phosphates, the value would be higher. A retention of double that volume was indicated by variations in body weights of the subjects in the different periods.

Considering the variations in the excretion and retention which would be caused by the variations in the water content of the body, the small differences which we have obtained in our experiments are much more significant, for our increases in ammonia, phosphate and acid output have been evident in spite of the tendency to retention and obscurity. In other experiments in this laboratory, where ordinary tap water has been used, the variations were much more pronounced. This was undoubtedly favored by the presence of salts in the water which made it less necessary for the body to supply the necessary material for development of sufficient osmotic pressure.

It will be observed that the increase in urinary ammonia which followed the increased water intake by the subjects of these tests was not proportional to the volume of water ingested. This lack of relationship is easily explained on the basis of certain experiments now in progress by one of us.[1] In the tests mentioned the introduction of distilled water into the empty stomach causes an increased flow of gastric juice but the increased flow is, in some cases at least, in no way proportional to the volume of water introduced into the stomach. Inasmuch as we believe the ammonia output, under such conditions, is regulated to a large degree by the amount of acid entering the intestine, the non-parallelism of the water intake and the ammonia output may be logically explained.

PHILADELPHIA, PA.

[FROM THE LABORATORIES OF PHYSIOLOGICAL CHEMISTRY OF THE UNIVERSITY OF ILLINOIS AND JEFFERSON MEDICAL COLLEGE.]

STUDIES ON WATER DRINKING. XIX. INTESTINAL PUTREFACTION AS INFLUENCED BY THE INGESTION OF SOFTENED AND DISTILLED WATERS.

BY C. P. SHERWIN AND P. B. HAWK.

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Investigations already reported by one of us[1] indicated that the drinking of copious (1000 cc.) or moderate (500 cc.) volumes of water with meals decreased intestinal putrefaction as measured by the urinary indican output, and that copious water drinking caused a more pronounced lessening of the putrefactive processes than did the moderate water drinking. Softened water was employed in the experiments in question. In the present instance the influence of both distilled and softened water was studied.

The investigation here reported embraced two experiments, young men

[1] Rehfuss, Bergeim and Hawk, Unpublished.

serving as subjects in each instance. A general description of the subjects, diets, etc., used in the two experiments will be found in other connections.[2, 3]. The indican determinations were made by Ellinger's[4] method as modified by Maillard.[5] The former method has already been given in another connection.[1] The modification consists in washing the chloroform extract with an equal volume of 0.1% sodium hydroxide and removing the adherent alkali by careful washing with distilled water. From this point the Ellinger procedure is followed. The ethereal sulfates were determined by Folin's procedure.

Experimental.

First Experiment.—This experiment was divided into three periods, a preliminary period of three days, a water period of five days, and a final period of two days. A uniform diet was ingested throughout the study, with the exception that the water ingestion of each day of the water period was increased by three liters, taken at meal time, one liter with each meal. The water was a freshly softened water. Data from this experiment are given in Table I.

TABLE I.

Day.	Urine. Cc.	$KMnO_4$ soln. in titrating 40 cc. of the clarified sample. Cc.	$KMnO_4$ soln. used to titrate the entire urine volume. Cc.	Indican output per day. Mg.
Preliminary Period (3 Days).				
1	830	5.90	135.3	35.6
2	920	6.70	168.5	44.1
3	880	4.50	107.8	28.4
Average	877	5.70	137.2	36.0
Water Period (5 Days).				
4	3440	3.50	112.8	29.7
5	3840	3.60	125.8	33.1
6	3670	2.90	96.8	25.4
7	3610	3.05	99.9	26.3
8	4020	2.85	104.2	27.4
Average	3716	3.18	107.9	28.3
Final Period (2 Days).				
9	1590	6.65	290.9	76.5
10	885	9.83	237.6	62.5
Average	1237	8.24	264.2	69.5

An examination of the last column in Table I will serve to show that the average output of indican for the preliminary period was 36.0 mg. per day. During the five-day interval of high water ingestion this value was reduced to a daily average of 28.3 mg. It is evident, therefore, that the drinking of one liter of softened water with each meal for a period of five

days caused a lessening of the processes of intestinal putrefaction as measured by the urinary indican excretion.

Second Experiment.—This experiment was divided into five periods, a preliminary period of 6-8 days, a moderate water period of ten days, an

TABLE II.—INDICAN AND ETHEREAL SULFATES.

Subject C.

Day of exp.	Cc. urine.	Specific gravity.	Ethereal sulphates Mg.	Indican Mg.	$\frac{SO_3}{\text{Indican}—SO_3}$
Preliminary Period.					
5	620	1.032	153.8	27.2	17.73
6	615	1.033	153.8	23.4	20.62
Average	618	1.033	153.8	25.3	19.17
Moderate Water Period.					
1	995	1.019	24.3	20.2	3.78
2	1465	1.014	16.9	24.4	2.18
3	1215	1.015	98.1	31.2	9.86
4	1620	1.012	142.6	15.4	29.16
5	2040	1.010	172.6	28.1	19.24
6	2050	1.009	108.9	9.2	37.04
7	1800	1.011	137.5	5.3	80.99
8	2230	1.010	78.0	29.6	8.29
9	2330	1.009	171.6	22.2	24.20
10	1930	1.010	206.0	27.9	23.17
Average	1767	1.012	115.6	21.3	23.79
Intermediate Period.					
1	860	1.023	170.9	22.3	24.04
2	675	1.038	130.1	27.3	14.97
3	700	1.030	76.9	26.6	9.07
4	770	1.028	69.8	16.1	13.56
5	710	1.027	118.5	13.8	26.96
Average	743	1.029	113.2	21.2	17.72
Copious Water Period.					
1	2900	1.008	128.0	14.9	26.99
2	2670	1.007	155.7	13.8	35.34
3	3360	1.007	174.9	16.8	32.71
4	3210	1.007	154.0	15.3	31.64
5	3300	1.006	152.8	16.8	28.53
Average	3088	1.007	153.1	15.5	31.04
Final Period.					
1	920	1.023	219.2	20.6	33.37
2	820	1.024	183.8	24.6	23.45
3	835	1.024	209.6	30.1	21.85
4	810	1.026	132.2	24.6	16.89
5	850	1.026	139.9	22.2	19.74
Average	847	1.025	176.9	24.6	23.06

intermediate period of five days, a copious water period of five days and a final period of five days. Two subjects were employed and the water used was distilled water. A uniform diet was fed and was supplemented by an increase of 500 cc. in the water ingestion of each meal of the moderate

TABLE III.—INDICAN AND ETHEREAL SULFATES.

Subject V.

Day of exp.	Cc. urine.	Specific gravity.	Ethereal sulfates. Mg.	Indican. Mg.	$\frac{SO_3}{Indican-SO_3}$.
Preliminary Period.					
7	665	1.029	...	64.7	...
8	690	1.029	...	79.7	...
Average	677	1.029	...	72.2	...
Moderate Water Period.					
1	2110	1.008	91.2	60.6	4.74
2	2210	1.009	81.5	62.2	4.12
3	1620	1.012	112.1	53.7	6.56
4	1970	1.008	221.4	70.8	9.82
5	2380	1.008	118.5	89.6	4.14
6	2550	1.008	235.5	83.1	8.88
7	2165	1.008	247.8	90.6	8.57
8	2635	1.007	121.1	90.3	4.21
9	2205	1.010	182.0	89.3	6.40
10	2410	1.007	200.0	93.6	6.72
Average	2254	1.009	154.4	79.2	6.04
Intermediate Period.					
1	1230	1.016	66.8	71.5	2.92
2	1025	1.020	135.0	81.3	5.21
3	1000	1.020	227.3	78.9	9.04
4	1195	1.017	179.1	81.6	6.90
5	1670	1.015	180.1	73.6	7.69
Average	1224	1.018	157.7	77.4	6.35
Copious Water Period.					
1	3400	1.005	322.2	68.5	14.75
2	3140	1.005	110.7	74.0	4.68
3	3600	1.006	211.1	60.8	10.89
4	3860	1.006	165.1	76.9	6.75
5	3660	1.006	184.5	64.7	8.95
Average	3532	1.006	198.7	64.9	9.20
Final Period.					
1	920	1.021	207.9	99.1	6.59
2	1240	1.017	203.8	99.8	6.40
3	835	1.024	151.5	95.3	4.99
4	815	1.022	170.9	84.5	6.34
5	1010	1.020	156.0	85.0	5.74
Average	964	1.021	178.0	92.7	6.01

water period and an increase of 850 cc. in the water ingestion of each meal of the copious water period.

The data from this experiment are given in Tables II and III. From an examination of Table II it will be seen that subject C excreted 25.3 mg. of indican per day during the preliminary period. The ingestion of a moderate volume (500 cc.) of water at each meal reduced this indican value slightly (21.3 mg.), whereas the ingestion of a larger volume of water (850 cc.) at each meal caused a more pronounced drop in the indican value, as is shown by an average daily output of 15.5 mg. for the copious water period. An examination of Table III will show that the minimum indican value for subject V was also secured during the period of high water ingestion. In each instance the water evidently caused a decrease in the putrefactive processes.

It is interesting that, coincidently with the most pronounced *decrease* in the excretion of indican, *i. e.*, during the period of copious water intake, there was a correspondingly pronounced *increase* in the ethereal sulfate output. This failure of the indican and total ethereal sulfate values to run parallel has been previously discussed by ourselves[1,7] and others.[6] Such observations furnish strong evidence in favor of the current belief that indican has a different origin from the other ethereal sulfate.

Discussion.

The data herewith submitted indicate that the ingestion of water, either distilled or softened, is accompanied by a decrease in the processes of intestinal putrefaction. The examination of the stools from these same subjects has shown that the output of fecal bacteria was also decreased during the periods of high water intake.[2, 3] The logical conclusion, therefore, would appear to be as follows: The ingestion of the large volume of water stimulated the flow of a gastric juice of increased acidity.[8, 9, 10] The acid chyme upon its entrance into the intestine inhibited the activity of the indole-forming bacteria thus causing a decreased output of indol and consequently a decreased indican exeretion. The fact that a high water intake is accompanied by better digestion and absorption of the ingested protein[2], [11] would cause the protein residues in the intestine to be lessened in amount, thus reducing the quantity of material available for the growth and development of the bacteria in question. Hence the lowering of the putrefactive processes would naturally be accompanied by a decrease in the development of the intestinal flora and a consequent drop in the fecal bacteria values.

So far as the data from the present investigation are concerned, it is evident that distilled and softened water are equally efficient in causing a decrease in the processes of intestinal putrefaction.

Many objections have been raised against the practice of drinking distilled water. Most of these objections we believe to have but slight

foundation in fact. According to Findlay[12] the ingestion of distilled water is followed by the swelling of the surface layers of the epithelium of the stomach, due to the passage of water into the cells because of the difference in osmotic pressure. The cells finally die, are cast off and catarrh of the stomach may result. Koeppe[13] and Harlow[14] have expressed somewhat similar ideas, whereas Nocht[15] and Winkler[16] cite instances showing prolonged drinking of distilled water to have been unaccompanied by any serious consequences. Recently, Oehler[17] claims to have produced hemoglobinuria in white mice by the introduction of distilled water into the stomach. We are rather skeptical as to the possibility of producing hemoglobinuria in any such manner. That hemoglobinuria will follow the introduction of distilled water into the circulation is well known. It is, however, rather surprising that the introduction of distilled water into the stomach should cause such a phenomenon. As soon as distilled water reaches the stomach it ceases to be distilled water, due to the fact that it at once takes unto itself various electrolytes which are present in the food and digestive juices.

We have shown that even the prolonged ingestion of large volumes of distilled water over a long period of time was not accompanied by the production of any observable catarrhal affection of the gastric mucosa. This observation was made in connection with a fasting dog which received 700 cc. of distilled water daily for a period of 104 days.[18] No evidences of catarrh of the stomach were apparent. Certainly, if distilled water was able to produce this type of disorder, here was an excellent opportunity. There was no food ingested for 104 days and consequently no electrolytes from this source to lessen the harmful (?) influence of distilled water to which various authors have referred.

Conclusions.

Both softened and distilled water when taken with meals in volumes ranging from 500 cc. to 1000 cc. have a tendency to cause a decrease in the putrefactive processes in the intestine as indicated by the urinary indican excretion.

The non-parallelism of the indican and total ethereal sulfate elimination was again observed.

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A PIPETTOMETER.

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The pipettometer is a new piece of apparatus for measuring out precise amounts of fluids without the use of graduated pipets. It was originally intended for work in the bacteriological laboratory but will, no doubt, be found of interest to those working in other laboratories, such as those of chemistry, physics and medicine.

It consists essentially of an upright graduated glass tube with an upper side arm to which, by means of a piece of rubber tubing, ungraduated glass pipets may be readily attached. At the lower end of this graduated tube, another tube is attached by means of a flexible rubber joint. This tube has a bulb at the outer end and is so arranged that the bulb end can be readily raised or lowered. The upright tube and this movable arm with bulb are partially filled with mercury. The whole apparatus is supported on a wooden or metal frame which is so attached to a ring stand that its height can be varied. By moving the bulb up or down, the height of mercury column in the graduated upright can be raised or lowered. When the mercury is lowered in this tube, the pipet draws up the fluid into which its tip is immersed and when it is raised the fluid is forced out. The amount of fluid taken up or discharged is measured by reading the position of the mercury in the graduated upright.

The details of the construction and the use of the pipettometer can best be understood by reference to the accompanying figure.

A is the wooden or metal support with its short arm on the top and left *C*, while *B* is the longer arm on the right, hinged at the bottom. The whole is supported on a ring stand, *D*, to which it is held by the screw clamps *ff*. Mounted on this frame is the bent glass tube *abcd*, with a flexible joint at *c* and a bulb at *d*.

When the arm *B* is moved up to position I, the mercury stands at 1.0, and when it is lowered to II the mercury stands at 0. A graduated pipet,