optimal phytosterol intake for children is still not well established, and there is a risk of excessive intake if fortified foods (margarines, yogurts in tubs or drinks, salad dressings, etc.) are consumed frequently. The effective and well-tolerated dose is between 1.6 and 2 g/day, bearing in mind that in adults no additional benefit has been shown for intakes above 3 g/day.

Regular exercise can lower LDL cholesterol and raise HDL cholesterol. You should aim to be physically active for 30 minutes most days. Being overweight can also raise your cholesterol levels. Losing weight can help lower your LDL, total cholesterol, and triglyceride levels, as well as your HDL.

4- Obesity

In 2016, an estimated 41 million children under the age of 5 were overweight or obese. Once considered problems specific to high-income countries, overweight and obesity are now on the rise in low- and middle-income countries, particularly in urban areas. In Africa, the number of overweight or obese children has increased by almost 50 percent since 2000. Nearly half of all overweight or obese children under the age of 5 lived in Asia in 2016. More than 340 million children and adolescents aged 5 to 19 were overweight or obese in 2016.

Overweight and obesity are defined as an abnormal or excessive accumulation of body fat that can be detrimental to health. The body mass index (BMI) is a simple measure of weight relative to height commonly used to assess overweight and obesity in adults. It is calculated by dividing weight by the square of height, expressed in kg/m^2. Thus, overweight is defined as a BMI greater than 25 kg/m^2 and obesity as a BMI greater than 30. Different stages of obesity severity can be distinguished:

- Type 1 (moderate) with a BMI between 30 and 34.9;
- Type 2 (severe) with a BMI between 35 and 39.9;
- Type 3 (morbid) with a BMI ≥ 40.

Obesity affects all aspects of human life and is associated with numerous diseases. Scientific data supports the idea that the higher the BMI, the greater the risk of morbidity, while a weight loss of 10 kg can significantly reduce this risk.

The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, the WHO has observed an increase in the consumption of high-calorie, high-fat foods and a rise in physical inactivity due to the increasingly sedentary nature of many types of work, changing modes of transportation, and increasing urbanization.

A high BMI is a major risk factor for certain chronic diseases such as cardiovascular diseases (primarily heart disease and stroke); diabetes; musculoskeletal disorders (especially osteoarthritis—a degenerative joint disease that is very debilitating); and certain cancers (endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon). The risk of

developing non-communicable diseases increases with BMI. Childhood obesity is associated with an increased risk of obesity, premature death, and disability in adulthood. But, in addition to these future risks, obese children may experience breathing difficulties, an increased risk of fractures, high blood pressure, the appearance of early markers of cardiovascular disease, insulin resistance, and psychological problems.

According to the literature, approximately 75 to 80% of diabetic patients are obese, demonstrating that obesity is a significant risk factor for the development of type 2 diabetes. The risk of developing type 2 diabetes increases with a high BMI, while in individuals who already have the disease, weight loss reduces this risk as well as mortality rates. A weight loss of nine kilograms reduces mortality rates associated with type 2 diabetes by 30 to 40%, and a weight loss of 10 to 20% can significantly improve metabolic control and potentially life expectancy. Fat accumulation is accompanied by a proportional increase in the volume of the heart chambers and the heart wall, while a reduction in body fat is associated with a reduction in the adverse effects on cardiac function. Furthermore, the increase in body fat leads to a corresponding increase in cardiac workload, which in the long term causes cardiac hypertrophy as the myocardium adapts to the increased demands. This increased cardiac workload gradually leads to fatigue and heart failure.

The age at which obesity begins is another risk factor for developing cardiovascular disease. According to the literature, weight gain after the age of 18 to 20 is associated with a statistically significant incidence of cardiovascular disease. Furthermore, fat distribution, and in particular the accumulation of fat in the abdomen rather than obesity itself, is closely associated with the development of coronary artery disease.

Obesity is strongly associated with hypertension and atherosclerosis. The accumulation and swelling in the artery walls, which are produced by immune cells and consist primarily of lipids and connective tissue, leads to the development of atherosclerotic plaques.

Hypertension is a common condition in people whose weight increases with age, while nearly half of obese individuals suffer from hypertension.

According to the literature, a 10% increase in body weight raises systolic blood pressure by 6 mmHg and diastolic blood pressure by 4 mmHg. The risk is even higher in individuals with a genetic predisposition. Generally, for every 1% reduction in body weight, systolic blood pressure decreases by 1 mmHg and diastolic blood pressure by 2 mmHg.

Obesity is characterized by a pathological condition marked by elevated total cholesterol and triglycerides, high LDL cholesterol levels, and reduced HDL cholesterol levels. Insulin resistance, increased plasma free fatty acid levels, reduced muscle lipoprotein lipase activity, and reduced LDL receptor efficacy are among the mechanisms contributing to the development of metabolic syndrome.

Obesity affects menstruation, regardless of fat distribution. Studies have shown that obese girls experience their first period earlier. Weight loss has beneficial effects on ovarian function and can lead to the normalization of the menstrual cycle in obese women with amenorrhea. In men, central obesity is associated with reduced testosterone levels. Mortality rates from prostate and colon cancer are higher in obese men. Consequently, mortality rates from endometrial, uterine, cervical, ovarian, breast, and gallbladder cancers also increase in obese women. Diet and endocrine disorders are the two factors that may explain the link between obesity and cancer. Diet is linked to gastrointestinal cancer, and endocrine disorders to hormone-related cancers.

Overweight and obesity, as well as the non-communicable diseases associated with them, are largely preventable. Supportive environments and communities are crucial for influencing population choices, making healthier foods and regular physical activity more accessible, available, and affordable, and thus preventing overweight and obesity. At the individual level, one can:

- Limit energy intake from total fats and sugars;
- Consume more fruits and vegetables, legumes, whole grains, and nuts;
- Engage in regular physical activity (60 minutes per day for a child and 150 minutes per week for an adult).

Managing obesity sometimes involves medication. Orlistat, the only currently available medication, can be prescribed at a dose of 120 ml with each meal. Despite limited benefit, the medication is relatively well-tolerated. The main side effects are digestive. The primary risk of orlistat, which interferes with the absorption of other medications, lies in potential drug interactions. To ensure any benefit, adherence to the low-calorie diet must be closely monitored.

BIBLIOGRAPHIC REFERENCES

-Armstrong L. E. and Johnson E. C., (2018). Water Intake, Water Balance, and the Elusive Daily

Water Requirement. Nutrients, 10(1928) : 1-25.

-Apfelbaum M., Romon M., Dubus M., (2009). Diététique et nutrition. Ed : 7ème Elsevier Masson, Paris, PP : 512.

-Avignon A., Barbe P., Basdevant A., Bresson J.-L., Colette C., Constans T. *et al.*, (2001). Collège des Enseignants de Nutrition. Cah. Nutr. Diét, 36 : 2S1-2S163.

-Battu C., (2013). La prise en charge nutritionnelle d'un adulte atteint d'hypercholestérolémie. Actualités pharmaceutiques, 531 : 55-58.

-Beaufrere B., Birgé J., Burlet C., Campillo B., Couet C., *et al*., (1999). Carences nutritionnelles : étiologies et dépistage. Rapport de recherche, Institut national de la santé et de la recherche médicale (INSERM), PP : 337.

-Bournérias F., (2019). Déshydratation, médecine. Encyclopædia Universalis [en ligne], consulté le 30 juillet 2019. URL: http://www.universalis.fr/encyclopedie/deshydratation-medecine/

-Burgess A. and Glasauer P., (2004). Family nutrition guide. Ed: Food and Agriculture Organization of The United Nations, ROME, PP: 126.

-Campbell B., Kreider R. B., Ziegenfuss T., La Bounty P., Roberts M., Burke D., Landis J., Lopez H. and Antonio J., (2007). International Society of Sports Nutrition position stand: protein and exercise. Journal of the International Society of Sports Nutrition, 4(8): 1-7.

-Chevallier L., (2009). Nutrition : principes et conseilles. Ed : 3ème Masson, Paris, PP : 256 pages.

Chiva-Blanch G. and Badimon L., (2017). Effects of polyphenol intake on metabolic syndrome: current evidences from human trials. Oxidative Medicine and Cellular Longevity, 2017: 18.

-David C. et Boinet T., (2018). Diabète de type 2 non équilibré et haut risque cardiovasculaire. Actualités pharmaceutiques, 573 : 14-17.

-Delarue J., Joly F., Desport J-C. et Fontaine E., (2018). Les nouveaux critères de diagnostic de la dénutrition de l'adulte. MCED, 95, 60-64.

-Dribault H., (2014). Les vitamines : Intérêt d'une supplémentation à visée préventive ou curative chez l'Homme. Thèse de Doctorat en pharmacie, Université de Poitiers, France. http://nuxeo.edel.univ-poitiers.fr/nuxeo/site/esupversions/035bf14f-42d7-455b-94ab-b0632ace5c91

-Faure S., (2014). Médicaments de l'obésité. Actualités Pharmaceutiques, 53(532), 53–55.

-Ferland G., (2019). Nutrition in Aging. Encyclopedia of Gastroenterology, 2nd Edition, 9 Elsevier Inc: p 1-8.

-Ferry M., (2003). Hydratation, déshydratation, et sujets âgés. Cholé-doc, 78 : 1-6.

-Gibney M. J. Lanham-New S.A., Cassidy A. & Vorster H. H., (2009). Introduction to human nutrition. Ed : 2nd Wiley-Blackwell, United Kingdom, PP : 386 pages.

-Gomez-Merino D. et Portero P., (2008). Nutrition lipidique, santé et sport. Kinesither Rev, (73): 57-62.

-Greenfield H. et Southgate D. A. T., (2007). Données sur la composition des aliments : production, gestion et utilisation. Ed : 2ème, FAO, Rome, Italie. PP : 319 pages.

-Guezennec C-Y, (2017). Les glucides. In : Bigard X. et Guezennec C-Y. Nutrition du Sportif, 3ème édition, Elsevier Masson, PP : 304 pages. https://doi.org/10.1016/C2016-0-01443-2

-HADR Z. (2020). Polycopié du cours de Nutrition Humaine. Département Des Sciences Agronomiques. Centre universitaire Ahmed Zabana, Ghélizène, Algérie

-Hébuterne X., (2001). Nutrition artificielle : indications, modalités, résultats. Gastroentérologie Clinique et Biologique, 25(1), 48-57.

-Inserm, (2019). Diabète de type 1 : Une maladie auto-immune de plus en plus fréquente. https://www.inserm.fr/information-en-sante/dossiers-information/diabete-type-1

-Institut National de Santé Publique du Québec, (2003). La consommation alimentaire et les apports nutritionnels des adultes québécois. www.inspq.qc.ca/pdf/publications/931_RapportNutritionAdultes.pdf

-Koch W., (2019). Dietary Polyphenols—Important Non-Nutrients in the Prevention of Chronic Noncommunicable Diseases. A Systematic Review. Nutrients, 11(1039) : 1-35.

-Labarde S. et Sicard J., (2018). Le sportif, des besoins particuliers. Actualités pharmaceutiques, 575 : 20-24.

-Larousse, (2019). Avitaminose.

https://www.larousse.fr/encyclopedie/medical/avitaminose/11459

-Latham M. C., (2001). La nutrition dans les pays en développement. Ed : FAO, Rome, Italy, http://www.fao.org/3/W0073F/w0073f00.htm#toc

-Latham M. C., (1979). Nutrition humaine en Afrique tropicale. Ed : 2ème, FAO, Italie, http://www.fao.org/3/x0081f/X0081F0d.htm#19.%20La%20malnutrition%20protéino-énergétique

-Lebacq T., (2015). Anthropométrie (IMC, tour de taille et ratio tour de taille/taille). Dans : Lebacq T, Teppers E (éd.). Enquête de consommation alimentaire 2014-2015. Rapport 1. WIV-ISP, Bruxelles.

-Lebars M-A., Rieu D. et Girardet J. P., (2010). Traitement diététique de l'hypercholestérolémie de l'enfant. Archives de pédiatrie 17 : 1126–1132.

-Lecerf J-M., (2018). Glucides : de la théorie à la pratique. Médecine des maladies Métaboliques, 12(5) : 432-435.

-Lloret-Linares C. et Oppert J-M., (2009). La mesure de la composition corporelle : nouveaux aspects. Sang Thrombose Vaisseaux, 21(5-6): 232-9.

-Ma H. and Shieh K-J., (2006). Cholesterol and Human Health. The Journal of American Science, 2(1): 46-50.

-Martin F. (2001). Apports Nutritionnels Conseillés de la population française. Tec & Doc, Paris, France.

-Maughan R. J., (1999). Role of micronutrients in sport and physical activity. British Medical Bulletin, 55 (3): 683-690.

-Maury E., Bigé N., Alves M., Galbois A., Ait-Oufella H., Baudel J-L., Offenstadt G. et Guidet B., (2013). Syndromes carentiels sévère. Réanimation, 22(2), 417–427.

-Mourey A., (2004). Manuel de nutrition pour l'intervention humanitaire. Ed : Comité international de la Croix-Rouge Division assistance, Genève, Suisse, PP : 724 pages.

-Nani O. M., (2016). Relationship between nutrition knowledge and food intake of college students. Master thesis, Kent State University College, USA https://etd.ohiolink.edu/!etd.send_file?accession=kent1469155764&disposition=inline

-Nantel G., (1999). Carbohydrates in human nutrition. http://www.fao.org/3/X2650t/X2650t02.pdf

-OMS, (2019). Alimentation saine. https://www.who.int/fr/news-room/fact-sheets/detail/healthy-diet

-OMS, (2018). Obésité et surpoids. https://www.who.int/fr/news-room/fact-sheets/detail/obesity-and-overweight

-OMS, (2012). La nutrition chez la femme pendant la période préconceptionnelle, la grossesse et l'allaitement. Soixante-cinquième assemblée mondiale de la santé, http://apps.who.int/gb/ebwha/pdf_files/WHA65/A65_12-fr.pdf

-OMS, (2003). Obésité : Prévention et prise en charge de l'épidémie mondiale. https://apps.who.int/iris/bitstream/handle/10665/42734/WHO_TRS_894_fre.pdf?sequence=1

-Polikandrioti M. and Stefanou E., (2009). Obesity disease. Health science journal, 3(3): 132-138.

-Popkin B. M., D'Anci K. E. and Rosenberg I. H., (2010). Water, Hydration and Health. Nutr Rev. 68(8): 439–458.

-Regost C, (2001). Effets des lipides sur la qualité nutritionnelle, physique et organoleptique de la chair de la truite fario (*Salmo trutta*) et du turbot (*Psetta maxima*). Thèse de doctorat, Université de Rennes I, France, p : 13.

-Richard R. (2014). Nutrition du sportif, apports macronutritionnels en fonction des disciplines. Nutrition clinique et métabolisme, 28(4) : 272-278.

-Ritz P. et Couet C., (2006). La dépense énergétique. J. Réadapt. Méd. 4 (26), pp. 97-103.

Schlienger J-L., (2018). Fibres alimentaires. In : Manuel de nutrition pour le patient diabétique ; Ed : Elsevier Masson SAS, p : 101. https://doi.org/10.1016/B978-2-294-75606-1.00009-9

-Schlienger J-L., (2014). Besoins nutritionnels et apports conseillés : adultes, femmes enceintes, personnes âgées, sportifs. In : Nutrition clinique et pratique chez l'adulte et l'enfant. Ed : 2ème, Elsevier Masson SAS, p : 43-56. https://doi.org/10.1016/B978-2-294-73976-7.00003-X

-Serraj K., Federici L., Ciobanu E. et Andrès E., (2007). Les carences vitaminiques : du symptôme au traitement. mt, 13(6), 411-420.

-Sommer A., (1995). Vitamin a deficiency and its consequences a field guide to detection and control. Ed: 3ème , World Health Organization, PP: 88 pages.

-Tenenbaum M., Bonnefond A., Froguel P. et Abderrahmani A., (2018). Physiopathologie du diabète. Revue Francophone Des Laboratoires, 502 : 26–32.

-Touitou Y., (2005). Biochimie : structure des glucides et lipides. Faculté de médecine, Université Pierre et Marie Curie.

-UNICEF, (2019). Les micronutriments.
https://www.unicef.org/french/nutrition/index_iodine.html

-UNICEF, (1998a). Les micronutriments.

https://www.unicef.org/french/sowc98/pdf/prappel3.pdf
-UNICEF, (1998b). La malnutrition : causes, conséquences et solutions. https://www.unicef.org/french/sowc98/pdf/presume.pdf
-Vignoles A., (2014). Etude des facteurs influençant la dépense énergétique de repos mesurée chez le sujet âgé hospitalisé : Analyse rétrospective de 143 patients hospitalisés au Centre Hospitalier Lyon-Sud de 2011 à 2014. Thèse de Doctorat en médecine, Université Lyon 1. P : 14.
-Williamson C., (2006). The different uses of food composition databases. Synthesis report, Ed: European Food Information Resource Consortium. Norwich, UK, PP: 48.