Effect of excessive water intake on body weight, body mass index, body fat, and appetite of overweight female participants

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Abstract

Objective: Drinking plenty of water is commonly recommended in weight loss regimens; however, very limited scientific evidence is available to justify this. Here we studied the effect of drinking 1.5 L of water, over and above the usual intake on body weight, body mass index (BMI), body fat, and appetite score in overweight female participants. **Materials and Methods:** The study was done on 50 overweight female participants, who were instructed to drink 500 mL of water, three times a day 30 min before breakfast, lunch, and dinner. The 1.5 L water intake was over and above their daily water intake and was continued for 8 consecutive weeks. Body weight, BMI, body fat, and appetite score was measured pre and post-study; and the values were compared by paired *t*-test using Statistical Packages for Social Sciences (SPSS) version 14.0.1. **Results:** All the parameters tested were lower after 8 weeks: body weight (pre-study 65.86 ± 3.614 kg vs post-study 64.42 ± 3.704 kg; $P < 0.01$); BMI (pre-study 26.7002 ± 0.9423 vs post-study 26.1224 ± 1.0632; $P < 0.01$); sum of skinfold thickness (pre-study 79.626 ± 10.385 mm vs post-study 76.578 ± 10.477 mm; $P < 0.01$); and the appetite score (pre-study 36.880 ± 4.170 vs post-study 34.673 ± 3.845; $P < 0.01$). **Conclusions**: Our study establishes the role of drinking 1.5 L of excessive water in weight reduction, body fat reduction, and appetite suppression in overweight female participants.

Key words: Body mass index, overweight, skinfold thickness, visual analogue scale for appetite, water-induced thermogenesis

INTRODUCTION

The current obesity epidemic in adults and children alike is a major public health concern worldwide. Obesity confers physical stress on multiple biologic processes and is associated with an increased risk of developing cardiovascular disease, type 2 diabetes mellitus, osteoarthritis, and certain forms of cancer.[1] Recent studies associate drinking water with sympathetic stimulation, which increases the metabolic rate (thermogenesis) and augment daily energy expenditure.[2] Although the concept of water-induced thermogenesis is controversial, nevertheless drinking plenty of water is universally recommended as a means to reduce body weight. This study was designed to test whether increase in sympathetic nervous system activity following 1.5 L/day of excess drinking water for 8 weeks contributes to body weight loss.

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MATERIALS AND METHODS

This study was conducted in a tertiary care hospital in Mumbai and was approved by the Committee for Academic Research Ethics, Department of Clinical Pharmacology, Seth GS Medical College and KEM Hospital, Parel, Mumbai, India.

Fifty female participants were enrolled for this study after explaining the purpose and rational of the study. Written informed consent was given by each participant. Inclusion criteria: Overweight female participants (body mass index (BMI): 25-29.9) of the age group 18-23 years were included in the study. Exclusion criteria: Participants were free of major illness, had no eating disorders, and were not on any medication. Pre-study body weight, BMI, sum of skinfold thickness, and appetite scores were measured and compared with the post-study values.

BMI was assessed as an index of obesity.[3] BMI = Weight (kg)/(Height (m)) ^{2} The normal range is 18.5-24.9, overweight is 25-29.9, and obese ≥30.[4]

Body composition scores were computed by measuring skinfold thickness (millimeters) by using skinfold calipers at three different sites: Triceps, abdomen, and thigh. Skinfold thickness is used as valid anthropometric indicator of regional body fatness and was measured by lifting a fold of skin and subcutaneous fat away from the underlying muscle and bone. Each skinfold thickness was measured in duplicate with Harpenden skinfold calipers (John Bull; British Indicators Ltd., West Sussex, England) on the left side of the body. When a difference between the first and the second measurement exceeded 6 mm, a third measurement was taken.[5,6] The 'sum of skinfolds' reflects absolute or percentage changes in fatness before and after physical conditioning or diet regimens.

Appetite Score: In order to assess subjective appetite sensations, visual analogue scales (VAS) were used. VAS are composed of lines (of varying length) with words anchored at each end, describing the extremes (i.e., 'I have never been more hungry'/'I am not hungry at all'). Participants were asked to make a mark across the line corresponding to their hunger sensation. The data was quantified by measuring the distance from the left end of the line to the mark.[7] The VAS specifically assessed 'desire to eat', 'hunger', and 'fullness'.

Pre-study body weight and height were measured after overnight fasting (a day before the study started). BMI was calculated. Post-study readings were similarly recorded. Body fat was calculated as a sum of skinfold thickness taken at three different sites. Appetite score was measured using VAS 1 day before start of the study. Participants were instructed to rate their appetite on the scale of 0-10, in response to six various questions. Separate scores were recorded before breakfast, lunch, and dinner on the same day. Average score for the day was calculated. The same procedure was followed to measure the post-study appetite score. The participants were instructed to increase their water intake by 1.5 L, over and above their usual daily water intake. To achieve this, 500 mL of water was consumed 30 min before breakfast, lunch, and dinner. The water intake by the participants before breakfast and lunch was directly supervised, while the intake before dinner was not supervised.

The participants were instructed to keep the dietary habits and physical activity levels unchanged during the study period to allow better assessment of effect of water on weight loss. At the end of 8 weeks, parameters of the study were reassessed. The compliance to the instructions given to the participants was good on an average because the increment in the water intake before breakfast and lunch was done under direct supervision.

Statistical analysis

The statistical analysis of the data was performed independently using Statistical Packages for Social Sciences (SPSS) version 14.0.1. A paired *t*-test was used to determine the statistical significance of the results with statistical significance set at $P < 0.01$.

RESULTS

- Body weight: The mean value for the pre-study body weight was 65.86 ± 3.614 and post-study body weight was 64.42 ± 3.704 ($P < 0.01$) as depicted in Table 1, thus establishing the role of drinking excessive water in body weight reduction
- Body mass index (BMI): The mean value for the pre-study BMI was 26.7002 ± 0.9423 and post-study BMI was 26.1224 ± 1.0632 ($P < 0.01$) as depicted in Table 2, thus establishing the role of drinking excessive water in body weight reduction
- Body fat: The mean value for pre-study sum of skinfold thickness was 79.626 ± 10.385 mm and the post-study value was 76.578 ± 10.477 mm ($P < 0.01$) as depicted in Table 3, thus establishing the role of drinking excessive water in body fat reduction
- Appetite score: The mean value for the pre-study appetite score was 36.880 ± 4.170 and for post-study appetite score was 34.673 ± 3.845 ($P < 0.01$) as depicted in Table 4, thus establishing the role of drinking excessive water in appetite suppression.

DISCUSSION

The current worldwide epidemic of obesity in adults and children alike has led to the search for compounds that can increase energy expenditure, thereby promoting weight loss. Because thermogenesis is partly regulated by sympathetic activity, substances that interact with the sympathetic nervous system can be considered as potential agents for weight reduction. Sympathomimetic compounds such as ephedrine are effective at increasing

Table 1: Pre-and post-study body weight

Parameter	Paired samples statistics						Paired samples test			
	Pre-study body weight			Post-study body weight			Paired differences		*t* value	*P* value
	Mean	SD	SEM	Mean	SD	SEM	Mean	SD		
Body weight (kg)	65.86	3.614	0.511	64.42	3.704	0.524	1.44	0.993	10.254	<0.01*

*P<0.01 is statistically significant, SD: Standard deviation, SEM: Standard error of the mean

Table 2: Pre- and post-study BMI

Parameter	Paired samples statistics						Paired samples test			
BMI	Pre-study BMI			Post- study BMI			Paired differences		*t* value	*P* value
	Mean	SD	SEM	Mean	SD	SEM	Mean	SD		
Body weight (kg)	26.7002	0.9423	0.1332	26.1224	1.0632	0.1503	0.5778	0.4002	10.208	<0.01*

*P<0.01 is statistically significant, SD: Standard deviation, SEM: Standard error of the mean, BMI: Body mass index.

Table 3: Pre- and post-study sum of skinfold thickness

Parameter	Paired samples statistics						Paired samples test			
	Pre- study			Post- study			Paired differences		*t* value	*P* value
	Mean	SD	SEM	Mean	SD	SEM	Mean	SD		
Individual skinfold thickness: (in mm)										
Triceps	26.490	3.685	0.521	25.316	3.780	0.534	1.174	0.6945	11.953	<0.01*
Abdomen	26.632	3.634	0.514	25.780	3.563	0.504	0852	0.979	6.151	<0.01*
Thigh	26.504	3.616	0.511	25.482	3.698	0.523	1.022	0.541	13.347	<0.01*
Sum of skinfold thickness (in mm)	79.626	10.385	1.468	76.578	10.477	1.481	3.048	1.687	12.774	<0.01*

*P<0.01 is statistically significant, SD: Standard deviation, SEM: Standard error of the mean

Table 4: Pre- and post-study appetite score

Parameter	Paired samples statistics						Paired samples test			
	Pre-study score			Post-study score			Paired differences		*t* value	*P* value
	Mean	SD	SEM	Mean	SD	SEM	Mean	SD		
Individual scores										
Breakfast	37.78	5.040	0.713	35.34	4.968	0.703	2.44	1.786	9.660	<0.01*
Lunch	37.04	4.467	0.632	34.88	4.119	0.582	2.16	1.448	10.549	<0.01*
Dinner	35.82	4.484	0.634	33.80	4.056	0.574	2.02	1.301	10.976	<0.01*
Total score	36.880	4.170	0.589	34.673	3.845	0.543	2.206	1.122	13.899	<0.01*

*P<0.01 is statistically significant, SD: Standard deviation, SEM: Standard error of the mean

thermogenesis, but can have undesirable side effects. Safe, preferably nonpharmacological substances that can stimulate thermogenesis without causing side effects are hence preferable. Water can be once such agent.[8]

Drinking half a liter of water increases activity of the sympathetic nervous system as measured by enhanced plasma norepinephrine levels and muscle sympathetic nerve activity.[9]

Recent studies suggest that water drinking elicits acute changes in human physiology. Water drinking profoundly increases blood pressure in patients with autonomic failure. Also, water drinking was shown to increase energy expenditure. The acute changes in cardiovascular regulation and in energy expenditure with water drinking appear to be mediated through activation of the sympathetic nervous system. The acute water pressor response has been exploited in the treatment of patients with impaired orthostatic tolerance.[10-12]

Boschmann *et al.*,[2] showed that the sympathetic activation after water drinking might stimulate thermogenesis and increase resting energy expenditure by 30% within 10 min of drinking the water (peaked at 30-40 min) and was sustained for over an hour. The water-induced thermogenesis was attributed to sympathetic nervous system activation because ingestion of a beta-adrenoreceptor blocker before drinking water almost completely abolished this response. Drinking water that had been heated to 37°C, attenuated the thermogenic response by 40%; which led to the suggestion that water-induced thermogenesis could be partly attributed to the energy cost of warming the water to body temperature. The authors extrapolated that increasing daily water intake by 1.5 L would augment energy expenditure by approximately 200 kJ/d.[2]

A previous study evaluating the effect of drinking water on the resting energy expenditure (REE) in overweight children demonstrated an increase of up to 25% in REE lasting for over 40 min following drinking of 10 ml/kg of cold water.[13] However, the concept of water-induced thermogenesis is controversial. Several studies in humans have reported that water drinking has little or no effect on resting energy expenditure.[8,14,15] Hence, the 30% increase in energy expenditure after water drinking reported by Boschmann *et al*., although impressive, is not supported by other published studies. This whole-room indirect calorimetey vs ventilated hood or mouthpiece techniques. Ventilated hood and mouthpiece apparatus have a small dead space, thereby permitting rapid attainment of steady-state gas concentrations. In contrast, whole-room calorimeters may require over an hour to attain steady-state conditions because of their large size in relation to ventilation rate and hence is less suitable for acute measurements.[8,14,15]

The mechanism causing sympathetic activation with water drinking is not fully understood. Studies in tetraplegic patients suggest a spinal mechanism. The nature of the afferent stimulus and the afferent pathway causing activation of efferent sympathetic neurons is unknown. Water temperature, distension of gastrointestinal organs, or changes in osmolarity could also be involved.[14] Water drinking-induced cardiovascular and metabolic responses are not solely explained by a thermal stimulus because in autonomic failure patients, drinking colder or warmer water elicited an identical pressor response. In healthy normal weight subjects, approximately 60-70% of the water-induced thermogenesis could not be attributed to heating of the ingested water. Indeed, drinking 37°C warm water elicited a substantial thermogenic response.[14]

Gastric distension increases sympathetic nerve traffic in human subjects. However, gastric distension is not considered as the crucial mechanism for water drinking induced sympathetic activation. The idea is supported by the observation that water drinking elicits more pronounced cardiovascular responses than drinking the same volume of saline. Also, human magnetic resonance imaging (MRI) studies demonstrated that after 40 min, only 25% of the ingested water remains in the stomach.[14] It is likely that the water-induced changes may be explained by stimulation of osmosensitive structures. Indeed, the time course of the changes in sympathetic activity, blood pressure, and metabolic rate parallel the time course of altered plasma osmolarity post water drinking. Moreover, infusion of hypoosmotic solutions through a gastric tube in humans caused a greater increase in sweat production, a sympathetic response, than infusion of isosmotic solutions.[8,14,15]

In the present study, effect of excessive water intake on body weight, BMI, body fat, and appetite score of overweight female participants was evaluated in view of the inadequacy of the studies addressing this issue. Although the concept of water-induced thermogenesis is open to debate and investigation, our study suggests drinking excessive water, when continued for 8 weeks, actually translates into body weight/fat loss, as depicted in Table 1, 2 and 3, possibly involving combination of thermogenesis, distention of gastrointestinal organs, and/or changes in osmolarity. Additionally, drinking excess water also suppresses appetite; as depicted in Table 4, thus supporting water as a natural appetite suppressant.

One limitation of the present study was that the dietary intake and physical activity levels were not reported. However, the subjects were instructed specifically to keep the dietary habits and physical activity levels unchanged to allow better assessment of effect of water on weight loss.

CONCLUSION

Obesity is a major public health issue, which is prevalent pandemically among all age groups. Hence, the urgent need to manage this overwhelming epidemic of obesity cannot be overemphasized. In the present study, an attempt has been made to see the effect of drinking excessive water in female overweight participants, in terms of weight loss. The decrease in body weight, BMI, sum of skinfold thickness, and appetite score of overweight participants at the end of study period establishes the role of drinking excessive water in weight reduction, body fat reduction, and appetite suppression of participants. Thus, water drinking induced increase in sympathetic activity is an important and unrecognized component of daily energy expenditure. If confirmed in future studies with larger number of subjects, this cost free intervention may be a useful adjunctive treatment in overweight and obese individuals to attain an increase in energy expenditure.

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