European Journal of Clinical Nutrition (2010) 64, 350–355

0954-3007/10 $32.00
www.nature.com/ejcn

EJCN Open

ORIGINAL ARTICLE

A study of fluid intake from beverages in a sample of healthy French children, adolescents and adults

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Background/Objectives: To assess the intake of fluid in healthy French children, adolescents, adults and seniors, considering amounts, types of beverages, time and place of consumption.
Subjects/Methods: Data regarding fluid intake were extracted and analyzed from the National Intake Survey, which was conducted in quota samples of the French population (Comportement et Consommations Alimentaires en France study). Seven-day questionnaires were administered to free-living individuals in 2002–2003. A total of 566 children (aged 6–11 years), 333 adolescents (aged 12–19 years), 831 adults (aged 20–54 years) and 443 seniors (aged $\geqslant$55 years) were included in this study.
Results: The average total intake of fluid was 1–1.3 l per day depending on age groups. Water accounted for about one-half of daily fluid intake. The contribution of other types of beverages varied with age (for example, dairy drinks in children and adolescents; alcoholic drinks in adults and seniors). Intake of sodas (including regular and light) was highest in adolescents (169 ml a day). Beverages were mainly consumed at home during meals.
Conclusions: This is the first description of fluid intake in French children, adolescents, adults and seniors, considering amounts, types of beverages, time and place of intake. It shows that water is the main source of fluid in all age groups. Selection of various types of beverages is different according to age.
European Journal of Clinical Nutrition (2010) **64,** 350–355; doi:10.1038/ejcn.2010.4; published online 17 February 2010

Keywords: fluid intake; children; adolescents; adults; seniors

Introduction

Body hydration is essential for adequate physical and mental function. A number of symptoms have been described corresponding to various degrees of dehydration. Whereas mild dehydration can result in adverse effects on both mental and physical performance, more severe dehydration induces important impairment of survival capacity and, ultimately can lead to death (Lieberman, 2007). In elderly individuals, one important effect of dehydration is an alteration of many crucial physical and mental functions that affect life expectancy (Ferry, 2005; Szinnai *et al.*, 2005; Mentes, 2006). Similar, although not as dramatic, results have also been reported in children (D'Anci *et al.*, 2006).

Fluid needs vary in the human species depending on a large number of factors. Age and body size are important, as well as level of perspiration (affected by temperature and intensity of physical exercise, among many factors) and food habits (such as intake of salt), in addition to other individual or environmental contributors (Lieberman, 2007; Manz, 2007). Given this large inter-individual variability of needs, it is difficult to propose recommendations for the general public, as has been done in many countries for energy and nutrient intakes.

The French national recommendations for daily fluid intake encourage a level of intake adequate for body weight, age, physical activity and other factors (Martin, 2001). For adults, it is stated that fluid intake should be sufficient to

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Contributors: MT initiated and supervised this research. The database was collected under the responsibility of PH. Statistical analyses were carried out by MD. FB and ST identified the critical parameters to be investigated, analyzed and interpreted the data, and wrote the manuscript.
Received 7 November 2008; revised 24 June 2009; accepted 24 August 2009; published online 17 February 2010

cover daily needs that vary according to each individual's characteristics and lifestyle. Seniors should be particularly careful that their fluid intake is sufficient, as dehydration can have dramatic consequences. In addition to fluid intake from drinks, about one more liter of water should be obtained from the fluid contained in ingested foods, so that under the usual conditions, the total daily intake of fluid should be ~2.6 l (Martin, 2001).

In spite of the general consensus that an appropriate level of fluid intake is of paramount importance for health and even survival, the actual intake of fluid or total water is not often reported as such in studies of food or nutrient intakes. A study of water intake in the participants of the NHANES (National Health and Nutrition Examination Survey) 1999–2002 indicated a mean total water intake (from foods and beverages) of ~1.4 l a day in children and adolescents (4–18 years) and of 2 l in adults (Fulgoni, 2007). Plain drinking water contributed to more than half of this total intake (0.78 l in 4–18 year olds; 1.28 l in adults). By contrast, in a recent study of beverage intake in American preschool children, beverage intake was examined but water intake was excluded, because water is not part of the US Department of Agriculture's Food and Nutrient Database categories (O'Connor *et al*., 2006). Clearly, more information is required regarding the total fluid intake of populations, whether or not it is associated with the intake of nutrients.

This study presents the self-reported intake of beverages, recorded in a quota sample recruited to be representative of the general population in France. Intake in different age groups was assessed: children, adolescents, adults and seniors.

Methods

Participants

The sample included in this was a subset of the participants in a national survey conducted by the CREDOC (Centre de Recherche pour l'Etude et l'Observation des Conditions de Vie), a nonprofit governmental research organization whose goal is to follow living conditions in France. The national survey dealt with food/beverage choices and intake in France (Comportements et Consommations Alimentaires en France, CCAF study). Previous papers have been published to present some of the results obtained from this particular survey (Hébel, 2007). The survey was carried out between fall 2002 and summer 2003 and included 1042 families, representative of French households. All family members aged $\geqslant 3$ years were interviewed. To have a sufficient number of children, an additional sample of 622 households was constituted in which only 1 child was interviewed.

The details of participant recruitment have been described fully in an earlier paper (Hébel, 2007). In brief, on the basis of a quota sample of the French population, 1361 adults ($\geqslant 15$ years) were included. The energy intake reported by these adults was consistent with the estimated energy needs (1.05 times the metabolic rate), in accordance with earlier CREDOC studies, such as the INCA (Enquête Individuelle et Nationale sur les Consommations Alimentaires) survey of 1999 (Volatier, 2000) and the ASPCC (Association Sucre-Produits Sucrés Communication Consommation) 1994 survey (Volatier and Verger, 1999). Subjects were excluded if their reported intake was inconsistent with the estimated energy needs. Among excluded subjects, the proportion of overweight and obese individuals (body mass index >25 kg/m^2) was larger than among the included participants ($\chi^2=30$; $P<0.00001$). Gender distribution and education level were not different between the included and excluded subjects. A group of 1090 children (aged 3–14 years) were also included in the CCAF study.

From the participants in the CCAF study, a sample was extracted to study fluid intake in several age groups. The final sample for this analysis comprised 566 children (aged 6–11 years), 333 adolescents (aged 12–19 years), 831 adults (aged 20–54 years) and 443 seniors ($\geqslant 55$ years). Weight and height, physical activity and sedentary behaviour were reported in the questionnaires. Data for children were obtained either from the parents or from the children themselves.

Seven-day intake

Intake was assessed on the basis of a 7-day report of all intakes (fluid and solid), with recording of occasions, circumstances, location, people present, etc. This survey allowed a highly detailed analysis of food and beverage consumption. Food and portion reporting was made easier by the use of a validated reference book showing various portions of the common food and beverage choices (Suvimax, 2000).

Special attention was devoted to beverages. Six categories of beverages were considered: water (all kinds), hot beverages (tea, coffee, etc.), sodas (regular or 'light'), dairy drinks, juices and fruit-flavored drinks, as well as alcoholic beverages. As an inherent part of the CCAF study, energy and nutrient intakes were also studied, as well as the circumstances of each intake occasion. The content in energy and nutrients (including water) was obtained from a French food composition table (Favier *et al*., 1995).

To control for seasonal differences in intake, the study was carried out in four phases (October–December, January–March, April–May and June–July). In each phase, the survey sample was representative of the French population.

Statistics

The statistical procedures used were the same as those used in earlier analyses in the context of the CCAF study. We used the generalized ranking procedure to improve the quality of estimators for each sample. The SAS 8.0 software was used for statistical analysis (SAS Institute Inc., Cary, NC, USA). The statistical procedures included PROC FREQ to assess the

Table 1 Daily intake of total fluid and of six types of beverages (ml) in four age groups (children (6–11 years), adolescents (12–19 years), adults (20–54 years) and seniors (⩾55 years)

	Children (6–11 years) n = *566*				*Adolescents (12–19 years)* n = *333*			
	Mean	*s.e.m.*	*Min*	*Max*	*Mean*	*s.e.m.*	*Min*	*Max*
Alcohol	0.6	0.2	0.0	57.1	16.8	2.8	0.0	311.4
Water	549.0	13.3	0.0	1818.6	577.8	17.8	0.0	2107.1
Hot drinks	6.7	1.3	0.0	385.7	28.6	4.5	0.0	585.7
Juice	128.4	6.4	0.0	1628.6	104.0	7.1	0.0	750.0
Sodas	114.5	6.9	0.0	1257.1	169.3	13.3	0.0	1640.0
Dairy drinks	246.7	6.3	0.0	1392.9	215.3	8.1	0.0	771.4
Total fluid	1046.0	15.2	372.9	2487.1	1111.8	20.7	404.3	2528.6
	Adults (20–54 years) n = *831*				*Seniors (⩾55 years)* n = *443*			
Alcohol	183.9	9.0	0.0	1528.6	185.6	10.9	0.0	1532.1
Water	564.2	13.9	0.0	3292.9	547.9	17.6	0.0	2028.6
Hot drinks	266.6	8.9	0.0	2548.6	250.1	11.3	0.0	1604.3
Juice	54.0	3.1	0.0	607.1	33.2	3.8	0.0	471.4
Sodas	92.9	6.0	0.0	1650.0	16.7	3.0	0.0	612.9
Dairy drinks	144.4	6.1	0.0	1165.7	164.2	8.5	0.0	842.9
Total fluid	1306.0	16.6	415.7	4315.7	1197.7	20.2	387.1	2902.1

Abbreviations: CCAF, Comportements et Consommations Alimentaires en France; CREDOC, Centre de Recherche pour l'Etude et l'Observation des Conditions de Vie. Means, s.e.m., lowest and highest individual values are given for each group.
Source: CCAF 2004 Survey—CREDOC.

effects of independent variables on qualitative effects. Differences between proportions were tested using χ^2. To assess effects on quantitative variables (such as intakes), we used the generalized lineal model (PROC GLM) and Student's *t*-tests. Means and s.e.m. are presented in text and in Tables.

Results

Table 1 presents the average (± s.e.m.) daily fluid intake from beverages, as well as the minimum and maximum intakes recorded in each age group. The first observation is that inter-individual differences were extremely large in all age groups. Differences in fluid intake appeared between the successive survey phases in three age groups (children, adolescents and adults; $P \leqslant 0.0137$) but not in seniors. Fluid intake increased over successive study phases: in the last phase (June–July), the intake was 24 (children), 13 (adolescents) and 4% (adults) higher than during the first phase (October–December). The estimated amount of fluid ingested from solid foods was 593, 673, 719 and 819 ml in the four age groups, respectively.

Water represented about one-half of daily beverage intake in all groups. Dairy drinks contributed to ~20% of the total fluid intake in children and adolescents, whereas alcoholic beverages were consumed by adults and seniors. Sodas were consumed by all groups, but adolescents showed the highest intake (169.3 ml a day; 15% of daily fluid). In the case of sodas, it is impossible to discriminate the proportion of the reported intake that corresponded to regular (sugar containing) versus 'light' products. Although the respondents could report the intake of 'light' sodas, they did not necessarily do so. It is thus likely that the reported intake of sodas included a certain proportion of 'light' products, which were not necessarily identified as such. In France, it is not usual to give 'light' sodas to children. Consequently, the reported figure for children (114.5 ml) most likely represents intake of sugar-containing sodas. The intake of sodas (both sugar containing and light) by adults and seniors was very low (7 and 1.4% of daily fluid, respectively).

Table 2 shows that most beverages were ingested during main meals (breakfast, lunch and dinner), with small amounts consumed between meals. In children and adolescents, >10% of the total daily intake was consumed along with the afternoon snack, which is a traditional eating occasion for youths in France. The survey also showed that ~80% of total daily fluid intake was consumed at home. This was confirmed for each beverage type and age group. The total amount of energy ingested from beverages was 238, 239, 233, 194 kcal per day, representing 12.5, 10.8, 10.3, 9.2% of total energy intake in the four age groups, respectively. These figures were computed from data collected from the total sample (as opposed to data restricted to consumers of a certain type of beverage).

A few overweight or obese individuals were present in the sample, according to the definitions proposed by the WHO (1998) and the Obesity Task Force (Cole *et al*., 2000) ($N = 140$, $N = 40$, $N = 232$ and $N = 230$ in the four age groups, respectively). In this category of respondents, the total daily fluid intake was 1075.5, 1106.2, 1364.8 and 1225.3 ml per day, respectively, in the four age groups. The associated intake of energy was 236, 193, 256 198 kcal per day, respectively. Those numbers are extremely close to those observed for the

Table 2 Intake of beverages (ml) at various occasions according to age groups

	Children (6–11 years) n = *566*		*Adolescents (12–19 years)* n = *333*	
	Mean	*s.e.m.*	*Mean*	*s.e.m.*
Breakfast	274.1	4.9	280.6	5.8
Morning snack	8.3	1.2	8.5	1.6
Lunch	285.1	5.6	324.7	7.7
Afternoon snack	161.9	4.2	119.0	5.7
Before dinner snack	29.5	2.9	30.2	3.9
Dinner	277.9	5.3	341.1	8.6
Night snack	9.3	1.7	7.7	1.8
Total fluid	1046.0	15.2	1111.8	20.7
	Adults (20–54 years) n = *831*		*Seniors (⩾55 years)* n = *443*	
Breakfast	325.7	5.1	325.5	6.8
Morning snack	27.1	2.6	17.5	3.6
Lunch	407.0	6.2	386.1	8.0
Afternoon snack	59.7	3.2	59.6	4.3
Before dinner snack	67.8	5.0	64.7	6.5
Dinner	395.8	6.2	330.4	7.4
Night snack	22.9	2.7	13.9	2.4
Total fluid	1306.0	16.6	1197.7	20.2

Abbreviations: CCAF, Comportements et Consommations Alimentaires en France; CREDOC, Centre de Recherche pour l'Etude et l'Observation des Conditions de Vie.
Source: CCAF 2004 Survey—CREDOC.

whole sample (within the range mean ± s.e.m.), suggesting no statistical difference.

Discussion

This study addresses ingestion of beverages in a quota-based sample of the French population. The total amount of fluid is examined in the four age groups, along with the type of beverages contributing to this total input, and the circumstances of intake. Attention was paid to fluid intake in overweight respondents.

The intake data presented in this study were declared by the participants or by a parent in the case of children. This survey method, as used in the cross-sectional French INCA1 food consumption survey, is recognized as the best method to evaluate intakes in a representative sample (Lioret *et al*., 2007). The data agree with other sources of information about beverage intake in the French. For example, the 2006 CANADEAN unpublished report for the food and drink industry reveals a soda consumption of 124.3 ml per day per capita, whereas our respondents declared ~100 ml per day. However, in certain cases, the possibility of some underdeclaration cannot be ruled out. For example, there might be some underdeclaration for alcohol intake, because of social overtones.

The largest part of fluid intake, in all age groups, is from water. Most beverage intake (water and other categories) occurs with meals and is consumed at home. Beyond this very general observation, it seems that beverage choices vary with age. Soda intake is mainly reported by teenagers, whereas alcoholic drinks and hot drinks (mainly tea and coffee) are reported by adults and seniors. Dairy drinks (mainly milk) contribute to the fluid intake of children and adolescents.

Our data are difficult to compare with those reported for the American participants in the NHANES 1999–2002. While total water intake (foods plus beverages) was 1.4 l in American children (up to the age of 18 years) and 2 l for adults, the reported plain water intake was 0.8 l in children and 1.2 l for adults. These figures indicate higher fluid intakes in the French (as the beverage intake in the French was just below the total intake from foods plus beverages in the Americans), but the intake of plain water was higher in Americans (Fulgoni, 2007). This apparent inconsistency might be derived from the fact that total water intake in the American sample was computed on the basis of a 24 h recall of intake, and plain water data were extrapolated from a food frequency question. Intake of sodas reported in this study agrees with the observation made by the CANADEAN organisation (Hants, UK; 2006 unpublished report) showing that the French ingest smaller amounts of sodas than do comparable populations of 15 other European countries.

These data indicate that energy from beverages represents 200–250 kcal a day, or ~10% of daily energy intake. There are large variations around the mean. In some individuals, in all age groups, the energy input from fluids can be relatively large. However, it is impossible to decide whether such intake represents an adequate complement to the energy obtained from solid foods or comes in excess of body energy needs. Intake of energy from liquids and solids contributes to the body energy balance and can induce weight gain or weight loss only if it does not match individual energy needs. Therefore, the intake of energy from fluids appears modest on average, although it may in some cases contribute to excessive intake of energy relative to body needs.

Given the large variations around mean values, it seems that some people might be at risk of insufficient hydration. This situation could potentially induce adverse effects in the short and long term. There may be a potentially adverse effect on the cardiovascular system (see below). The consequences of dehydration are an increase in blood osmolality and a decrease in blood volume or hypovolemia. In response to these physiological events, the body releases three hormones (namely antidiuretic hormone, angiotensin and aldosterone), in an attempt to try and maintain the blood supply to the brain and other essential organs. It is interesting to note that antihypertensive medication is currently prescribed against these very same hormones (Deedwania, 2007; Nesbitt, 2007). In 2002, a meeting was organized in Dortmund to study the physiological effects of mild dehydration, yet the majority of presentations showed the benefits of increased consumption of fluid, be it at the level of cognition (Wilson and Morley, 2003), exercise performance (Maughan, 2003), urolithiasis

(Siener and Hesse, 2003), urinary tract infection (Beetz, 2003), dental disease (Smith and Shaw, 2003), constipation (Arnaud, 2003) or even broncho-pulmonary infection (Kalhoff, 2003). Such reports are the outcome of scientific studies, rather than 'urban myths found on the Internet' (Negoianu and Goldfarb, 2008).

Classic 'recommendations', such as 'at least 8×8 ounce glasses of water per day', have been questioned in an elaborate review by Valtin (2002). However, although there seems to be little scientific support for such recommendations, there is no evidence to show that drinking such a level of fluid might be bad for health. Recently, experts have suggested that such a level of intake may actually be insufficient to appropriately cover bodily needs, even in a sedentary middle-aged individual living in a temperate environment. As much as 3 l of fluid daily have been recommended recently by American experts (Institute of Medicine of the National Academies, 2004). This report did not specify the exact requirements for water intake, but set general recommendations for women at $\sim$2.7 l of total water—from all beverages and foods—each day, and for men an average of $\sim$3.7 l of total water. The panel did not set an upper level for water.

This report is the first specific description of beverage intake among the French, based on a quota sample of the population. Differences have appeared between the four age groups in the selection of various types of beverages, as well as consistencies (the major part of daily fluid intake is water). The proportion of daily energy obtained from drinks (all types combined) is $\sim$10%. Wide variations are observed around mean values, suggesting that fluid intake could be insufficient in some people, or that energy intake from fluids might contribute significantly to adequate or inadequate total energy intake. Longitudinal studies should be carried out in different populations (different countries, different age groups, different socioeconomic levels, etc.) to determine whether the chronic contribution of beverages does impact health or body weight control, as suggested in studies examining the longitudinal changes in body weight associated with the intake of energy-containing drinks (Ludwig *et al*., 2001; Schulze *et al*., 2004; Stookey *et al*., 2008; Wang *et al*., 2009).

Conflict of interest

Maha Tahiri was an employee of Coca-Cola France at the time of the study. France Bellisle is a consultant for Coca-Cola.

Acknowledgements

The extraction and analysis of data about beverage intakes collected in the context of the CCAF study, carried out by the CREDOC and the preparation of this paper were supported by a grant from Coca-Cola.

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