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The Effect of Consuming Mineral Water and Piped Water on Blood Pressure and Lipid Profiles of Hypertensive Men

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ABSTRACT

Background: Hypertension is the third risk factor for the cardiovascular diseases. This study investigated the effects of mineral water from Damavand spring on the blood pressure and serum lipid profiles in men with hypertension. **Methods:** In this study 41 hypertensive men were randomly assigned to Damavand mineral water (DM) and Tehran water groups (TW). The DM and TW received 1.5-liter bottle of mineral water of Damavand spring and Tehran piped water bottled, respectively. The participants' blood pressure, serum triglyceride (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDLc), and high-density lipoprotein cholesterol (HDLc) were measured at the beginning and end of the study. Total hardness of water was measured by titration with EDTA. **Results:** The results showed that the mean systolic and diastolic blood pressures decreased in both groups at the end of the study compared to the baseline ($P < 0.05$), but the difference was not significant. Serum TC and LDLc significantly in the case group at the end of week 8 compared to the baseline ($P < 0.05$) and this reduction was significant ($P < 0.05$). Moreover, no significant differences were observed between the two groups with regard to the mean changes of TG and HDLc ($P > 0.05$). **Conclusions:** The findings showed that the daily consumption of 1.5 liters of premium mineral water of Damavand springs decreased the systolic and diastolic blood pressure, total cholesterol, and LDLc levels.

Keywords: *Hypertension; Serum lipid profiles; Mineral water.*

Introduction

Different definitions have been provided for hypertension or high blood pressure. The model provided by the Joint National Committee on prevention, detection, assessment and treatment of hypertension in adults stated that if in two consecutive time intervals, the average systolic blood pressure is more than 130 mmHg and the average diastolic blood pressure is 85 mmHg or higher, the person is considered to have hypertension (Cleeman *et al.*, 2001)

It seems that the prevalence of hypertension is increasing among the developing countries. In the

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Mediterranean and the Middle East countries, high blood pressure prevalence is reported as 26 and 21.7 percent, respectively (Motlagh *et al.*, 2009, Musaiger and Al-Hazzaa, 2012). The prevalence of hypertension in the population studied in Tehran Lipid and Glucose Study after adjustment for age was determined as 19.4 percent in women and 23.3 percent in men (Azizi *et al.*, 2002).

In the long run, hypertension causes irreparable damages to the cardiovascular system and increases the incidence of stroke (Azizi *et al.*, 2002). Hypertension is the third risk factor in the triangle of death from cardiovascular disease following the low-density lipoprotein cholesterol (LDL-c) and cigarettes (Jairath, 1999). Studies showed that non-pharmacological methods can reduce blood pressure and act as an effective method to reducing hypertension and cardiovascular diseases (Ralapanawa *et al.*, 2017).

In recent years, various studies examined the role of nutrient elements such as calcium, magnesium, and sodium on the blood pressure and serum lipids. They argued that increased intake of calcium and magnesium is associated with reduced serum triglyceride and cholesterol levels (Azoicăi *et al.*, 1996, Bain *et al.*, 2015, Bostick *et al.*, 1999) and leads to 30-35 percent reduction in ischemic disease or heart failure (Bostick *et al.*, 1999). However, epidemiologic studies demonstrated a strong correlation between water hardness and cardiovascular disease, so that cardiovascular diseases were 10-30 percent more frequent in areas with light drinking water than areas with hard drinking water (Crawford and Crawford, 1967).

Some studies showed that mineral water reduced systolic blood pressure about 5 mm Hg, total cholesterol, and LDL-c (Capurso *et al.*, 1999, Nerbrand *et al.*, 2003).

Due to the high prevalence and serious complications of hypertension and the effects of mineral water on blood pressure and serum profile lipids and the controversies in this field, this study was conducted. The aim was to investigate the effects of consuming mineral water of Damavand spring on blood pressure and serum lipid profiles in men with hypertension.

Materials and Methods

Type study & participants: This double blind clinical trial was conducted on men with hypertension, who referred to the cardiovascular clinics in Tehran. After conducting simulating the participants' age, body mass index (BMI), waist hip ratio (WHR), smoking, type, dose of drugs, and duration of disease, 41 hypertensive men were randomly assigned to Damavand mineral water (DM) and Tehran water groups (TW). The DM and TW received 1.5-liter bottle of mineral water of Damavand spring and Tehran piped water bottled, respectively. Participants were advised not to change their diet, physical activity, and drug regimen during the study. Sample size was determined using sample size in small groups by following equation that $\alpha = 0.05$ and power test was considered as:

$$N = (z_1 - \alpha/2 + z_1 - \beta)\, 2\, (\delta_1^2 - \delta_2^2)/(\mu_1^2 - \mu_2^2)$$

Measurements: After obtaining permission from the management of the cardiovascular clinics and collecting written consents from the patients, height, waist, and hip circumference were measured with a tape measure with an accuracy of 1 cm. Weight was also calculated by Seca scale with an accuracy of 100 g. At the beginning of the study, blood pressure was measured with a mercury sphygmomanometer and 5 mL blood was taken from both group members to measure serum lipids. At the end of the study, their blood pressure measurement was repeated and 5 mL blood was taken from all participants again. Furthermore, at the baseline as well as four, and eight weeks after the study, 24-hour food recalls were taken from the participants in two days. The food recalls were analyzed using optimized Nutritionist 4 software according to the Food Bank of Iran.

Total cholesterol (TC), triglycerides (TG), and high density lipoprotein cholesterol (HDL-c) of serum were measured enzymatically using commercial kits (Pars Azemoon Co., Tehran, Iran), with the aid of a Hitachi 717 auto-analyzer (Boehringer Mannheim Diagnostics, Mannheim, Germany). The coefficient of variation (CV) for serum lipids was less than 5 percent. Since the serum TG concentration was less than 400 mg/dL

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in all participating patients, serum LDL-c was estimated using the Friedewald equation (Friedewald WT, 1972).

Calcium, magnesium, and total hardness of Damavand Mineral Water and Tehran Piped Water were measured in the Water Laboratory of School of Public Health affiliated to Tehran University by titration with EDTA. In addition, sodium and potassium of water were measured by flame photometer.

Ethical considerations: People freely participated in the study and did not pay any fee. They could also be excluded freely from the study. All participants signed an informed consent form.

Data analysis: Data analysis was performed using SPSS version 11.5 and paired and independent *t*-tests.

Results

In this study, a total of 41 male patients were investigated. The mean age of participants was 48 ± 8 years, their mean BMI was 27.1 ± 3.1 kg per square meter, the mean WHR was 0.95 ± 0.5, and the duration of hypertension was 7 ± 3 years. No significant difference was observed between the two groups with regard to the mentioned variables.

The mean systolic blood pressure of both groups was reduced at the end of the study; 21.43 percent in case group and 14.88 percent in control group, compared to the baseline. Although the difference between the measures calculated at the baseline and end of the study was significant, the difference between the DM and TW not significant (**Table 1**).

Diastolic blood pressure at the end of the study was reduced to 17.61 percent and 16.47 percent compared to the beginning of the study for the DM and TW, respectively, which was statistically significant. However, the difference between the DM and TW was not significant (**Table 1**).

The mean of serum TG concentration was not statistically significant at the end of the study compared to the baseline measure in each group and between the two groups ($P > 0.05$). At the end of the study, the mean serum TC showed 15.95 percent increase in TW and 11.78 percent decrease in the DM compared to the baseline. The difference were statistically significant in each group and between the two groups. The mean serum LDL-c at the end of study changed -6.84 and 22 percent compared to baseline for the DM and TW, respectively. The difference was statistically significant in each group and between the two groups. The mean serum HDL-c at the end of study increased by 26.05 and 18.64 percent for the DM and TW, respectively, which was statistically significant compared to the baseline but was not statistically significant between the two groups (**Table 1**).

The mean ± SD of mineral contents as well as the hardness of Damavand mineral water and Tehran water are represented in **Table 2**.

At the beginning of the study, energy intake was 1750 ± 420 and 1810 ± 360 Kcal for the DM and TW, respectively, which reached 1780 ± 512 and 1850 ± 470 as well as 1730 ± 450, and 1750 ± 350 at the 4^{th} and 8^{th} weeks, for the DM and TW, respectively. However, the difference was not statistically significant ($P \geq 0.05$).

Moreover, in the present study, intake of nutrients and minerals through diet did not show any statistically significant difference between the case and control groups at the beginning, the fourth and final weeks of the study ($P > 0.05$).

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Table 1. Comparison of mean (± SD) of systolic pressure, diastolic pressure and lipid profiles in two groups

Groups	Damavand mineral water (n = 20)		Tehran water (n = 21)	
Vaiables	Baseline	Week 8	Baseline	Week 8
Systolic blood pressure (mmHg)	151.50 ± 14.24	119.50 ± 12.24[a]	144.0 ± 8.31	122.62 ± 13.29[a]
Diastolic blood pressure (mmHg)	96.50 ± 5.64	76.50 ± 8.72[a]	95.48 ± 4.71	79.76 ± 12.5 [a]
Triglyceride (mg/dl)	189.35 ± 97.49	191.60 ± 95.29	186.95 ± 86.80	190.14 ± 47.43
Cholesterol (mg/dl)	149.50 ± 31.16	133.75 ± 31.97[ab*]	136.10 ± 24.62	157.81 ± 19.04
Low density lipoprotein cholesterol (mg/dl)	55.53 ± 27.11	50.73 ± 27.38[b*]	56.09 ± 33.35	68.48 ± 25.53[a]
High density lipoprotein cholesterol (mg/dl)	44.15 ± 12.23	55.56 ± 11.99[a]	46.61 ± 14.97	55.30 ± 14.24[a]

[a]: Changes reflect week 8 versus baseline values; [b]: Changes reflect week 8 versus Tehran water values; ∗ Denote $p < 0.01$ versus Tehran water

Table 2. Mean (± SD) of hardness and mineral contents of Damavand mineral water and Tehran water

Minerals Type of Waters	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Total Hardness mg/l $caco_{3)}$
Damavand mineral water	58.9 ± 2.84[a]	16.31± 0.84[b]	0.60 ± 0.2 [b]	4.48 ± 0.17 [b]	225 ± 15 [b]
Tehran water	49.32 ± 0.94	12.83 ± 0.83	1.55 ± 0.5	30.00 ± 1.00	183 ± 13

[a] and [b] denote $p < 0.01$ and $p < 0.001$ versus Tehran water, respectively.

Discussion

In this study, consumption of mineral water and municipal water of Tehran reduced the systolic and diastolic blood pressure, but the impact of mineral water was more significant. Moreover, in the study of Erceg-Rukavina, mineral water consumption by patients with stage 1 hypertension decreased the blood pressure (Erceg-Rukavina and Stefanovski, 2014). These findings were consistent with the results of Luft (Luft *et al.*, 1990) and Rylander (Rylander and Arnaud, 2004).

It seems that the impact of mineral water on blood pressure reduction was higher than the municipal water of Tehran, which could be due to higher total hardness of this water. In addition, mineral water contains more ions of calcium, magnesium, and potassium, whereas, its level of sodium is less than Tehran municipal water.

The results of this study showed that the serum TG concentration after eight weeks of consuming mineral water and municipal water did not change significantly compared to the baseline in the case and control groups. The results of this study are consistent with the study of Capurso, in which drinking mineral water for three weeks did not have any effects on the serum TG (Capurso *et al.*, 1999).

In our study, TC and serum LDL-c levels reduced significantly after eight weeks of drinking mineral water. However, serum HDL-c levels increased significantly after eight weeks of consuming water compared to the beginning of study. The results of this study were consistent with the results of Bostick (Bostick *et al.*, 1999). In the study of Bostick, prescription of calcium supplements reduced serum LDL-c by 4.5-11 percent, while serum HDL-c showed a slight decrease.

The findings of this study were consistent with the results of Bain (Bain *et al.*, 2015). He stated that mineral water was rich in calcium and magnesium; so, it could be considered as an important source of calcium and magnesium supplement. Due to alkaline nature and osmotic effect, mineral water can have effect on fat and cholesterol absorption or bile acids excretion increase. It is demonstrated that absorption of fatty acids and cholesterol in the small intestine decreased throughout the water consumption period

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and the functions of pancreatic enzymes and bile salts enhanced with increased PH. Thus, increased luminal PH, caused by mineral water reduces intestinal uptake of cholesterol and fat (Chijiiwa and Linscheer, 1984, 1987, Shils *et al.*, 1994).

Other researchers also indicated the reduced size of gallbladder with consuming mineral water rich in calcium sulfate (Coiro *et al.*, 1997, Cuomo *et al.*, 2002), bicarbonate and calcium (Potischman, 2003), as well as sulfate and bicarbonate (Grossi *et al.*, 1996). A variety of mineral waters are able to increase the excretion of bile. So, it seems that mineral water with different ionic compounds affect stimulation of the bile flow into the duodenum due to high osmolarity (Capurso *et al.*, 1999).

The mechanisms by which mineral water reduces serum TC and LDL-c are similar to those on which soluble fiber acts through. Soluble fibers reduce cholesterol absorption mainly due to the intestinal viscosity and interference with enterohepatic cycle (Rylander and Arnaud, 2004).

Our results were consistent with the results of Aslanabadi et al. In their study, consuming a liter of mineral water for a month, decreased total cholesterol and LDL-c, but had no effect on serum triglyceride and HDL-c (Aslanabadi *et al.*, 2014).

Conclusions

The results of this study showed that daily consumption of 1.5 liters of premium mineral water of Damavand springs decreased systolic and diastolic blood pressure, TC, and LDL-c levels. Therefore, more research is required to verify the involved mechanisms as well as the effect of mineral water on the above-mentioned factors in longer periods.

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Authors' contribution

All authors equally contributed in this study. All authors read and approved the final manuscript.

Conflict of Interest

The authors declared no conflict of interest.

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