

Hydration bioanalyses of the effects of hydrogen-rich water (HRW)

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ABSTRACT

Aim: To demonstrate the effects of hydrogen-rich water (HRW) on hydration by examining hematocrit, blood viscosity, and urine osmolality.

Materials and Methods: Hydrogen Evodrop rich water (HEW), produced from a patented device with hydrogen concentration therein 900–1200 ppb or 0.9–1.2 ppm, ORP ranging from –450 to –580 mV, and pH=7.1–7.3. Blood viscosity, hematocrit and urine osmolality had been determined in 10 volunteers (five women and five men) during the 21-day period of HEW intake, under standard dietary conditions.

Results: No evidence of erythrocyte agglutination or morphological abnormalities was observed. Urine osmolality in both men and women decreased after HEW consumption, likely due to improved hydration. However, osmolality before the consumption was higher in men compared to women. Both men and women exhibited statistically significant changes in hematocrit and blood viscosity parameters after consuming HEW, which decreased. This suggests improved hydration and reduced blood viscosity.

Conclusions: These results suggest that measurable hydration effects in the human body may be achieved through regular intake of HEW. The findings of the research support the benefit of the use of HEW in promoting body hydration. The analysis suggests that hematocrit is more closely associated with other factors, such as hydration status and plasma volume following HEW consumption. HEW consumption consistently affected urine osmolality, which may reflect in overall hydration status. Overall, HEW intake produced consistent changes in key hematological and renal hydration markers, indicating favorable effects on blood fluidity and water balance.

KEY WORDS: hydrogen-rich water (HRW), hydration, hematocrit, blood viscosity, urine osmolality

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INTRODUCTION

Numerous studies and analyses have examined the factors contributing to health and longevity in the XX and XXI centuries. The key factors are heredity, physical activity, proper nutrition and hydration, psychological factors, and regular movement. Empirical data have shown that long-lived individuals and centenarians tend to reside primarily in mountainous regions. One of the co-authors, Ignatov, studied over 500 long-lived individuals, including centenarians and their siblings, in Bulgaria from 2012 to 2019. Mountain spring water was analyzed as a contributing factor. The results were published in the Journal of the Ministry of Health, Bulgaria [1,2]. The conclusion from this project is that optimal levels of calcium (Ca²⁺), magnesium (Mg²⁺), potassium (K⁺), sodium (Na⁺), manganese (Mn²⁺), and zinc (Zn²⁺) content in water and food are essential for the physio-

logical balance [3]. The significance of these minerals is demonstrated in [4]. The antioxidant properties of trace elements in food and water are also analyzed [4]. Although trace elements are found in greater quantities in food than in water, researchers have also reported them in water.

It is important to note that molecular hydrogen, whether in gaseous form or dissolved in water, has no known toxic effects [5]. Despite this safety profile, its potential in medicine remained largely unexplored until 2007. That year, Oshava et al. reported that inhalation of 1–4% hydrogen gas reduced hydroxyl radicals and peroxynitrate levels [6]. This discovery represented a significant breakthrough, opening new avenues for medical applications of hydrogen.

Scientists have achieved antioxidant results with molecular hydrogen (H₂), which can be administered by

inhalation or dissolved in water [7]. Molecular hydrogen reduces oxidative stress caused by increased ROS [8]. Potential anti-inflammatory and radioprotective effects have also been observed [6,9]. The HRW has anti-inflammatory effects also [10]. A significant advantage of its application in these directions is the absence of smell, color, and taste, as well as its non-toxicity [4]. The results with molecular hydrogen were achieved on animals – anti-tumor effects of hamsters [11], anti-inflammatory intestinal influence of rats [12].

A lot of studies were performed with mice. Drinking H₂-water prevented aging-dependent memory impairment induced by oxidative stress in DAL101 mice, and improved cognitive function [13]. In a D-galactose-induced aging mouse model, H₂ (administered via inhalation, HRW, or H₂-rich saline) significantly improved aging-related biomarkers and reduced oxidative stress in liver, brain, and heart tissues [14]. HRW improved chronic inflammatory pain [15]. Repeated inhalation of hydrogen-oxygen mixed gas significantly decreased both acute and chronic mild stress-induced depressive and anxiety-like behaviors in mice [16].

Molecular hydrogen has been shown to affect metabolic diseases when used in hyperbaric therapy, raising hope for its application in clinical practice in the future, especially in patients with metabolic diseases such as atherosclerosis, diabetes mellitus, metabolic syndrome, and obesity [17].

However, hydrogen-rich water has gained wider popularity. HRW has demonstrated antioxidant [18] and anti-inflammatory effects [19]. Nakao et al. proposed obtaining HRW by placing a portable metal magnesium stick in drinking water and recommend it as a safe, easy, and effective method of providing HRW for daily consumption [18]. The oral intake of hydrogen-containing fluids, mainly through tablets that release hydrogen when dissolved in water, is a convenient and practical method, making it easy for individuals to incorporate into their daily routines. These tablets are registered as dietary supplements. Their effects on blood lipid profiles and inflammation biomarkers have been documented [20].

Hydrogen-rich water has often been generated through the chemical reaction of metallic magnesium with water, a simple process that produces molecular hydrogen *in situ*. While this approach provides a straightforward means of enrichment, recent advances have shifted attention to dedicated devices capable of continuously producing hydrogen-rich water. A hydrogen-rich water cathode chamber refers to the part of the electrolytic device that generates hydrogen gas. It is then dissolved into water to produce HRW, a consumable beverage [21].

Hydrogen-rich water has been used prophylactically in the past two decades. Animal and human studies have been conducted to demonstrate the effects of HRW. The increasing number of investigations provides more detailed analyses of HRW's effects, significantly contributing to a better understanding of its potential benefits. This rapidly expanding body of research should instill optimism about the future applications of hydrogen-rich water. The beneficial effects of HRW on human health, including physical endurance, liver function, cardiovascular health, aging retardation, and mental health, are attracting increasing interest and research. These effects have been described in the current literature [22–26].

Good hydration is an essential factor for maintaining metabolism, physiological functions, and overall health.

AIM

This study aims to demonstrate the effects of HRW on hydration by examining hematocrit, blood viscosity, and urine osmolality.

MATERIALS AND METHODS

HYDROGEN RICH-WATER

Hydrogen-rich water was produced using a patented device, the parameters of which are also published in [11,27]. In the papers [11,27] the water was defined as Hydrogen Evodrop-rich water (HEW). The hydrogen concentration therein is 900-1200 ppb or 0.9~1.2 ppm, ORP is (–450~ –580) mV, and pH=7.1~7.3.

DEVICE FOR MEASUREMENT OF VISCOSITY

IKA-Werke®GmbH&Co. KG, type: Brookfield DV2T with shear rate 94.5 s⁻¹ with 5.7-inch Full-color Touch Screen Display, enhanced security, Convenient Bubble Leveling, built-in RTD Temperature Probe, DV360 Software Optional.

DEVICE FOR URINE OSMOLALITY INVESTIGATIONS

Advanced Instruments INC, type: Advanced Micro-Osmometer model 3320. Determines the osmolality of solutions using freezing point depression (FPD). An automatic single-sample instrument is designed to process a sample with one-minute test time. Feature ease-of-use, internal diagnostics, automated calibrated, on-board statistical analysis.

Table 1. Results of hematocrit before and after consumption of hydrogen-rich water (HEW)

Number men	hematocrit result (L/L) before	hematocrit result (L/L) after	norm (L/L)	Number women	hematocrit result (L/L) before	hematocrit result (L/L) after	norm (L/L)
1.	0.51	0.48	0.40–0.53	6.	0.42	0.39	0.36–0.48
2.	0.50	0.46	0.40–0.53	7.	0.42	0.40	0.36–0.48
3.	0.47	0.46	0.40–0.53	8.	0.39	0.39	0.36–0.48
4.	0.50	0.46	0.40–0.53	9.	0.40	0.39	0.36–0.48
5.	0.49	0.47	0.40–0.53	10.	0.43	0.40	0.36–0.48

Note: Reference ranges for hematocrit used in this table (men: 0.40–0.53 L/L), (women: 0.36–0.48 L/L)

Source: compiled by the authors of this study

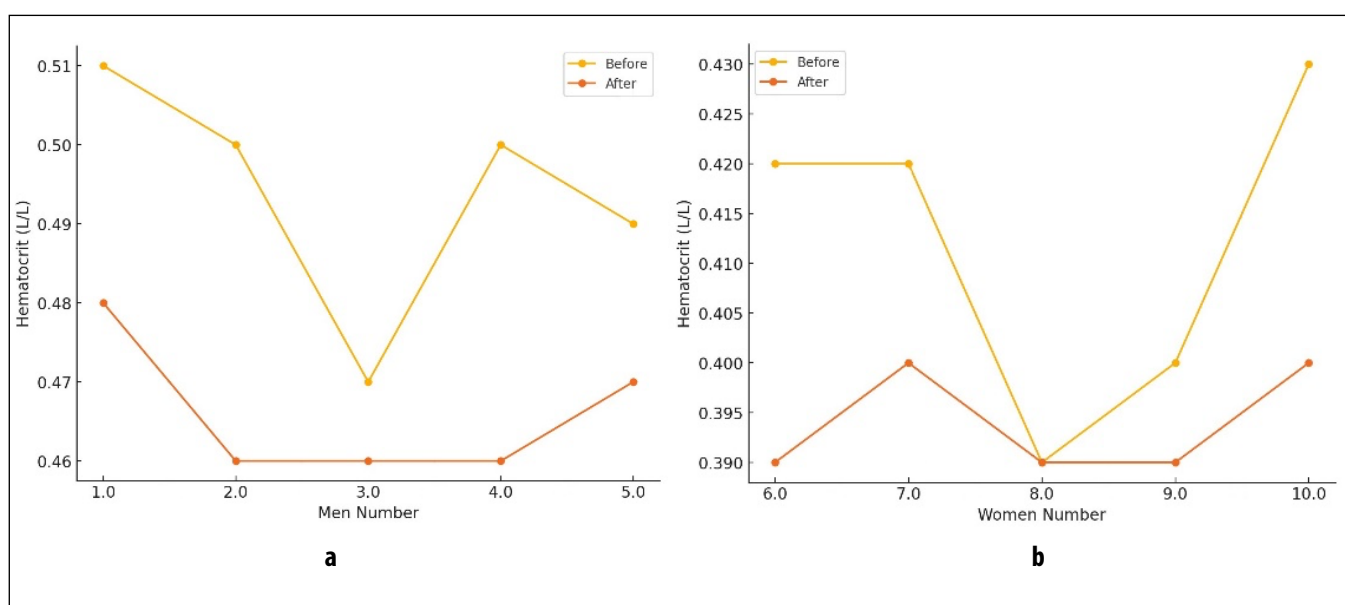


Fig. 1. Results of hematocrit before and after consumption of hydrogen-rich water (HRW): a – men; b – women

Picture taken by the authors

MICROSCOPE

The microscope for blood observation and analysis Olympus CX43 has the following parameters: head: binocular or trinocular; eyepiece: 10X/20; nosepiece: quintuple; Plan N 4x, 10x, 40x, 100 x Oil; stage: rackless XY Stage w/slide Holder; condenser: 1.25 N. A. Condenser, 7 Positions; light source: LED.

CLINICAL RESULTS OF HEMATOCRIT AND URINE

The values of hematocrit (HCT), blood viscosity and urine osmolality were determined. The research of blood and urine parameters was made in a licensed laboratory (Bodymed, Sofia, Bulgaria).

CONDITIONS FOR TESTING

The study involved 10 volunteers, five women and five men.

The present study was conducted using anonymous blood and urine samples voluntarily provided

by participants. No personal information, including age or health status, was collected, and no medical or pharmacological interventions were performed. All procedures adhered to the principle of data protection and ensured minimal risk to participants, eliminating the need for bioethical committee approval. The study focused on non-invasive analysis in accordance with international standards for scientific research. The standards and parameters of the water for the tests are in accordance with the European Drinking Water Directive 2020/2184 [28].

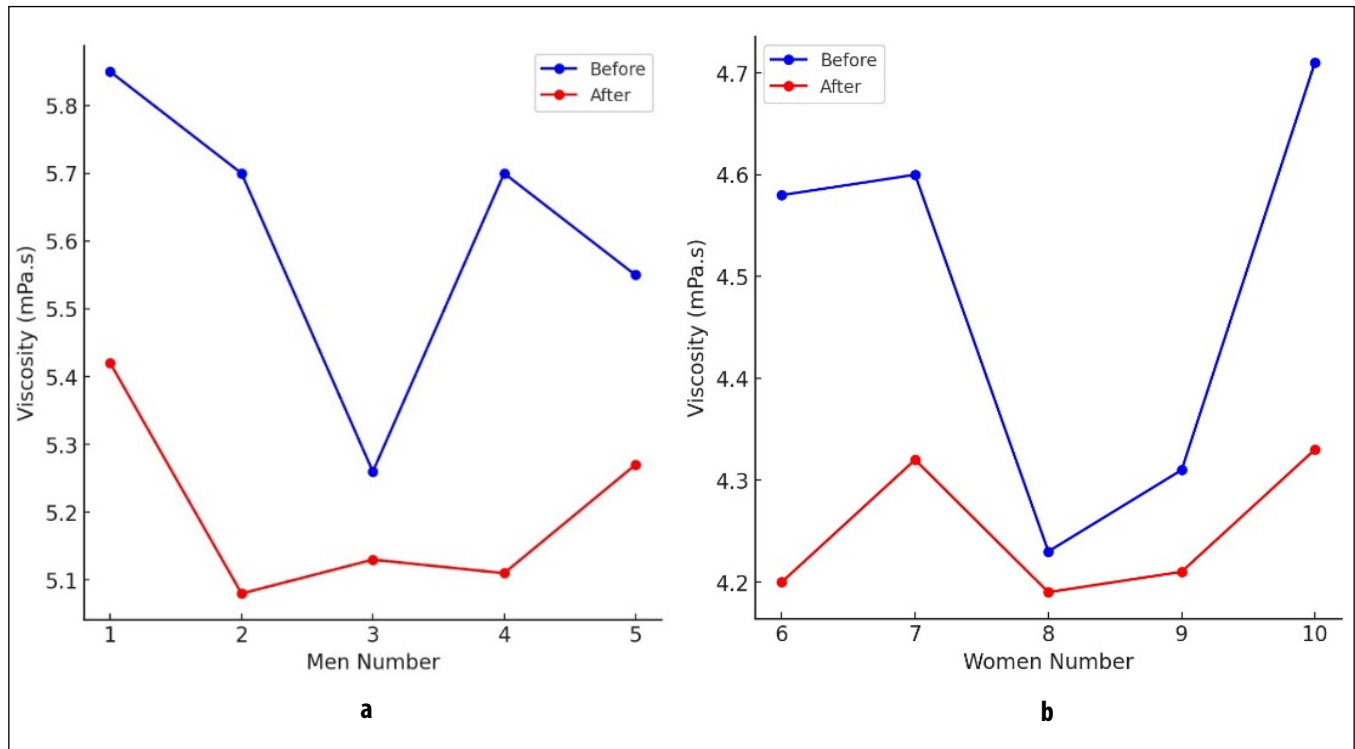
COMPUTER PROGRAM PROCEEDING WITH PROGRAM PYTHON RELEVANCE AS A SOFTWARE DEVELOPMENT

All statistical analyses and figure generation were performed using Python programming language, utilizing libraries as Matplotlib for data visualization and statistical packages such as SciPy and pandas for data analysis.

Table 2. Results of viscosity before and after consumption of Hydrogen Evodrop-rich water (HEW) for men and women

Number men	viscosity result (mPa.s) before	viscosity result (mPa.s) after	norm (mPa.s)	Number women	viscosity result (mPa.s) before	hematocrit result (mPa.s) after	norm (mPa.s)
1.	5.85	5.42	4.0-5.5	6.	4.58	4.20	3.5-5.0
2.	5.70	5.08	4.0-5.5	7.	4.60	4.32	3.5-5.0
3.	5.26	5.13	4.0-5.5	8.	4.23	4.19	3.5-5.0
4.	5.70	5.11	4.0-5.5	9.	4.31	4.21	3.5-5.0
5.	5.55	5.27	4.0-5.5	10.	4.71	4.33	3.5-5.0

Source: compiled by the authors of this study

**Fig. 2.** Results of viscosity before and after consumption of Hydrogen Evodrop-rich water (HEW) for men (a) and women (b)

Picture taken by the authors

CONDITIONS FOR THE TESTING

The study involved 10 volunteers, five women and five men.

The present study was conducted using anonymous blood and urine samples voluntarily provided by participants. No personal information, including age or health status, was collected, and no medical or pharmacological interventions were performed. All procedures adhered to principle of data protection and ensured minimal risk to participants, eliminating the need for bioethical committee approval. The study focused on non-invasive analysis on accordance with international standards for scientific research. The standard and parameters of the water for the tests according the European Drinking Water Directive 2020/2184 with certificate No. 13100/02.02.2023 is published in [28].

ETHICS

According to the Bulgarian Law on Medicinal Products in Human Medicine and Ordinance No. 31 on Good Clinical Practice, ethical approval is mandatory only for clinical trials involving medicinal products. Drinking water is not a medicinal product. All ten participants provided informed consent before their inclusion.

RESULTS

BLOOD CLINICAL TESTING

HEMATOCRIT TEST RESULTS

Table 1 and Figs. 1a and 1b illustrate the results of hematocrit for men and women before and after consuming Hydrogen Evodrop-rich water (HEW).

Table 3. Results between osmolality of urine before and after consumption of hydrogen-rich water

Number men	osmolality result (mOsm kg ⁻¹) before	osmolality result (mOsm kg ⁻¹) after	norm (mOsm kg ⁻¹)	Number women	osmolality result (mOsm kg ⁻¹) before	osmolality result (mOsm kg ⁻¹) after	norm (mOsm kg ⁻¹)
1.	820	760	500-850	6.	790	710	500-850
2.	790	710	500-850	7.	770	720	500-850
3.	750	710	500-850	8.	780	720	500-850
4.	790	720	500-850	9.	760	690	500-850
5.	780	730	500-850	10.	800	730	500-850

Source: compiled by the authors of this study

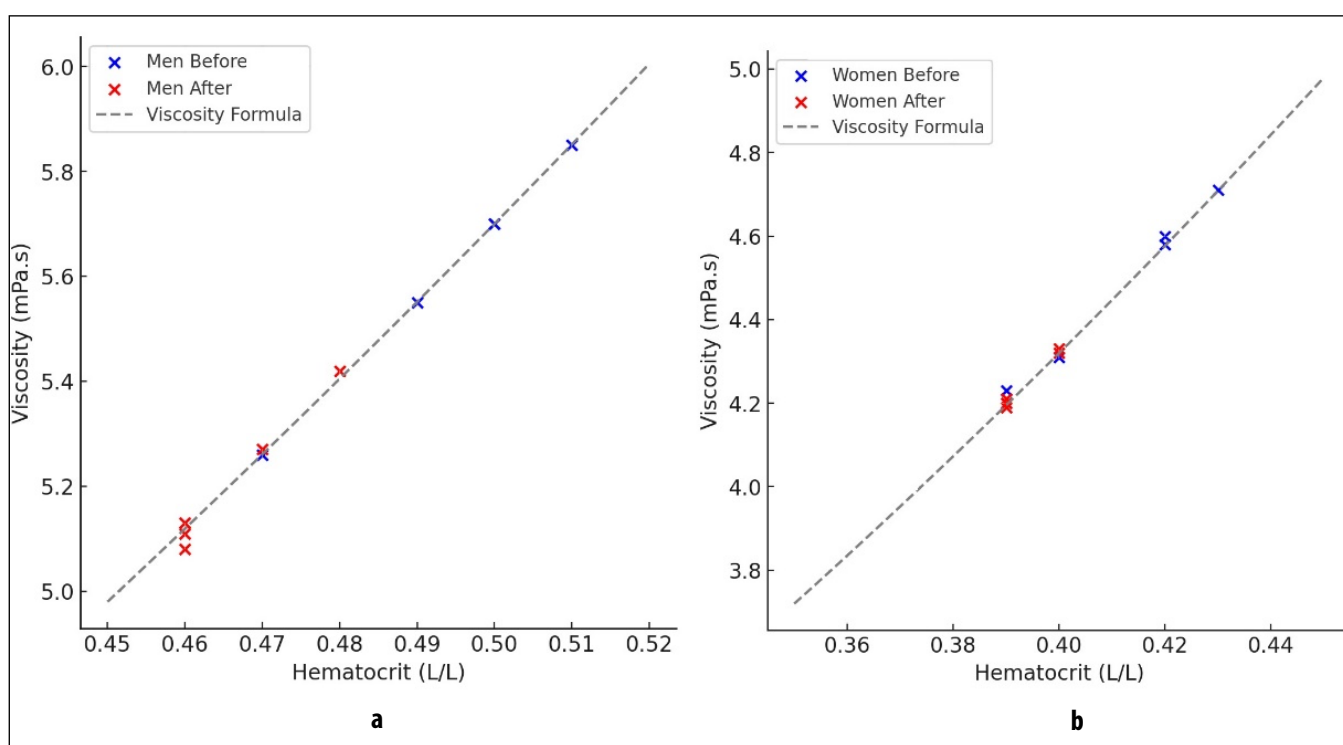


Fig. 3. Relationship between the hematocrit and blood viscosity in men (a) and women (b), both before and after consuming Hydrogen Evodrop rich-water

Picture taken by the authors

correspond to standard clinical laboratory protocols, in line with internationally accepted reference intervals as reported in *Tietz Textbook in Clinical Chemistry and Molecular Diagnostics* (6th ed., 2018) and *Henry's Clinical Diagnostic and Management by Laboratory Methods* (23rd ed., 2018)

The statistical results with the Student t-test are as next:

Men: $p < 0.01$;

Women: $p < 0.05$;

Paired Student's t-test showed significant differences:

Men: $t(4) = -4.84, p = 0.0086, \text{mean difference} = -0.028 \pm 0.013$ L/L; Cohen's $d_z = -2.15$

Women: $t(4) = -3.09, p = 0.0367, \text{mean difference} = -0.018 \pm 0.013$ L/L; Cohen's $d_z = -1.38$

The correlation coefficient (Men: $r = 0.516$; Women: $r = 0.722$) reflect the association between pre- and post-values, not effect size.

Both men and women exhibited statistically changes in hematocrit parameters after consuming HRW (Fig. 1).

BLOOD VISCOSITY TEST RESULTS

Table 2 and Fig. 2 present the viscosity results before and after consuming Hydrogen Evodrop-rich water (HEW) in men and women.

By the t-test of Student the following results were achieved:

Men; $p < 0.05$;

Women: $p < 0.05$;

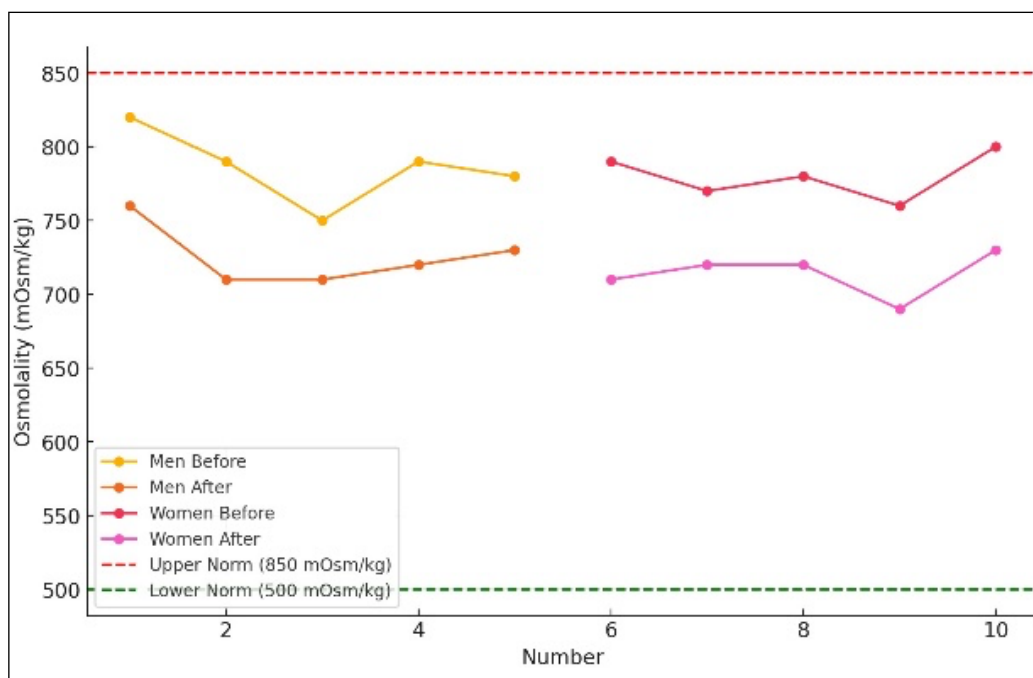


Fig. 4. Results between osmolality of urine before and after consumption of hydrogen-rich water

Picture taken by the authors

Paired Student's t-test showed significant differences:
Men: $t(4) = -4.42$, $p = 0.0115$, mean difference $= -0.410 \pm 0.208$ mPa.s; Cohen's $d_z = -1.98$

Women: $t(4) = -3.33$, $p = 0.0290$, mean difference $= -0.236 \pm 0.158$ mPa.s; Cohen's $d_z = -1.49$

The correlation coefficient (Men: $r = 0.43$; Women: $r = 0.77$) indicates the relationship between pre- and post-values rather than effect size.

Both men and women showed statistically changes in blood viscosity parameters after consuming HRW.

COMPARISON BETWEEN HEMATOCRIT AND BLOOD VISCOSITY

Let's compare the hematocrit and blood viscosity results. The study involved one group of 10 participants (5 men and 5 women) with pre- and post-intervention measurements.

The graphs in Figs 3a and 3b illustrate the relationship between the hematocrit and blood viscosity in men, both before and after consuming Hydrogen Evodrop-rich water (HEW).

The graphs present the relationship between hematocrit and viscosity.

There is a clear linear relationship between hematocrit and blood viscosity, visible from the figure. As the hematocrit increases, the blood viscosity increases.

The blue markers represent the values before HEW consumption, while the red markers represent the values after HRW consumption.

The red markers show that after consuming HEW, both hematocrit and blood viscosity decrease. This suggests improved hydration and a reduction in blood viscosity.

The dashed line represents the theoretical viscosity model as a function of hematocrit. The actual data points (both before and after) align closely with a linear model, indicating that the model accurately describes the relationship between these two variables.

The formulas for the linear equation, based on the data from the figure are:

For men: $\text{Viscosity} = 14.78 \times \text{Hematocrit} - 1.69$ (2).

For women: $\text{Viscosity} = 12.72 \times \text{Hematocrit} - 0.70$ (3).

The relationship between the two formulas, which describe the dependence between hematocrit and blood viscosity in men and women, can be analyzed by comparing their coefficients (slopes) and constants (intercepts):

Slope: for men (14.78) and for women (12.72)

Intercepts: (-1.69) and (-0.70)

The slope indicates how quickly blood viscosity changes with variations in hematocrit. The higher slope in (14.18) compared to women (12.61) suggests that blood viscosity increases more rapidly with increasing hematocrit in men.

The intercept represents the viscosity value when hematocrit is zero (a theoretical value). The difference in intercepts is relatively tiny but indicates that at equal hematocrit levels, blood viscosity in men would be slightly higher than in women if explored to lower hematocrit values.

OSMALALITY TESTS RESULTS

Table 3 and Fig. 4 show the results between osmolality of urine before and after consumption of hydrogen-rich water.

The graph illustrates that osmolality in both men and women decreases after the consumption of HRW, likely due to improved hydration. However, osmolality before the consumption was higher in men compared to women.

Results of t-test Student:

Men; $p < 0.01$; $r = 0.78$; moderate positive correlation.

Women; $p < 0.001$; $r = 0.73$; moderate positive correlation.

The statistical analysis confirms that HRW consumption has a significant and positive impact on hydration, as reflected by the decreased osmolality levels in both men and women. Both groups show moderate positive correlations ($r = 0.78$ for men and $r = 0.73$ for women), meaning that the changes in osmolality after HRW consumption are consistent and statistically significant. The slightly higher correlation in men could suggest that the effect of HRW is somewhat more pronounced in men, though the difference is relatively small.

DISCUSSION

The results obtained show that the elevated hematocrit values in men and women decreased after consuming hydrogen-rich water and approached normal values. This is an effect with a positive impact. The stronger correlation observed in women may indicate that hematocrit is more closely associated with other constant factors, such as hydration and plasma volume.

Hematocrit (HCT) is a percentage ratio of the volume of red blood cells (erythrocytes) to the total blood volume. It is a crucial indicator for evaluating the body's hydration status and other health conditions. When the body loses significant amounts of fluid or becomes dehydrated, the plasma volume decreases, increasing hematocrit. This occurs because the reduction of fluids increases the concentration of red blood cells. The movement of body water from the blood vessels to muscle tissue can cause hemoconcentration. It has been shown that an increase in HCT up to 60% can disrupt capillary blood flow, which hurts the body's capacity for physical activity [29,30]. Hematocrit is the main determinant of blood viscosity, and a doubling of HCT results in a 3- to 4-fold increase in blood viscosity. Elevated hematocrit is often a sign of dehydration and may be associated with symptoms such as dry skin, reduced urine output, and fatigue. The condition of the blood has a significant impact on the optimal physiological functions of the body. Deviations in the physical properties of blood are associated with the pathogenesis of various diseases. These deviations are also a valuable indicator of circulatory health and disease [29].

Dehydration increases the concentration of blood cells and proteins in the blood, leading in higher viscosity. Blood viscosity rises when less plasma dilutes the blood cells and other components. Elevated blood viscosity can impair average blood circulation and increase the risk of blood clot formation, which may lead to cardiovascular complications. Hyperviscosity may be due to changes in blood cells and plasma components. It can cause microvascular damage and subsequently a number of diseases.

Our analyses show gender influence on the relationship between hematocrit and viscosity. The shown formulas illustrate a stronger relationship between hematocrit and blood viscosity in men compared to women, which may be to differences in blood composition, hormonal factors, or other physiological indicators. The results also show that blood viscosity changes with variations in hematocrit. In men, blood viscosity increases more rapidly with increasing hematocrit. This may indicate that men's blood is more sensitive to changes in red blood cell concentration. The condition of the blood has a significant impact on the optimal physiological functions of the body. The physical properties of blood affect hemodynamics in health and disease, and their deviations are associated with the pathogenesis of various diseases. They are also a valuable indicator of circulatory health and disease. Aggregation of erythrocytes occurs normally in the circulation of healthy people, so it should not be considered harmful if it is within acceptable limits. However, pathological hyper aggregation is a non-specific marker in a wide range of diseases, including inflammatory disorders. Dehydration causes water-electrolyte imbalance and changes in blood volume. Adequate hydration with carbohydrate-electrolyte fluids during physical activity can prevent dehydration and delay the onset of fatigue, allowing proper biochemical and hematological responses during physical exertion.

Urine osmolality is another indicator of human health. It reflects the ratio of dissolved substances to water and can be estimated by determining the concentrations of dissolved substances and urea in it. It is used to assess kidney function and the body's hydration status. Urine osmolality is related to the body's hydration level. When a person is well-hydrated, urine osmolality is low because the kidneys excrete excess water. In cases of over hydration, urine becomes more diluted, resulting in a lower concentration of dissolved substances and lower osmolality. Conversely, during dehydration, urine osmolality increases as the body tries to conserve water. The kidneys reduce the amount of urine produced, making it more concentrated. This leads to a higher concentration of electrolytes and other dissolved substances, thereby raising urine osmolality.

Overall, our research demonstrates some of the human health benefits of consuming HRW. H_2 has been suggested in experimental and preclinical studies to have potential therapeutic effects. Consuming hydrogen-treated plant crops and hydrogen-containing beverages can offer numerous health benefits. Taking HRW has beneficial effects that enhance central nervous system functions, including mood, anxiety, and autonomic nerve function, which may help improve quality of life. The hydrogen intervention was applied with effects on rats. In addition, Toshkova et al. found experimentally in golden Syrian hamsters that hydrogen-rich EVOdrop water with an H_2 concentration of 0.9~1.2 ppm, pH=7.3 and oxidation-reduction potential ~450 mV has an antitumor effect. It has a normalizing effect on hematological parameters as well as an anti-cancer potential that can be used alongside conventional chemotherapeutics, even for the treatment and prevention of cancer.

Hydrogen-rich water (HRW) is enriched with molecular hydrogen (H_2). Initially, HRW was produced by dissolving magnesium in water. Currently, tablets are available as food additives that can generate hydrogen in water. Larger quantities of HRW are obtained through electrolysis devices, which produce water saturated with hydrogen. It's important to note that hydrogen gas and H_2 dissolved in water have no known toxic effects. This safety profile and hydrogen's potential in medical applications remained largely unexplored until 2007. That year, Ohsawa et al. reported that inhaling 1-4% hydrogen gas could significantly ameliorate cerebral ischemia-injury by selectively reducing hydroxyl radicals and peroxynitrite. This discovery marked a significant turning point in the field, opening up new possibilities for medical applications of hydrogen.

The medical effects were achieved with hydrogen concentration under 2.0 ppm [31]. In the hydrogen EVOdrop rich water, the hydrogen concentration is 0.9-1.2 ppm, ORP is (-450~ -580) mV, and pH=7.1-7.3 [21, 22]. Numerous studies have been conducted in recent years on the bioeffects of molecular hydrogen. Its antioxidant effects have also been demonstrated [23]. Experimental studies suggest that HRW may neutralize oxidants such as hydroxyl radical ($\cdot OH$) and peroxynitrite ($ONOO\cdot$) inside cells. Effects on mitochondria are also described. Hydrogen quickly penetrates tissues and cells, but with its mild action, it does not disrupt metabolic redox reactions or affect signaling by reactive oxygen species, so no adverse effects have been reported. In addition, it stimulates energy metabolism. Among the possible methods of preventive and therapeutic application in humans, such as inhalation of H_2 gas, injection of saline solution with H_2 , instillation of such solution

into the eyes, or taking an H_2 bath, drinking H_2 water is the most accessible option with potential for clinical applications in many diseases. Importantly, research on its effects on various diseases is underway, offering hope for potential medical applications.

Dehydration increases the concentration of blood cells in the blood, leading to higher viscosity. Blood viscosity rises when less plasma is diluted with the blood cells and other components. Elevated blood viscosity can impair average blood circulation and increase the risk of blood clot formation, which may lead to cardiovascular complications. Hyperviscosity may be due to changes in the blood cells and plasma components. It can cause microvascular damage and subsequently several diseases. Prolonged hyperviscosity has been linked to reduced oxygen delivery to tissue, further aggravating cellular hypoxia. Increased shear stress on the vascular endothelium can promote endothelial dysfunction and inflammation. Clinical studies indicate that hyperviscosity is associated with hypertension, stroke, and metabolic syndrome. Even mild dehydration can significantly affect hemorheological parameters, especially elderly individuals [32].

Therefore, maintaining optimal hydration is crucial for preserving normal blood rheology and preventing viscosity-related pathologies. Furthermore, the balance of hydrogen ions (pH) in plasma plays a critical role in modulating protein charge and red blood cell interactions, thereby influencing blood viscosity [33]. Alterations in pH can exacerbate oxidative stress and vascular dysfunction, while molecular hydrogen has been reported to reduce reactive oxygen species (ROS) and protect endothelial function [34].

This dual perspective – focusing both on hydration and redox regulation highlights the importance of water balance and hydrogen-related mechanisms in maintaining healthy microcirculation and preventing cardiovascular risk.

CONCLUSIONS

This study suggests that intake of hydrogen-rich water (HRW) with a concentration of molecular hydrogen 0.9–1.2 ppm, pH=7.2, and oxidation-reduction potential (-450) mV may be associated with changes in hydration-related markers such as hematocrit, blood viscosity, and urine osmolality.

The following results were achieved:

1. Hematocrit levels decreased after HRW intake in both men ($p < 0.01$) and women ($p < 0.05$).
2. Blood viscosity measured at shear rate of 94.5 s^{-1} was also reduced after HRW intake in both sexes ($p < 0.05$).
3. Both hematocrit and viscosity changed in the same

direction, indicating a consistent effect of HRW on blood rheology.

4. These preliminary findings support the need for further studies to establish the physiological relevance of HRW consumption. Moreover, the observed improvements in rheological properties suggest that

hydration-rich water (HRW) may contribute to better microcircularity function, more efficient oxygen delivery, and reduced cardiovascular strain. The alignment of decreased hematocrit and viscosity highlights a potential integrative role of HRW in modulating both plasma volume and cellular concentration.

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CONFLICT OF INTEREST

Author Fabio Huether is co-inventor of the Patent CH Patent WO2020169852A1. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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