Original Article

Volume, frequency and participation in plain drinking water consumption by third and fourth-grade schoolchildren in Quetzaltenango, Guatemala

Raquel Campos BS[1], Gabriela Montenegro-Bethancourt MSc[1], Marieke Vossenaar PhD[1], Colleen M Doak PhD[2], Noel W Solomons MD[1]

[1]*Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), Guatemala*
[2]*Institute of Health Sciences, Faculty of Earth and Life Sciences, Vrije Universiteit, Amsterdam, Netherlands*

Water intake was described and quantified in samples of urban Guatemalan schoolchildren stratified by gender and socio-economic status. The frequency of consumption and quantity of plain water drinking was estimated from one-day pictorial registries of all beverages, foods and snacks consumed over a 24-h period collected from 449 3rd and 4th graders from two social classes: 230 from higher SES and 219 from lower SES. Plain water was reported by 28.1% of participants on the day of registry. Quantities consumed ranged from 250 to 2250 ml. For the 449 one-day intake records, a cumulative total of 62,000 mL of water consumption was reported. This constitutes an average of 138 ± 289 ml across all participants but, when divided by for water consumers only, the mean is 492 ± 352 ml. Given the relatively low percentage of children consuming water, more attention is needed to ensure freely available, safe, drinking water in the school environment.

Key Words: drinking water, beverage choice, schoolchildren, 24-h food record, Guatemala

INTRODUCTION

Water has been termed the "silent nutrient".[1] With the highest specific demand of any nutrient in the body, constituting 50-70% of body weight,[2,3] and required on a continuous basis to replace obligatory losses in urine, stools, transpiration and perspiration. Given sufficient access to water, from the water created in metabolism, the moisture in foods and dishes, and the water in beverages,[4] the kidney can regulate water stores and maintain normal hydration.[5] Intense exercise[6,7] and high temperature[8] increase water losses and challenge the regulatory process.

Plain drinking water, obtained from condensation of rain water, snow, ice, static collections (puddles, ponds, lakes), flowing sources (springs, streams, rivers) and even condensation of dew on plants, was the original and major beverage for human consumption, being joined by milk and yogurt with the dawn of the pastoralist age, 40,000 year ago. It remained such until the dawn of the agricultural age, 10,000 years ago, when cultivation of plants allowed for juices, and fermented beverages from fruits and grain.

The issues surrounding the provision and consumption of plain drinking water have taken on a life of their own in recent years. The growth of populations, pushing back of wilderness, and changing climatic conditions are currently jeopardizing the availability of sources of potable water.[9] Chemical[10-12] and microbiological[13-15] contamination affect the drinking quality of the sources that remain. Essential scarcity aside, the bottling and consumption of drinking water, both for home and industrial use and for individual use, has expanded explosively among the affluent and those of modest incomes.[16,17] It is now realized that the choice of beverages is an important factor stemming the worldwide endemic of overweight and obesity. A United Nations panel defined certain foods and beverages of high energy density as among the main barriers to maintaining a healthy water weight.[18] It is obvious that plain drinking water is a zero-calorie beverage and the archetypical drink to be recommended for weight control. Various investigators have taken particular interest in the consumption of plain water, per se, alone[19-21] or in the context of other dietary beverages.[22-25] Some of them were particularly interested in what the behavior of selecting drinking implied for the general health and life-style behaviors of the consumers and non-consumers. We conducted a diet-intake survey, using a unique, pictorial self-registration approach to recording total, one-day dietary intake. Our purpose here was to present a descriptive analysis of the role of plain drinking water as part of the consumption patterns of young schoolchildren in an urban setting.

MATERIALS AND METHODS

Population

Quetzaltenango is a city of 127,600 inhabitants located in a mountain valley in the Western Highlands of Guatemala.

Corresponding Author: Dr Noel W Solomons, Center for Studies of Sensory Impairment, Aging and Metabolism, 17 Avenida #16-89(interior), Zona 11(Anillo Periferico), Guatemala City, 01011
Tel/Fax: +502-24733942
Email: cessiam@guate.net.gt
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The Quetzaltenango Province has an average annual temperature of 14^{o} and average annual precipitation of over a meter. It sits at an altitude of 2,333 meters above sea-level.

Subjects

We enrolled a total of 449 children, studying in the 3rd and 4th grades of 12 schools in the urban zones of Quetzaltenango City. Two-hundred thirty of the children were recruited from 7 private schools catering to affluent families, and have been defined as the higher socio-economic status (HSES) sub-sample; 219 were recruited from 5 public schools serving the majority low-income population, defined here as lower SES (LSES) sub-sample. The only exclusion criteria were self-proclaimed inability to comply with instructions or failure to present informed consent documentation or give verbal assent.

The Human Subjects Committee of the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) had approved the study protocol and permissions had been secured from the educational authorities at the district level and the individual schools. Parents or guardians signed a written informed consent form after a circular explaining of the nature, purpose, inconvenience, benefits and anonymity provisions had been distributed to the homes. In addition, children gave verbal assent to their own participation.

Dietary Intake Data Collection

Each participant filled in a 24-h registry of intake of all edible items consumed during the interval of interest for one single day in the course of the study; no child contributed more than one day's worth of data. We thus generated 449 individual child-registry days across the enrolled sample. This was performed in a pictorial manner, using a special 5-page workbook designed for the study. The first page contained a reminder of the instructions in simple language. Each of the following pages was blank sheets labeled in Spanish for the various repasts and meal settings of a day: breakfast; lunch; dinner; and snacks. Registries were made during school days, Monday through Thursday. School holidays and weekends were excluded. Each child received a box of coloring pencils both as an incentive for participation and to complete the task.

For the participation of a group of children, a staff research nutritionist provided detailed instructions for how the children were to make a pictorial record of the intake onto the pages of the workbook. On the following day, the registry was collected by the nutritionist and reviewed with the submitting subject. The depiction of each item was clarified and the quantities of items, in common measures were noted onto the collection form. Models of serving items were available for reference. If a child had failed to comply with the request, but was still interested in participation, he or she was enrolled into another cohort and given an additional opportunity to register a day's dietary intake.

Number of mentions for water consumption was based on the number of meals or snacks at which water was consumed, with a maximum allowed number of mentions as 4 per day (breakfast, lunch, dinner and combined snacks). Data were collected to determine, amongst water-consumers, the number of draughts, the meal-times of consumption, and the volume of water per drink reported over the course of the registry day. We view this pictorial method as a variant of a simple 24-h recall, a technique widely reported for children this age without specific validation. This pictorial approach was chosen because of its theoretical potential for reducing the memory (omission and substitution) errors for items and to provide a more exact estimation of portion sizes, but neither of these advantages has been formally demonstrated in a validation procedure.

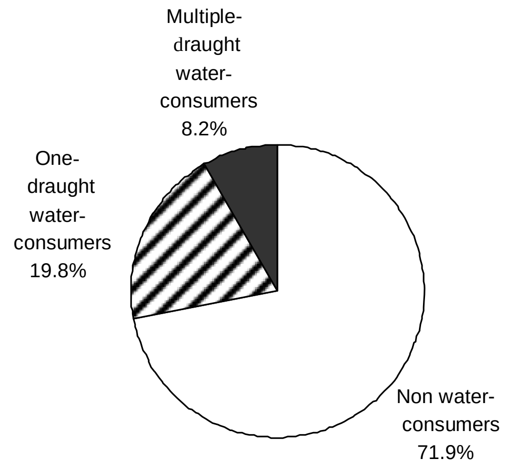

Figure 1. The pie-graph of the partition of the population into non-water-consumers, one-draught water-consumers and multiple-draught water-consumers among the 449 3rd and 4th grade subjects enrolled in the study.

Data Handling and Statistical Analysis

Percentages of non-water consumers, single- and multiple-draught water consumers were compared for the entire population of 449 registrants and stratified by gender and social class subgroups. Descriptive statistics were generated for the volume of drinking water recorded both for the entire sample and for the members who recorded drinking water on their 24-h registry. These included means ± standard deviation, minimum, median, and maximum values for the entire sample, stratified by gender and social class subgroups. In addition, the meal-time distribution (i.e. breakfast, lunch, dinner and combined snacks) of plain water was examined.

Differences in water intakes between SES were examined using one-way ANOVA or Mann-Whitney non-parametric test based on the distribution of the data. Differences in proportions were examined using chi-square test. A probability value of 5% or less was used to signify statistical significance.

RESULTS

At least one drink of plain water was reported on a total of 126 of the 449 child day registries, classifying 28.1% as water-consumers and 71.9% as non-consumers for the day of interest (Figure 1). This varied somewhat across social class, with 72 of 230 subjects from the HSES (31.3%) being water-consumers on the day of registry and 54 of 219 children of LSES (24.7%) within this category (p=0.120).

The frequency of water consumption recorded among the children is illustrated in Table 1. There was a single

Table 1. Distribution of non-water-consumers, one draught water- consumers and multiple-draught water-consumers as a percentage of the gender by socio-economic-status sub samples.

		No mentions (n=323)	One mention (n=89)	Multiple mentions (n=37)
HSES† (n=230)	Boys (n= 111)	85 (76.6%)‡	15 (13.5%)	11 (9.9%)
	Girls (n= 119)	73 (61.3%)	29 (24.4%)	17 (14.3%)
LSES‡ (n=219)	Boys (n= 106)	77 (72.6%)	21 (19.8%)	8 (7.5%)
	Girls (n= 113)	88 (77.9%)	24 (21.2%)	1 (0.9%)

†HSES= higher socio economic status; ‡ LSES = lower socio economic status. ‡ Percentages calculated across row.

Table 2. Comparison of the descriptive statistics of the volume of plain water (in ml) registered on the day of registry, disaggregated by the gender and socio-economic-status sub samples.

		All subjects (n= 449)		Water consumers (n= 126)	
		Volume in ml of water consumed	Min- Max	Volume in ml of water consumed	Min- Max
HSES†	Boys	131 ± 312 [0]	0-2000	558 ± 426 [500]	250-2000
	Girls	189 ± 289 [0]	0-1250	489 ± 263 [500]	250-1250
LSES‡	Boys	149 ± 341 [0]	0-2250	543 ± 463 [250]	250-2250
	Girls	82 ± 187 [0]	0-1250	370 ± 230 [250]	250-1250

Data presented as mean ± standard deviation [median]. †HSES= higher socio economic status; ‡ LSES = lower socio economic status

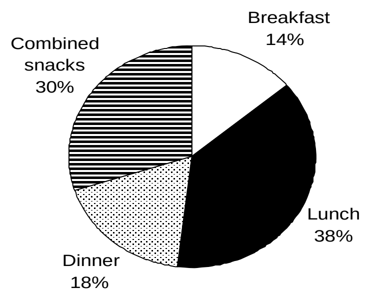

Figure 2. Mean percentage of plain water consumed per meal time among the 126 water-consumer children.

mention of water drinking in 44 of the 72 HSES consumers (61.1%), whereas 28 reported more than one draught of this liquid among the 54 LSES consumers (51.9%). Corresponding rates for one mention and multiple mentions of plain water in the 54 LSES consumers were 45 (83.3%) and 9 (16.7%), respectively. Thus, there was not only a tendency towards more consumers, but also towards more frequent mentions for plain water, in the children of greater economic means. Notably, only one LSES girl reported more than a single draught of water on a diet-registration day.

In terms of the total volume of water reported on the recorded days, this varied from none in 71.1% of the children who were classified as non-consumers for the day of registration to up to 2,250 ml in the highest consumer. An aggregate total of 62,000 ml of plain water was registered on the 449 records. The arithmetic mean for the water volume consumption by the entire sample was 138 ± 289 ml. For the 126 water-consumers in the sample, the arithmetic mean was 492 ± 352 ml. Table 2 presents the arithmetic mean values for all subjects and for the water-consumers in the subsamples. Comparison in the consumption of plain drinking water among water-consumers revealed no social class-related differences, although the LSES girls had a numerical deficit of about 100 ml compared to their more privileged counterparts (p<0.424).

It was of interest to examine the meal-time distribution of plain water consumption. The partition of the total volume of water consumed among the four repasts is illustrated in a pie-graph (Figure 2). Significant differences of consumption were found among each meal-time (p<0.001). As observed, lunch and snacks had predominantly higher percent proportion of water volume consumption, whereas dinner and breakfast were less. Consistently, the percentage of meals where plain water was reported as a beverage, water was consumed with almost 16% of the midday meals recorded, but only with 5% of the morning meals.

DISCUSSION

Adequate hydration status is clearly associated with better health and well-being.[26-29] There are, however, an array of foods and beverages that can provide water to maintain appropriate body water reserves,[4] but the focus of this inquiry has been on that portion of a day's hydration derived from plain drinking water. This can often be a source of protective nutrients such as iodine[30] and fluorine.[31] It has been speculated, moreover, that other trace elements in water, in addition to fluoride, can be beneficial to oral health.[32] Depending on the original sources, the conduits, and the handling in the home, plain water can pose health hazards from various microbiological [10-12] and toxic[13-15] contaminations.

Drinking plain water has been positively associated with various aspects of human Health,[33-36] although the nature of causality remains hard to extricate from the associations. However, the conduct of choosing a more appropriate beverage, with a greater proportion of plain water and low-caloric content, could merely be a component of a larger set of healthful eating and lifestyle practices.

In terms of associations at the macro level, two potentially contradictory facts meet the casual perusal. The greater net consumption and participation in consumption of plain drinking water is found among the HSES group. This is, however, the same class in which risk and prevalence of overweight was greater.[37] As such, the more telling analyses were generally those in which analyses were stratified by SES class.

It is extraordinarily rare to have a data collection that allows estimation of volumes of water intake. Much of the literature relates to inexact proxies such as bringing filled water bottles to school[36] [or consumption of *glasses* of water.[19-21] Our estimated mean intake of water, reported over a day, for water consumers was 492 ml. One point of comparison comes from a longitudinal study in Dortmund, Germany,[22] in which water consumption, specifically isolating *drinking* water was quantified in boys and girls with a mean age of 8.1 y using a 3-day record approach. Within tap or bottled water consumers, average daily consumption was 330 ml. This average intake is not materially different from the 344 ml for boys and 289 ml for girls in the 9 to 13 y age group for the entire duration of the Dortmund study,[23] taken in combination. Without a separate exclusion of those not consuming any plain water over the data-collection interval, however, a strict comparison with our findings is not possible.

Fulgoni[24] provided an analysis of the U.S. NHANES data for the 1999 to 20002 period, specifically focused on the age-group of 4 to 18 y among North American children. As reported by Popkin et al.[25] for that same period, 87% of the whole sample had consumed water on the day before interview. Hence, the median value for U.S. children might be a point of departure for comparison with the median value for our groups of water consumers. White children had a median intake of 470 ml, Hispanic children, 440 ml, and black children, 430 ml. These were all inferior to the 500 ml median of our more privileged sample and superior to the low-income group. Additional insight might be obtained from a survey in a suburb of Stockholm, Sweden.[21] It is limited in comparability in three respects, as it was: 1. performed in response to a water-borne diarrheal outbreak; 2. limited its interest to cold, tap water consumed in the home; and 3. inquired as to the usual number of 200 ml glasses consumed daily to create the quantitative estimate. For children 9 to 18 years, mean cold, tap water consumption was 590 ± 190 ml, as averaged across a sample of 18 subjects and without adjustment for water non-consumers. Bottled water was also consumed in this community; since this source was not a safety issue for the survey, however, it was excluded from consideration in this Swedish investigation.

In terms of *acceptable* intakes of plain water, a commentary on recommendations for adults in the U.S. population consuming a 2,200 kcal diet has recently appeared;[38] this ranged from 600 to 1,500 ml. Since the median energy intake for our population was 1,870 kcal, the range would be adjusted downward to 510 to 1,275 for the schoolchildren of interest. Obviously, those children with no plain water intake would all fall short of meeting the acceptable level on the day of registry. Among the 126 water consumers, 44 (35.3%) reported an intake that would enter into the acceptable range for this age group. Water intake recommendations for schoolchildren could be derived in a similar manner from the recent publication for the population of the neighboring republic of Mexico;[39] they only stipulate an *ideal* daily water intake which is much higher than the acceptable level from the U.S. Needless to say, even fewer of our subjects would meet this more demanding standard.

Interestingly, across the whole-sample level, a report of consumption of plain water on the recorded day was associated with consuming less dietary energy on that day. This replicates the observation of Stookey,[40] from a survey of 3-day measured dietary intake in over 5,700 hundred Chinese adults. When water and energy intake is considered for the same time frame, as here and in China,[40] we cannot discount a reverse-causality scenario for such a finding, i.e. people who were not feeling well on their day(s) of intake registry consumed less than usual and were drinking plain water as a response to illness. Looking at more optimistic rationales, however, we can embrace both the water drinking as a marker notion, i.e. those with modest and appropriate energy intakes also practice plain water consumption as part of an overall healthful pattern, and water drinking as a modulator of appetite, i.e. drinking plain water curbs the total caloric intake. Lending credence to the optimistic scenarios, and even to a regulatory effect in energy balance, are the concurrent associations in the same population of a lower body mass index status among those on the water-consumer side of the sample, at least as found in the higher SES group. There are a series of interventions that operate on the assumption that increasing the intake of plain water would directly or indirectly contribute to lower rates of excess weight in children.[23,35,36] The strongest empirical evidence for the validity of this association comes, again, from the findings of Stookey[40] in the Chinese survey, in which water intake independently explained the effects of energy density on risk of overweight.

We recognize and acknowledge a series of limitations in the research design and methods of our study; some of these extend to the comparative literature, as well. The pictorial workbook method represents a prospective and recorded variant of a collection of self-reported intake over 24-h. We have applied it in child participants with the notion that errors of omission or substitution will be lower than with a recall approach. As with most 24-h approaches in children,[41,42] however, it has not been validated against other dietary intake methods. In fact, it may specifically be with pictorial representation of intake that cover plain drinking water that we would run into a weakness with quantitative water estimation. Young children are known to slake their thirst by taking sips of water from drinking fountains, directly from a faucet, and even from outdoor sprinklers and gardening hoses. These are taken away from meal-time, and do not involve any vessel that could be represented in a picture. Hence, we recognize a limitation in our approach, which could lead us to underestimating the total and individual volume of plain water consumption or misclassifying water consumers on their day of registry as non-consumers.

Our analysis, and that of others cited,[25,43] is based on a single 24-h period; this is too short a period to assess the stable consumption pattern of an individual. This lead us to the caveat, expressed above, that observed associations of water drinking with other foods may operate on a day-to-day basis, due to appetite and satiety influences of the water intake. This principle would, however, serve as an a priori deterrent to the associative analyses of beverage drinking during one day in a life with an individually stable variable such as body mass index. We were not deterred, however, and our robust findings regarding BMI and water-consumer status lend some credence to the proposition of the 1-day classification being reasonably durable for the individual children in the sample.

CONCLUSION

Consumption of caloric drinks has been judged as a potentially detrimental dietary pattern in countries with high risks of juvenile obesity.[38] Plain drinking water is the quintessential non-caloric beverage. In countries in which sanitation is precarious and hygienic practices problematic, the microbiological safety of tap water is a legitimate concern. This may represent one of the barriers to consumption of this liquid by the students from low-income families in the present study. Pre-packaged drinks are perceived as more secure, but have other notable drawbacks. Most are sweetened, or at least intrinsically caloric in nature, and they are inherently more expensive. Indeed, selection of any commercial (bagged, carton-packed, canned or bottled) beverage has added labor, packaging and shipping costs, which weigh on the household economy of the consumer, with a differential prejudice for the poor. Hence, the associations documented in our sample of urban schoolchildren in Guatemala place a public health issue in relief. Promotion of the most healthful beverage selection pattern emerges as a priority. It might be speculated that the challenge for the wealthy would be curbing the cultural rush to commercial drinks and for the not wealthy improving the attractiveness and safety of the drinking water currently at their disposal.

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AUTHOR DISCLOSURES

Raquel Campos, Gabriela Montenegro-Bethancourt, Marieke Vossenaar, Colleen M Doak and Noel W Solomons, have no conflicts of interest.

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[1]*Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), Guatemala*
[2]*Institute of Health Sciences, Faculty of Earth and Life Sciences, Vrije Universiteit, Amsterdam, Netherlands*

瓜地馬拉 Quetzaltenango 的三、四年級學童飲水攝取量、頻率及使用

居住在瓜地馬拉城市區域的學童，以性別及社經狀態分層次取樣，由描述及量化其飲水攝取。以畫記的方式收集 449 名 3 年級及 4 年級學童的過去 24 小時所有飲料、食物及點心的攝取量。其中 219 名來自較低社經階層及 230 名來自較高社經階層。有 28.1%的參與者記錄一天內有喝到飲用水。飲水攝取量從 250 到 2250 mL。449 位學童一天的攝取紀錄，總共累積 62 L 水攝取量。所有參與者平均攝取 138 ± 289 mL，若是單以有喝水的學童來估算，平均值為 491±350 mL。學童喝水的比例相對性的低，所以需要更多關注，確保學校有安全飲用水的免費供應。

關鍵字：飲用水、飲料選擇、學童、24 小時飲食紀錄、瓜地馬拉