Comparison of men with impaired fasting glycaemia to controls and to diabetic subjects with fasting glycaemia from 7.0 to 7.7 mmol/l: clinical, nutritional and biological status

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SUMMARY

Objective: To compare medical history, clinical, nutritional and biological status of non-diabetic men to subjects with impaired fasting glycaemia (glycemia 6.1-6.9 mmol/l) and to newly diagnosed type 2 diabetic subjects (7.0-7.7 mmol/l) according to the criteria proposed by the American Diabetes Association.

Methods: Cross-sectional study of a cohort of 29,992 men, who were volunteers for a free periodic check-up offered by their medical insurance. Medical history, lifestyle and nutritional habits were recorded using a self-administered questionnaire. Clinical and biological data were also studied. To compare the three groups of subjects — normal, impaired fasting glycemia and newly diagnosed diabetics — three age stratified samples were randomly designed.

Results: Most of the well-known risk factors for developing type 2 diabetes mellitus such as overweight, abdominal obesity, familial history of diabetes mellitus, over-consumption of fat and alcohol were present in the group with impaired fasting glycaemia which presented the same risk factors as the group of subjects with fasting glycaemia from 7.0 to 7.7 mmol/l, but to a lesser degree. Hypertension was present in more than 50% of the subjects with impaired fasting glycaemia.

Conclusion: In this cross-sectional study, impaired fasting glycaemia is associated with the risk factors of type 2 diabetes mellitus. The subjects with impaired fasting glycaemia should be considered at risk for cardiovascular disease and might take advantage from early specific intervention about their lifestyle.

Key-words: Impaired fasting glycaemia - Type 2 diabetes mellitus - Metabolic syndrome - Epidemiology.

RÉSUMÉ

Étude comparative d'hommes présentant une hyperglycémie à jeun, et de témoins et de sujets diabétiques de glycaémie à jeun allant de 7,0 à 7,7 mmol/l : statut clinique, nutritionnel et biologique

Objectifs : Comparer les antécédents médicaux, les données cliniques, biologiques et nutritionnelles de sujets non diabétiques comparés avec des sujets ayant une hyperglycémie à jeun (glycémie 6,1-6,9 mmol/l) et à des sujets diabétiques méconnus (glycémie 7-7,7 mmol/l) selon les critères proposés par l’ADA.

Méthodes : Étude transversale d’une cohorte de 29 992 hommes volontaires pour effectuer un examen de santé gratuit pris en charge par les caisses d’assurance maladie. Les antécédents, le style de vie et les habitudes alimentaires ont été recueillis par auto-questionnaire. Des données objectives cliniques et biologiques ont été étudiées. Pour comparer les trois groupes de sujets (normaux, hyperglycémiques à jeun et diabétiques nouvellement diagnostiqués), trois échantillons stratifiés sur l’âge ont été tirés au sort.

Résultats : La plupart des facteurs de risque reconnus pour favoriser le développement d’un diabète de type 2 tels que excès de poids, obésité abdominale, histoire familiale de diabète, consommation excessive de graisses et d’alcool étaient présents chez les sujets ayant une hyperglycémie à jeun qui présentaient déjà les mêmes facteurs de risque que le groupe de sujets ayant une glycémie comprise entre 7 et 7,7 mmol/l mais à un degré moindre. L’hypertension artérielle était présente chez plus de 50 % des sujets ayant une hyperglycémie à jeun.

Conclusion : Dans cette étude transversale, l’hyperglycémie à jeun est associée avec les facteurs de risque du diabète de type 2. Les sujets ayant une hyperglycémie à jeun doivent être considérés comme porteurs d’un risque cardio-vasculaire augmenté et pourraient bénéficier d’interventions précoces et de conseils appropriés pour modifier dès ce stade leur style de vie.

Mots-clés : Hyperglycémie à jeun - Diabète de type 2 - Syndrome métabolique - Épidémiologie.

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type 2 diabetes mellitus is becoming a major public health care problem in the world, originally affecting industrialized countries, but now extending to developing countries [1, 2]. It is associated with a two- to three-fold increased incidence of cardiovascular complications and with a significantly reduced life expectancy [3, 4]. The pathophysiology of type 2 diabetes mellitus is not yet fully understood. A long period of impaired glucose tolerance precedes the emergence of type 2 diabetes mellitus [5, 6]. Like type 2 diabetes mellitus, impaired glucose tolerance is associated with a significant increased risk for cardiovascular disease [7]. It has been shown that risk factors for developing impaired glucose tolerance and type 2 diabetes include: abdominal obesity, family history of type 2 diabetes mellitus, ageing, history of gestational diabetes mellitus, insulin resistance, sedentary lifestyle. The annual rate of progression from impaired glucose tolerance to type 2 diabetes ranged from 1.5% to 6% in initial population-based studies [8, 9]. More recently, several interventional studies i.e. Da Quing, DPS, DPP, Stop-NIDDM [10-13] indicated more precisely this rate in control subjects: 68% after 6 years, 23% after 4 years, 11 per 100 person-years, 42% after 3 years respectively. Delayed diagnosis of diabetes mellitus is at least 4-7 years in the United States [14]. According to these data and in an attempt to propose earlier preventive action, the diagnostic criteria for diabetes mellitus have been revised by the American Diabetes Association [15]. A new category of subjects with mild hyperglycaemia (6.1-6.9 mmol/l) was defined and called “impaired fasting glycaemia”. Recent papers including results from the Paris Prospective Study show that even blood glucose concentration in the upper value of the normal range is a risk factor for cardiovascular mortality in middle-aged non diabetic subjects [16-20]. Little has been published on the detailed characteristics of non-diabetic subjects with impaired fasting glycaemia [21-23]. Our study concerns a large group of French men who were volunteers for a systematic medical check-up. We have compared lifestyle, nutritional habits, clinical and metabolic characteristics in men with impaired fasting glycaemia to those of control subjects and to those with newly diagnosed type 2 diabetes mellitus following the diagnostic criteria for diabetes mellitus, fasting glucose ≥ 7.0 to 7.7 mmol/L. Subjects with fasting plasma glucose > 7.7 mmol/l have been thoroughly studied [4, 8] and therefore have not been considered further in this study.

**Subjects-methods**

29,992 men, mean age 40.2 ± 12.4 yr. (range 20-81 yr.), volunteered from January 1995 to March 1996 for a free periodic medical and biological check-up in the “Institut inter-régional pour la Santé” (I.R.S.A., France) in six French departments (Calvados, Indre, Indre-et-Loire, Maine-et-Loire, Orne, Sarthe). This check-up is provided every five years by the French Health Care System (Sécurité sociale), about 85% of the whole French population being affiliated to. All 29,992 subjects completed a standardized questionnaire on their lifestyle and on their educational level, personal and family (first degree relatives) history of diabetes mellitus, hypertension, angina pectoris, myocardial infarction and stroke as well as drug consumption. Smoking status (current smoker or not) was noted. Data on physical activity were obtained from a self-administered questionnaire which asked about regularity and intensity of physical activity ("at least one hour walking a day or less"). Nutritional habits were assessed by an 18-item self-administered questionnaire [24]. This questionnaire focuses on the main dietary disorders such as an imbalance in daily intake, over-consumption of calories, lipids, sucrose, cholesterol, alcohol by the assessment of the intake of meet, fish, eggs, pork meats, fried food, butter, cheese, dairy products, bread, sugar, drinks. For example alcohol consumption was estimated from the questionnaire which asked for the usual daily intake of wine or beer/cider in 6 consumption classes (nothing, less than 0.5 l, 0.5 l to 1 l, 1 l to 2 l, 2 l to 3 l, more than 3 l); spirits data were collected by asking the number of glasses a week. Then, using a sex specific beforehand established multiple regression equation (24), we calculated the alcohol daily consumption expressed in grams. A similar procedure was applied for fat, cholesterol, sucrose consumptions and total energy intake.

Blood pressure was measured in a supine position by a physician after a 5-min rest. Hypertension was defined by systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg. Waist/hip ratio and body mass index were recorded in participants wearing only underwear. Abdominal obesity was considered as waist/hip ratio ≥ 1 and overweight as body mass index ≥ 27 kg/m². Blood samples were collected after a 12 hour-overnight fast. Fasting plasma glucose was assayed by the glucose-oxidase method (Trender) applied to fluoro-oxylated plasma using Technicon RA 1000 (Bayer Diagnostics, Puteaux, France). Total cholesterol, triglycerides, creatinine were assayed on DAX 24 from Technicon (Bayer Diagnostics, Puteaux, France). For each blood test, the intra- and inter-assay coefficient of variation was less than 5%. High values have been estimated to be the following: triglycerides ≥ 1.76 mmol/l, cholesterol ≥ 6.5 mmol/l.

**Statistical analysis**

Statistical analysis of the medical and biological data obtained from the 29,992 male subjects was performed with the NCSS60 (Number Cruncher Statistical Systems) software (License Dr J. Hintze, Kaysville, Utah, USA). For the sub-

**Abbreviations**

IRSA : Institut inter-régional pour la Santé

NHANES : National Health And Nutrition Examination Survey.
jackets without a personal history of diabetes mellitus or glucose lowering drugs, three groups were considered: 1) 24,924 men (83%) with fasting glycaemia < 6.1 mmol/l, 2) 2,710 men (9%) with fasting glycaemia from 6.1 to 6.9 mmol/l, 3) 300 men (1%) who were newly diagnosed as diabetic with fasting glycaemia from 7.0 to 7.7 mmol/l. In this last group, one man was excluded due to missing data. A group of 2,058 subjects (7%) already known as diabetic or with fasting glycaemia ≥ 7.8 mmol/l and/or glycemic lowering drugs were excluded from the study, since this population carrying a well-known cardiovascular risk has been already thoroughly studied. Moreover we wanted to compare men with impaired fasting glycaemia to men with normal FPG and diabetic subjects with fasting glycaemia from 7.0 to 7.7 mmol/l. Since the age distribution of the three groups was significantly different, the entire population was stratified in 5 year-age groups and the normal subjects and those with impaired fasting glycaemia (IFG) were aged-matched with the smallest group, i.e. subjects newly diagnosed as diabetics (NDD), the G3 sample. To define the sample size to be selected in the IFG group, we calculated for each age strata the number of subjects in the IFG group to the number of subjects in the NDD group. These ratios differed according to age strata, and we selected the smallest ratio. This ratio was then used as a multiplying factor for the NDD group size, to determine the number of subjects to be selected in the IFG group. The size of the sample to be selected in the IFG group, we calculated for each age strata in the NDD group, giving the G2 sample (Tab I). The process was repeated for the normal subjects giving the G1 sample (Tab I). Data are presented as mean ± SD or as percentages. The Mann-Whitney U test and Chi² or Fisher exact test were used to compare continuous and categorical variables. Results were considered significant if p < 0.05; if not, they were noted as NS.

Table I
Size and age (mean ± SD) before and after sampling to stratify on age in the 3 glycaemic groups.

<table>
<thead>
<tr>
<th>Before stratification</th>
<th>After stratification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Groups</strong></td>
<td>n</td>
</tr>
<tr>
<td>Controls</td>
<td>24,924</td>
</tr>
<tr>
<td>IFG</td>
<td>2,710</td>
</tr>
<tr>
<td>Newly diagnosed diabetics</td>
<td>300</td>
</tr>
</tbody>
</table>

* IFG: impaired fasting glycaemia subjects
G1: normal glycaemia < 6.1 mmol/l
G2: impaired fasting glycaemia [6.1-6.9 mmol/l]
G3: new diabetics [7.0 to 7.7 mmol/l].

Results
The glucose levels of the subjects were 5.33 ± 0.39 mmol/l, 6.39 ± 0.22 mmol/l and 7.28 ± 0.22 mmol/l respectively in the G1, G2 and G3 groups.

Socio-educational status
The proportion of subjects who were university graduates was higher in G1 than in G2 (22.3% vs 17.7%; p < 0.0001) but there was no difference between G2 and G3 (17.7% vs 17.0%).

Family and personal medical history
The percentage of subjects having a family history of diabetes mellitus was significantly higher in G2 vs G1 and in G3 vs G2 (p < 0.0001) (Tab II) but there was no difference for family histories of hypertension, coronary artery disease or stroke. With regard to personal medical history, there was no statistical difference between G1 vs G2 and between G2 vs G3 for myocardial infarction, angina pectoris and peripheral vascular disease. Subjects in G2 had more frequently a medical history of cardiovascular disease and were more frequently treated with anti-hypertensive drugs than in G1 (p < 0.0001) but no difference was seen between G2 and G3. Concerning lipid-lowering treatment, there was no difference between G2 and G1, but subjects in G3 were more frequently treated than those in G2 (p < 0.01).

Clinical data
All clinical data were at a higher risk level in G2 than G1 (p < 0.001). The body mass index in G3 was significantly higher than in G2 (p < 0.001), which was higher than in G1 (p < 0.001) (Tab III). Overweight was found in 44% of G2, significantly more than in G1 (p < 0.001). Waist/hip ratio was higher in G2 than in G1 (p < 0.001) and percentage of subjects with abdominal obesity was significantly higher in G2 than in G1 (p < 0.001). Systolic and diastolic blood pressure were higher in G2 than in G1 (p < 0.001) and in G3 compared to G2 (p < 0.01) and the percentage of subjects with systolic or diastolic hypertension was higher in G2 than in G1 (p < 0.001).

Biological data
Both total cholesterol and triglyceride levels were higher in G2 than in G1 (p < 0.001) (Tab III). The prevalence of hypercholesterolemia and hypertriglyceridemia was also higher in G2 (p < 0.001).

Daily food intake, smoking habits and physical activity
The lack of a daily breakfast was more frequent in G2 than in G1 (p < 0.001) and in G3 than in G2 (p < 0.01).
### Table II
Family and personal medical history presented as percentage in the G1, G2, G3 groups.

<table>
<thead>
<tr>
<th>Medical history</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G1 vs G2</th>
<th>G2 vs G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 2,150</td>
<td>n = 1,310</td>
<td>n = 299</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>5.5</td>
<td>10.6</td>
<td>18.1</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>High Blood Pressure (A)</td>
<td>12.6</td>
<td>12.0</td>
<td>13.4</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Angina Pectoris (B)</td>
<td>1.8</td>
<td>2.1</td>
<td>2.0</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Myocardial Infarction (C)</td>
<td>6.1</td>
<td>7.4</td>
<td>5.4</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Stroke (D)</td>
<td>5.3</td>
<td>4.7</td>
<td>3.7</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>(A) or (B) or (C) or (D)</td>
<td>20.0</td>
<td>20.7</td>
<td>19.4</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Personal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipid lowering drugs</td>
<td>9.8</td>
<td>8.3</td>
<td>13.7</td>
<td>NS</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Anti-hypertensive drugs (A')</td>
<td>8.3</td>
<td>13.6</td>
<td>16.4</td>
<td>&lt; 0.001</td>
<td>NS</td>
</tr>
<tr>
<td>Angina Pectoris (B')</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Myocardial Infarction (C')</td>
<td>0.9</td>
<td>1.0</td>
<td>0.3</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Peripheral vascular disease (D')</td>
<td>0.5</td>
<td>0.3</td>
<td>0.0</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>(A') or (B') or (C') or (D')</td>
<td>9.0</td>
<td>14.2</td>
<td>16.4</td>
<td>&lt; 0.001</td>
<td>NS</td>
</tr>
</tbody>
</table>

*: chi² test or Fischer exact test
NS: p ≥ 0.05
G1: normal glycaemia < 6.1 mmol/l
G2: impaired fasting glycaemia [6.1-6.9 mmol/l]
G3: new diabetics [7.0 to 7.7 mmol/l].

### Table III
Clinical ad biological data presented as mean ± S.D. or percentage in the G1, G2, G3 groups.

<table>
<thead>
<tr>
<th>Clinical data and lipid profile</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G1 vs G2</th>
<th>G2 vs G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 2,150</td>
<td>n = 1,310</td>
<td>n = 299</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index</td>
<td>kg/m²</td>
<td>25.3 ± 3.3</td>
<td>26.8 ± 3.6</td>
<td>27.6 ± 4.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Body mass index &gt; 27 kg/m²</td>
<td>%</td>
<td>27.0</td>
<td>43.7</td>
<td>51.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Waist/hip ratio</td>
<td>%</td>
<td>0.92 ± 0.07</td>
<td>0.95 ± 0.07</td>
<td>0.96 ± 0.06</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Waist/hip ratio ≥ 1</td>
<td>%</td>
<td>13.2</td>
<td>22.1</td>
<td>23.8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Systolic Blood Pressure (SBP)</td>
<td>mmHg</td>
<td>133.2 ± 13.7</td>
<td>138.7 ± 15.7</td>
<td>141.8 ± 17.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (DBP)</td>
<td>mmHg</td>
<td>80.8 ± 9.9</td>
<td>83.2 ± 10.5</td>
<td>85.3 ± 10.9</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SBP ≥ 140 or DBP ≥ 90 mm Hg</td>
<td>%</td>
<td>40.8</td>
<td>56.8</td>
<td>62.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Total cholesterol (mmol/l)</td>
<td>mmol/l</td>
<td>5.83 ± 0.99</td>
<td>6.04 ± 1.04</td>
<td>6.07 ± 0.99</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Total cholesterol ≥ 6.5 mmol/l (A)</td>
<td>%</td>
<td>24.3</td>
<td>30.1</td>
<td>30.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>mmol/l</td>
<td>1.03 ± 0.74</td>
<td>1.27 ± 0.92</td>
<td>1.43 ± 1.05</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Triglycerides ≥ 1.76 mmol/l (B)</td>
<td>%</td>
<td>9.9</td>
<td>19.6</td>
<td>24.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(A) or (B)</td>
<td>%</td>
<td>29.3</td>
<td>39.3</td>
<td>42.8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(A) and (B)</td>
<td>%</td>
<td>4.7</td>
<td>10.2</td>
<td>11.7</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

*: chi² test or Fischer exact test or Mann-Whitney U test
NS: p ≥ 0.05
G1: normal glycaemia < 6.1 mmol/l
G2: impaired fasting glycaemia [6.1-6.9 mmol/l]
G3: new diabetics [7.0 to 7.7 mmol/l].
The daily consumption of milk products was less frequent in G2 than in G1 ($p < 0.001$) and in G3 than in G2 ($p < 0.05$). Daily consumption of sugar cubes and sweet drinks was lower in G2 than in G1 ($p < 0.001$ and $p < 0.05$ respectively). Mean daily alcohol consumption was higher in G2 than in G1 ($p < 0.001$). No statistical difference existed between groups for smoking habits and physical activity.

Further analysis of the data excluding subjects with a family history of diabetes mellitus and subjects taking blood lipid lowering drugs or anti-hypertensive drugs was performed. Results concerning educational level, food intake, smoking habits, physical activity, clinical and biological status were unchanged (data not shown).

**Discussion**

We studied a large group of male volunteers to determine clinical, biological and lifestyle characteristics of subjects with impaired fasting glycaemia. According to age and socio-educational status, our population cannot be considered as strictly representative of the French population aged 20-74 compared to the national statistical data [25]. Some remarks have to be taken into account. The participants were people insured by the French Social Security System, which includes 85% of the French population who volunteered for health examination. Subjects aged less than 30 years (17% vs national 23%) and particularly those aged over 59 years (7% vs national 19%) were poorly represented. A higher educational level was observed in our studied group than in the French population (19% vs national 14% had university degrees). This could minor the number of unknown diabetics found [26]. However, our population is similar to the French population for dietary habits [27] and prevalence of obesity [28]. The prevalence of impaired fasting glycaemia in our population was 9.5%. In our study, fasting plasma glucose was measured only once and this could be a limitation. Fasting glycaemia is less subject to intra-individual variation and is more reproducible than the 2-hour glycaemia following an oral glucose challenge [29]. Moreover, recent studies have shown that a blood glucose concentration in the upper value of the normal range is nevertheless a risk factor for cardiovascular mortality in middle-aged non-diabetic men [17, 19]. To the best of our knowledge, our study is the first one to give the frequency of impaired fasting glycaemia in a large group of men in France: 9.5%. In the third National Health And Nutrition Examination Survey (NHANES III), the prevalence of impaired fasting glycaemia was 10.1% [30]. Most of the published studies concerning impaired glucose tolerance after an oral glucose tolerance test evaluate its role as a cardiovascular risk factor. With this approach, in NHANES II and in NHANES III, the prevalence of impaired glucose tolerance

**Table IV**

Food intake, tobacco and physical activity presented as percentage or mean ± S.D.in the G1, G2, G3 groups.

<table>
<thead>
<tr>
<th>Habits</th>
<th>G1 (n = 2,150)</th>
<th>G2 (n = 1,310)</th>
<th>G3 (n = 299)</th>
<th>G1 vs G2</th>
<th>G2 vs G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No daily breakfast %</td>
<td>18.2</td>
<td>27.2</td>
<td>34.7</td>
<td>$&lt; 0.001$</td>
<td>$&lt; 0.05$</td>
</tr>
<tr>
<td>No lunch &gt; once a week</td>
<td>4.0</td>
<td>4.0</td>
<td>4.8</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fried food &gt; once a week</td>
<td>13.1</td>
<td>11.8</td>
<td>15.5</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Meat &gt; 100 g/day %</td>
<td>76.7</td>
<td>78.7</td>
<td>81.4</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Eggs &gt; 3/week %</td>
<td>25.3</td>
<td>27.5</td>
<td>31.5</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>No daily milk products %</td>
<td>31.9</td>
<td>38.4</td>
<td>45.1</td>
<td>$&lt; 0.001$</td>
<td>$&lt; 0.05$</td>
</tr>
<tr>
<td>Sugar cubes &gt; 2/day %</td>
<td>46.8</td>
<td>40.7</td>
<td>36.2</td>
<td>$&lt; 0.001$</td>
<td>NS</td>
</tr>
<tr>
<td>Sweet drinks every day %</td>
<td>37.5</td>
<td>34.0</td>
<td>35.0</td>
<td>$&lt; 0.05$</td>
<td>NS</td>
</tr>
<tr>
<td>Wine every day %</td>
<td>61.5</td>
<td>70.1</td>
<td>73.3</td>
<td>$&lt; 0.001$</td>
<td>NS</td>
</tr>
<tr>
<td>Beer, cider every day %</td>
<td>26.4</td>
<td>32.3</td>
<td>31.3</td>
<td>$&lt; 0.001$</td>
<td>NS</td>
</tr>
<tr>
<td>Aperitives, liqueurs &gt; 5/week %</td>
<td>7.0</td>
<td>11.0</td>
<td>12.0</td>
<td>$&lt; 0.001$</td>
<td>NS</td>
</tr>
<tr>
<td>Alcohol g/day</td>
<td>25 ± 21</td>
<td>31 ± 23</td>
<td>35 ± 25</td>
<td>$&lt; 0.001$</td>
<td>$&lt; 0.05$</td>
</tr>
<tr>
<td>Energy intake kcal/day</td>
<td>2,538 ± 386</td>
<td>2,563 ± 392</td>
<td>2,612 ± 429</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fat g/day</td>
<td>98 ± 17</td>
<td>99 ± 17</td>
<td>102 ± 19</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Cholesterol mg/day</td>
<td>439 ± 79</td>
<td>445 ± 80</td>
<td>456 ± 86</td>
<td>NS</td>
<td>$&lt; 0.05$</td>
</tr>
<tr>
<td>Sucrose g/day</td>
<td>58 ± 21</td>
<td>57 ± 20</td>
<td>56 ± 18</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Regular cigarette smoker%</td>
<td>24.2</td>
<td>24.2</td>
<td>28.6</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Walking &gt; 1 hour/day %</td>
<td>63.7</td>
<td>60.7</td>
<td>59.0</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*: chi² test or Fischer test or Mann-Whitney U test, NS: $p \geq 0.05$, G1: normal glycaemia < 6.1 mmol/l, G2: impaired fasting glycaemia [6.1-6.9 mmol/l], G3: new diabetics [7.0 to 7.7 mmol/l].
is 11.2% and 15.6% respectively [31]. In the Paris Prospective Study, the prevalence of impaired glucose tolerance was 9.9% [32]. It should be mentioned that subjects with impaired glucose tolerance or impaired fasting glycaemia are not the same [33-35] and that 70% of people considered as having impaired glucose tolerance in NHANES III had normal fasting glycaemia according to the American Diabetes Association criteria [31]. However, a recent study from the San Antonio Heart Study shows that impaired glucose tolerance and impaired fasting glycaemia are both significantly associated with the development of diabetes mellitus [36]. We observed that a family history of diabetes mellitus was associated with impaired fasting glycaemia. Present in 5.5% of the cases in group G1, this proportion rose significantly to 10.6% in G2 and 18.1% in G3. In our study, we looked for several components of the metabolic syndrome associated with type 2 diabetes mellitus. There were more hypertensive subjects in G2 (56.8%) than in G1 (40.8%) and more subjects taking anti-hypertensive drugs (13.6% vs 8.3% respectively). Hypertension is frequent in newly diagnosed type 2 diabetic subjects and in most subjects, high blood pressure occurs many years before an increase in plasma glucose [37]. The proportion of hypertensive subjects did not differ between G2 and G3. The link between insulin resistance and hypertension is supposed to be a major point in the apparition of cardiovascular disease [38]. A recent study has shown that a slight reduction of blood pressure significantly reduces the risk of cardiovascular events [39]. According to these data, hypertensive subjects in G2 might be at an increased risk of cardiovascular disease [40]. Increased body mass index with high waist/hip ratio is another characteristic of the metabolic syndrome and is highly correlated with insulin resistance and the emergence of type 2 diabetes mellitus [38]. Subjects in G2 had a higher body mass index and waist/hip ratio than those in G1, suggesting a predisposition to develop diabetes mellitus and cardiovascular disease. In the D.E.S.I.R. study, the body mass index also increased with the fasting plasma glucose levels [41]. In the Paris Prospective Study, whatever the fasting plasma glycaemia, the risk for developing type 2 diabetes mellitus is higher in subjects with the highest body mass index at the start of the study [42].

The lipid profile in G2 also favored an increased risk of cardiovascular complications. Indeed, nearly 40% of the subjects in G2 had high plasma cholesterol or high triglyceride levels. The hallmark of type 2 diabetic dyslipidemia is the tendency to high VLDL triglyceride levels and low HDL concentrations [43]. The causal role of hypertriglyceridemia on cardiovascular diseases is still debated [44, 45] but low HDL-cholesterol level is an independent risk factor and is closely linked to the increase of VLDL triglycerides. Thus, considering cholesterol and triglyceride levels, one can speculate that a significant percentage of subjects in G2 would be at a higher risk of cardiovascular disease, although we did not measure HDL cholesterol levels.

The lipid profile encountered in type 2 diabetes mellitus is explained in part by overweight and diet. In particular, a diet with high glucose intake and alcohol consumption leads to high triglyceride levels [46]. Although energy intake was not different between the 3 groups, it should be noted that alcohol consumption was higher in G2 compared to G1 whatever the type of alcoholic drink (wine, beer or cider, aperitif or liqueur). This could be a factor which induces a higher triglyceride level, a greater waist/hip ratio over a long-term [47, 48] and increases cardiovascular risk [49]. The intake of sugar and sweet drinks was lower in G2 than in G1 and it is possible that some of these subjects with “upper-limit glycaemia” had previously been advised to reduce their consumption of sucrose but did not diminish alcohol intake. A recent study shows that the consumption of spirit is a significant factor in 24-hour energy intake increase [50]. It could be associated with overweight. The daily cholesterol intake tended to be higher in G2 compared to G1 and was significantly higher in G3 than in G2 (p < 0.05). No statistical difference was seen between the groups concerning total daily fat and total energy intake. These results could be puzzling compared to the increase in BMI and WHR across the 3 groups. A more detailed nutritional investigation by means of a dietetic interview might have revealed more substantial differences between groups. Although not different from other French reported data, total fat and cholesterol intakes were higher than the recommended consumption for a French population [27, 51]. It has been clearly demonstrated that diets with lipid-excess and low fiber content are associated with a higher risk of diabetes mellitus [52, 53]. Thus, the high proportion of daily fat intake in G2 associated with other risk factors of type 2 diabetes mellitus — overweight, family history of diabetes mellitus or abdominal obesity — is yet another factor favoring type 2 diabetes mellitus. Lastly, we want to highlight the fact that nearly 30% of subjects in G2 did not eat breakfast regularly, a proportion significantly higher than that observed for G1. This percentage was still increased in the group G3 (35%), and was nearly two-fold higher than in the group G1 (18%). Irregular feeding and “snacking” or other abnormal patterns of food consumption are considered as risk factors for overweight [54, 55] and subjects should be informed of the importance to eat regularly meals.

Finally, subjects in G2 were very similar in many aspects to subjects in G3 with newly diagnosed type 2 diabetes mellitus. Family history, clinical and biological data as well as patterns of food consumption observed in our G2 subjects are known to be factors leading to diabetes mellitus. We therefore believe that these subjects should be considered at risk and that weight control by appropriate diet and physical activity are important for preventing type 2 diabetes mellitus [56]. The difficulty of obtaining long-term weight loss and the effects of health beliefs in this domain [57-59] are in favor of early specific interventions to reduce the incidence of ab-
dominal obesity and its metabolic and cardiovascular complications. Early screening for type 2 diabetes mellitus should reduce the cost and the burden of this disease [60]. Recent data have clearly shown that impaired fasting glycaemia and impaired glucose tolerance select different groups and that mortality is higher in the group with impaired glucose tolerance [61]. Other studies suggested that parameters such as glycated haemoglobin which still requires interlaboratories standardization will be useful to early identify subjects at high-risk for type 2 diabetes [41, 62]. Further prospective studies are needed to better diagnose and follow these subjects and to assess their outcome [34] especially cardiovascular morbidity and mortality. In this regard, the follow-up of subjects with impaired fasting glycaemia during a long period should provide findings to answer these questions and this work is currently ongoing.

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References


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