THE DAILY WATER CONSUMPTION OF ADULTS

By H. E. MAGEE, D.Sc., M.B.

There are very few records in the literature of direct determinations having been made on the daily water consumption of normal individuals. In text-books are to be found figures for normal consumption of water which vary so widely as to give rise to doubts as to their accuracy. An opportunity in the early spring of 1936 was found to carry out a study of the water and milk consumption in two Public Assistance Institutions. The arrangements in these institutions were such that the supplies of water, milk, and other beverages could be controlled, and the inmates could be kept under supervision both day and night. These conditions, which are necessary for a study of this kind, did not hold throughout the institution as a whole, but only in the divisions set aside for the mentally deficient, able-bodied inmates. The studies were, therefore, confined to the parts of the institutions reserved for these inmates.

In Institution A there were, at the commencement of the studies, 20 male and 23 female inmates, and in Institution B 56 males and 67 females. There were a few additions and discharges in B which were taken into account.

The age distribution of the inmates of the two institutions is shown in Table I.

Table I. *Age distribution of inmates*

Age	Sex	Institution A	Institution B
9–13	Male	—	3
	Female	—	—
14–18	Male	1	2
	Female	—	1
19–25	Male	—	3–4
	Female	—	4
26–60	Male	11	23
	Female	20	36–37
61–80	Male	8	24–22
	Female	3	22–24
Over 80	Male	—	2
	Female	—	4
Total	Male	20	57–56
	Female	23	67–70

The majority of the inmates were either idle or carried out light indoor duties such as washing and cleaning. A few of the males worked daily in the gardens or farms attached to the institutions. All the inmates received the ordinary full diet provided by the institution. In both institutions there were separate dining rooms for both sexes, and the results are therefore stated as the average consumption for males and females separately for each institution.

METHODS

The practical work of the enquiries was carried out by the staffs of the institutions under the supervision of the Medical Officer and Master. The method was explained to these officials and also to the nursing and kitchen staffs, and special forms were drawn up for recording the results. The procedure was essentially the same in both institutions, but there were some minor variations due to differences in arrangements for supply of water and foods. The procedure consisted in measuring the amounts of fluid set on the tables for each meal and also the quantities left unconsumed at the end of the meal. Access to water taps was closed during the period of the study, but water was available in abundance for all inmates during the day and night. Measured amounts of water were left in suitable places for those who desired it between meals. Those who were engaged in outside work were given measured quantities of water and the unused water was measured at the end of each day. Soups, stews, puddings and other dishes containing added water were weighed or measured when served, and at the end of the meal in the same way as the beverages. From the recipes the consumption of water and/or milk in these forms was determined.

The intake of calcium in water and milk was also calculated. For the calcium content of water consumed in tea, coffee and cocoa, the figures for the permanent hardness were used, as the greater part of the calcium responsible for the temporary hardness is precipitated out before these beverages are made. For drinking water and for that added to soups, stews, puddings, porridge and similar dishes, the figures for total hardness were employed because the temporary hardness, although precipitated out, is consumed along with the solid food. The consumption of milk was arrived at by measuring the amount of milk consumed as such before and after meals, and by taking into account the quantities present in or supplied with tea, coffee, cocoa, milk puddings and porridge.

The study lasted from 17 to 23 February 1936 inclusive, in Institution A, and from 17 to 23 March 1936 inclusive, in B.

RESULTS

The results are stated in Table II as the average consumption of raw and boiled water and of milk for both sexes in the two institutions. The term "raw" water means cold water which had not been previously heated. "Boiled" water means water added in the making of all beverages and cooked foods such as tea, soup and porridge.

The consumption of water in all forms was on the average 0·41 pint per head daily greater for the women than for the men. This difference is largely due to the higher consumption of boiled water, mainly in the form of tea, by the women, especially in Institution A. The higher consumption of milk by men in Institution B is due to the fact that many of the men chose milk for

supper in preference to tea or cocoa. The intake of raw water by the women in Institution A is negligible, while in B both sexes drank about one-third of a pint each on an average.

The figures in Table II do not cover the entire consumption of water because water is also ingested along with and as a natural constituent of, all solid foods. For example, bread contains approximately 42, meat 60, and potatoes 76 per cent of water. In order to estimate accurately the consumption

Table II. *Average consumption (pints) of water and milk per head daily.*

Institution and sex	Nos.	Raw water	Boiled water	Total water	Milk	Calcium (g.) in water and milk: Raw water including water used in puddings, porridge and stews	Boiled water used for tea, cocoa and coffee	Total water	Milk	Water and milk
A. Male	20	0·21	2·07	2·28	0·52	0·0057	0·0155	0·0212	0·354	0·375
Female	23	0·08	2·98	3·06	0·65	0·0042	0·0236	0·0278	0·442	0·470
B. Male	57–56	0·33	2·69	3·02	0·81	0·0052	0·0074	0·0126	0·551	0·564
Female	67–70	0·35	3·01	3·36	0·69	0·0045	0·0093	0·0138	0·469	0·483

Average water consumption (pints)		Average milk consumption (pints)		Total average water consumption in fluids (pints)	
All males	All females	All males	All females	Males	Females
2·80	3·24	0·73 (0·63 water)	0·69 (0·60 water)	3·43	3·84

	Calcium in water (g. per 100 c.c.) Permanent	Total
Institution A	0·00156	0·00189
,, B	0·00068	0·00084

of water in the form of solid foods, an exact determination of the total intake of these foods would have been necessary. This was not practicable, but data were available from which an approximation to the water intake in the form of solid foods could be ascertained. These data were obtained from recently conducted (unpublished) studies of working-class family diets. A number of families was selected whose intake of food on a man-day basis provided approximately the amounts of protein, calories, calcium, phosphorus and iron generally regarded as adequate. The total consumption of water in the solid foods eaten was determined by applying to them analytical figures for the moisture content of the foods in the raw state. Water added to "home-made" dishes like porridge, soup, stews and puddings was excluded as this was taken into account in the studies in both institutions. The figures obtained were:

Family no.	Pints of water per man daily
1	0·50
2	0·60
3	0·74
4	1·20
5	1·10
6	1·20
7	1·02
8	1·16
9	1·20
10	0·98
Average	0·97

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The mean of these values may be taken to give a rough indication of the average daily intake of water in the form of solid foods. This mean, however, applies to the hypothetical average man, and as the average requirements of energy-giving foods, which form the great bulk of diets, is less for the average woman in the ratio of 1 : 0·83, the mean must be multiplied by this equivalent to get a figure applicable to the women in the institutions. Adding the above mean and its equivalent for women to the average intakes of water in fluid form for men and women respectively, the following figures are obtained:

$$3{\cdot}43 + 0{\cdot}97 = 4{\cdot}40 \text{ pints for males}$$

and

$$3{\cdot}84 + (0{\cdot}97 \times 0{\cdot}83) = 4{\cdot}64 \text{ pints for females.}$$

Account must also be taken of water which is formed in the body from the oxidation of energy-giving foods. According to von Noorden (1907) 12 c.c. of water are formed for every 100 calories produced in metabolism, so that a man engaged in a sedentary occupation and liberating, say, 2600 calories daily would produce thereby 312 c.c. of water. Siebeck (1926) places the average figure for oxidation water between 260 and 360 c.c. daily. If we add, say, 300 c.c. for men and 250 for women to the above-estimated intakes, we get totals of 2799 c.c. for men and 2885 c.c. for women.

Water is excreted from the body mainly in urine, but also by the skin, lung and faeces. Under ordinary conditions in this climate excretion by the last three channels is relatively steady, whereas the urinary excretion may vary considerably. Benedict, Carpenter and others (see Marriott, 1923) concluded that the average adult in temperate climates loses from 650 to 1400 c.c. of water daily by the skin, say 1000 c.c. on the average. The loss from the lungs is placed at 260–360 c.c. and from the intestine at 100–200 c.c. per day by Siebeck (1926), say 310 and 150 c.c. respectively on the average. It would therefore seem that the water balances of the inmates were somewhat as follow:

		Men c.c.	Women c.c.
Intake:			
Beverages, fluids and solid food		2499	2635
Oxidation		300	250
	Total	2799	2885
Loss:			
Skin		1000	1000
Lungs		310	310
Faeces		150	150
Urine		1339	1425
	Total	2799	2885

It is generally believed that the average daily water consumption is less for women than men. These studies show that this is not generally true, but there is no apparent physiological reason why women should drink more water than men. It would be inadvisable to generalize from these findings, because the consumption of water by ordinary people depends not only on the needs of the body but also on the taste for beverages such as tea, beer and sweet drinks and on social habits and conventions. These factors are operative to a

much smaller extent in institutions of the type in question than in ordinary life. Many of the subjects of these enquiries are, it is true, below the average intelligence; but there is no physiological reason for believing that the water requirements of the body are dependent on intellectual capacity. The water consumption found in these studies is therefore believed to afford a better indication of the needs of the body than the determinations carried out on ordinary individuals. As the studies were conducted in spring it is probable that the results are not far from the average daily consumption throughout the year.

The amount of calcium (0·004–0·006 g.) taken in with raw water and in puddings, soups and stews was negligible in both institutions, and that in tea, coffee and cocoa varied from 0·007 to 0·024 g. per head daily. The total consumption of calcium in water varied from 0·013 g. for the males in Institution B to 0·028 g. for the females in Institution A, i.e. from 1·9 to 4·1 per cent respectively of 0·68 g. the daily calcium requirements of an adult man or woman.

These amounts of calcium are so small that the water supply of the institutions, which is very soft, cannot be regarded as a source of significant amounts of calcium. A hard water on the other hand, such as that of Epsom, which contains 0·0108 g. of calcium per 100 c.c. total, and 0·0018 g. per 100 c.c. permanent hardness, would at the consumption level of the A males give an intake of about 0·051 g. of calcium from raw and boiled water which is nearly 2·5 times the actual intake of the A males in these forms. A calcium intake of this magnitude would probably make a significant addition to the calcium content of a diet containing only a minimum, which is about 0·45 g. daily, of this mineral.

The intake of calcium in milk varied from 0·354 g. for the A males to 0·551 g. for the B males, or 52 and 81 per cent respectively of the standard adult requirement. The corresponding values for water and milk combined are 0·375 and 0·564 g. which are 55 and 83 per cent respectively of the standard adult requirement.

These results show that more than half the standard calcium needs came from milk. Experience of studies of working-class family diets has shown that families which receive less than half the standard requirement of calcium in the form of milk or cheese, are almost certain to consume too little calcium, or in other words that the daily calcium content of the constituents of working-class diets, other than milk and cheese, generally contain less than half the standard calcium requirement for the adult, i.e. less than about 0·34 g. Although a quantitative survey of the food consumption of the institutions was not carried out, there can be little doubt that the calcium intake in the institutions was adequate.

Summary

The consumption of water and milk in the form of beverages, fluid foods and foods to which water or milk was added in cooking was determined over a period of a week in early spring in two Public Assistance Institutions

containing 166 adults and 3 children aged 9–13 years. The results obtained are summarized in Table II. The consumption of water in the form of solid foods could not be estimated directly, but was calculated from the results obtained from quantitative dietary studies of ten working-class families whose diet was adequate. The intake of water in solid food was calculated as 0·97 pint for males and 0·80 pint for females per head daily. Water formed in oxidation was assumed to be 300 c.c. per head daily for men and 250 c.c. for women. The total water consumed and formed in the body was therefore probably in the region of

Men	4·93 pints (2799 c.c.) per head daily,
Women	5·08 pints (2885 c.c.) per head daily.

The amounts of water lost by the kidneys, bowel, skin and lungs are tentatively suggested and tables of water balance are put forward as approximations to the water requirements and exchanges of normal people. The water supplies of the institutions are soft and the amounts of calcium consumed in water were very small and are probably not of much nutritional significance. Hard waters are, however, probably of some importance as sources of calcium, especially when the diet otherwise is poor in this mineral.

The amounts of milk consumed per head daily were in excess of 0·5 pint and the amount of calcium consumed in the form of milk amounted to more than half the standard requirement for adults. The calcium intake in both institutions was probably adequate.

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