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Report of the IDECG Working Group on lower and upper limits of carbohydrate and fat intake

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Carbohydrate intakes

The theoretical minimal level of carbohydrate (CHO) intake is zero, but CHO is a universal fuel for all cells, the cheapest source of dietary energy, and also the source of plant fiber. In addition, the complete absence of dietary CHO entails the breakdown of fat to supply energy (glycerol as a gluconeogenic substrate, and ketone bodies as an alternative fuel for the central nervous system (CNS)), resulting in symptomatic ketosis. Data in childhood are unavailable, but ketosis in adults can be prevented by a daily CHO intake of about 50 g. This value appears to approximate the quantity of glucose required to satisfy minimal glucose needs of the CNS and during starvation. The Group therefore concluded that the theoretical minimum intake of zero should not be recommended as a practical minimum.

For the definition of the lower limit of carbohydrate intake the following set of assumptions were made:

1. Estimates are based on the assumption that energy and protein intakes are adequate.
2. Only absorbable non-alcohol CHO are taken into consideration.
3. The CHO must come from a variety of sources.
4. The minimum level of CHO intake must be adequate to maintain an appropriate body weight and composition in adults and allow for adequate growth and development in children; ideally it should minimize protein carbon use for gluconeogenesis.
5. It should be compatible with food preferences, community needs, religious rites and other societal factors.
6. It should meet requirements that are based on calculations of irreversible carbon loss in brain metabolism, allowing for the uncertainty of available data. It is assumed that at ages above 3–4 y the adult irreversible oxidation rate applies.

Under these assumptions about 100 g of glucose/d are irreversibly oxidized by the brain from the age of 3–4 y onward. However, this excludes recycled carbon, gluconeogenic carbon, for example, from glycerol, and it does not account for glucose used by other non-CNS tissues. For example, in the adult, muscle and other non-CNS account for an additional 20–30 g of glucose daily. For this reason a safety margin of 50 g/d is arbitrarily added to the value of 100 g/d and the practical minimal CHO intake set at 150 g/d beyond the ages of 3–4 y. This can then be expressed as a fraction of the total daily energy requirement that should be provided as absorbable CHO. The balance of the diet has to be supplied by protein and lipids. Too much of the latter could contribute to the risk of cardiovascular disease, obesity and insulin resistance. This minimal CHO requirement should therefore not be taken as an optimal recommendation from a public health point of view.

Special populations:

- From the age of 0–3 y there is a rapid increase in brain size and irreversible glucose oxidation, amounting to about 25% of total energy expenditure. Allowing for the same safety factors as mentioned for adults, we arrive at a recommendation that at least a third of dietary energy should be supplied from CHO.
- In individuals with significant risk factors for cardiovascular disease the relation of CHO to fat intake may have to be different than that of a general population.
- A small fraction of individuals engaged in sustained endurance activities at 60% of maximum oxygen consumption (VO_2max) are likely to require a high CHO intake.

With regard to the upper limit of CHO intake, the basic assumptions include the following:

1. Those made for the low CHO intake.
2. There is no intrinsic upper limit to the oxidation of CHO. However, while the body is highly efficient in matching CHO oxidation to intake, it should be recognized that increased fat deposition can occur at a level of CHO intake exceeding energy expenditure.
3. Additionally, account must be made of the need to supply other essential nutrients, fatty acids, amino acids, vitamins (including fat-soluble vitamins) and various micronutrients, which may be deficient in

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certain high-CHO diets (for example, those containing predominantly simple sugars).

4. Individuals have adequate β-cell function and reserve, and adequate peripheral insulin sensitivity.
5. An upper limit of CHO intake must be consistent with maintenance of a practical dietary energy density, such that it supplies sufficient energy to meet energy needs, particularly in individuals with low body mass indices and/or high levels of energy expenditure.
6. We must also take into account the potential deleterious effects that overconsumption of CHO can have, such as the production of fatty liver, hypertriglyceridemia, elevated VLDL levels, and a risk of insulin resistance due to obesity. Offsetting these constraints, one must recognize the possible advantages of high CHO diets in augmenting physical performance and potentially lessening the risk of obesity in western societies by reducing high energy density fat intake.

It follows from these assumptions that the practical upper limit of CHO intake is somewhat less than 70% of energy intake, beyond which level body weight maintenance may become difficult due to reduced energy density and palatability. This could be particularly the case when high carbohydrate foodstuffs predominantly consumed are very high in roughage. This upper level is compatible with the lower limits of fat and protein intakes discussed previously.

Special populations:

- These recommendations require modification with reference to the elderly, especially with coronary disease, where postprandial hypotension can occur after a high-CHO meal. It is easier for obese populations to meet energy reduction targets with high CHO rather than high fat intake. Individuals at risk for dyslipidemic effects of high-CHO diets may have a different upper limit of optimal CHO intake.

Research needs

More information is required on the relationships between CHO intake and physical performance both in adults and in children, particularly on the consequences of the lower or marginal dietary CHO intakes on physical activity. In addition, the long-term implications of carbohydrate restriction or excess CHO consumption in young children are unknown, specifically in connection with growth and development, cognitive function, or in relation to possible metabolic programming during critical periods of development. Additional information is needed on atherogenicity of high CHO diets relative to (a) their acute and chronic effects on the synthesis, composition, and catabolism of lipoproteins, and (b) the genetic basis for individual variability and responses to high or low CHO intakes. The impact of different forms of dietary CHO (simple sugars *vs*. complex carbohydrates; specific sugars including fructose, glucose, galactose; etc.) also requires further research.

Fat intakes in adults

We concluded that 10% of dietary energy as fat does not sustain desirable fat stores for continuous work at high levels, for the prevention of fat depletion during breast feeding, and for the prevention of the consequences of energy depletion for instance during disease states, periods of food shortages, etc. 10% does not sustain fat stores even if food is available, because there usually is insufficient *de novo* lipogenesis to balance obligatory fat oxidation. Additionally, when the energy density is low, food volumes are high, making it difficult to meet total energy needs. For these reasons the lower limit of fat intake was set at at least 15% of total energy intake. The caveats are the need to provide 3% of fat intake as omega-6 fatty acids, and 0.5% as omega-3. This can be done if all of the fat is obtained from plant sources. It is not entirely clear that a 15% fat diet will allow for the absorption of sufficient fat-soluble vitamins.

The upper range of fat intake, both in adults and children, would be in the order of 65–70% given our estimates of required minimal protein and carbohydrate intakes. The caveats are: One has to be particularly concerned about high-fat diets contributing to increased energy density, high consumption and therefore obesity, particularly in industrialized societies and other settings characterized by a sedentary life-style; high-fat diets leading to the increased intake of saturated fats, particularly C12–C16 saturated fatty acids, and of trans fatty acids and therefore increasing cardiovascular risk. For these reasons, practical recommendations of fat intakes are likely to lie in the range of approximately 30% of energy for sedentary individuals and perhaps 35–40% of energy for active individuals. With regard to cardiovascular risk reduction, we concur with the recommendation that C12–C16 saturated fatty acids and trans fatty acids should provide less than 10% of energy.

Research needs

Since variation in dietary fat intake results in the *pari passu* inverse effect on dietary carbohydrate intake, the research needs for dietary fat intakes are essentially the same as those for dietary carbohydrate intake mentioned previously. In children, because of the lack of systematic controlled data, further considerations include efforts to more precisely define the limits of optimal fat intakes, that is the lower limits below which growth, development, satisfaction of essential fatty acid and fat soluble vitamin requirements are no longer optimal, and the upper level intakes beyond which obesity and cardiovascular disease risk increase. Further, additional effort must be made to (a) define the childhood ages at which tracking of dietary fat intake patterns and habits persist into adult life, (b) describe the development of the behavioral variables that drive these habits, (c) determine whether there are critical periods of development or metabolic imprinting in reference to dietary fat and cholesterol intakes, and (d) establish at which ages dietary fat intake effects on lipid deposition in blood vessels are reversible, in order to make science-based dietary fat intake recommendations in childhood for preserving cardiovascular health in adult life.