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HYDROGEN WATER - HOW HEALTHY IS IT?

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ABSTRACT

Hydrogen-rich water (HRW) has recently gained attention as a potential therapeutic modality in health and wellness.
H2 is postulated to possess antioxidant properties that can neutralize free radicals in the human body and the evidence suggests that ROS are related to diverse abilities of cancer cells: increased cell proliferation, DNA synthesis, survival, cellular migration, invasion, tumor metastasis, and angiogenesis (Xiao & Miwa, 2017).
The potential benefits of hydrogen-rich water have been investigated for liver function, cardiovascular disease, mental health, and oxidative stress. After applying predefined search criteria, numerous relevant publications addressing these aspects were reviewed.
Preliminary findings from clinical trials and experimental studies are promising; furthermore, its favorable safety profile, low cost, and ease of administration make hydrogen-rich water an attractive candidate for future preventive and therapeutic applications. However, further research involving larger cohorts and more rigorous methodologies is required to validate these results. Additionally, the underlying mechanisms responsible for the observed effects of hydrogen-rich water remain to be fully elucidated.

KEYWORDS

Policy development, School Management, Indiscipline, Leadership, Challenges and Strategies

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Methods and materials

This narrative review was conducted using PubMed databases (2008-2025) with the following search terms: hydrogen water, hydrogenated water, hydrogen rich water, anti-oxidant, anti-inflammatory.

The methodology for this review involved a selection process for the included studies. Articles were excluded based on a couple of criteria: (1) inability to obtain outcome data and (2) duplicates of already considered publications.

Introduction

Several methods are available for H_2 administration. These include inhalation of hydrogen gas, ingestion of hydrogen-dissolved water (hydrogen water), hydrogen baths, injection of hydrogen-dissolved saline (hydrogen saline), topical application of hydrogen saline to the eye, and enhancement of intestinal H_2 production. The most common route of administration is hydrogen water, which this review will focus on. Hydrogen water, often referred to as hydrogen-rich water or hydrogenated water, is ordinary water that has had molecular hydrogen gas (H_2) infused into it. Hydrogenation of water occurs by dissolving molecular hydrogen gas into water at high pressure, leading to a supersaturated solution. Main benefits of H_2 consumption are related to its largely described antioxidant properties. Four primary reactive oxygen species (ROS) are present in the human body: superoxide anions (O_2-), hydrogen peroxide (H_2O_2), singlet oxygen (O_2), and hydroxyl radicals (OH) (Hirano et al., 2021; 'Molecular Hydrogen as a Novel Antioxidant', 2015a)Oxygen that escapes from the mitochondrial electron transport chain is reduced to form O_2-, which is subsequently converted to H_2O_2 by superoxide dismutase (SOD) and further reduced to water by enzymes such as catalase. Hydroxyl radicals (OH) are generated when water molecules are exposed to ionizing radiation or when H_2O_2 is subjected to ultraviolet light. H_2 can scavenge large amounts of OH produced in the mitochondria by converting it to water molecules (Figure 1).

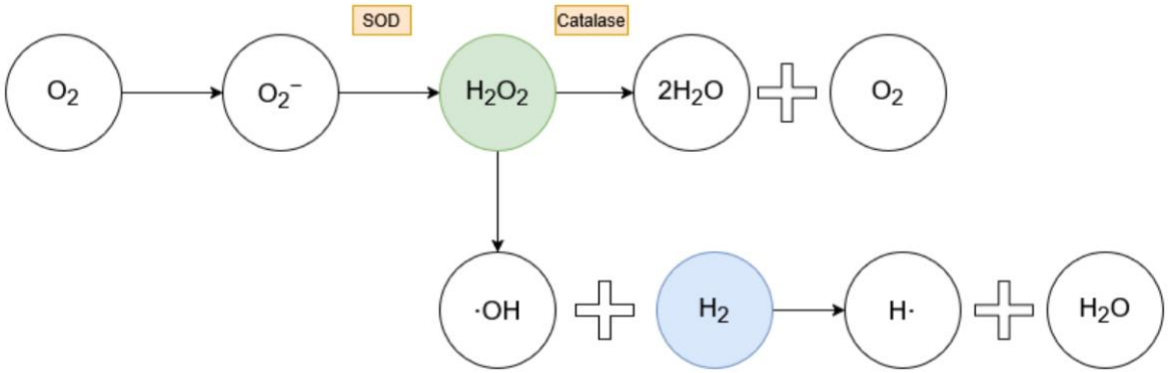

Fig. 1. *Selective action of molecular hydrogen (H_2).*

Research has been conducted on both animals and humans in recent decades, demonstrating that molecular hydrogen-enriched water exhibits antioxidant and anti-inflammatory effects (Hu et al., 2024; 'Molecular Hydrogen as a Novel Antioxidant', 2015b; Sim et al., 2020), metabolic health improvement (LeBaron et al., 2019; Song et al., 2013), neuroprotective effects (Fujita et al., 2009; Gao et al., 2017; Mizuno et al., 2018; Nishimaki et al., 2018) and anti-cancer properties(Kang et al., 2011; Yang et al., 2017). Through this review the authors aim to showcase the most important findings related to consumption of hydrogen water.

Results & Discussion

The summary of the results is organized under the categories included in Figure 2.

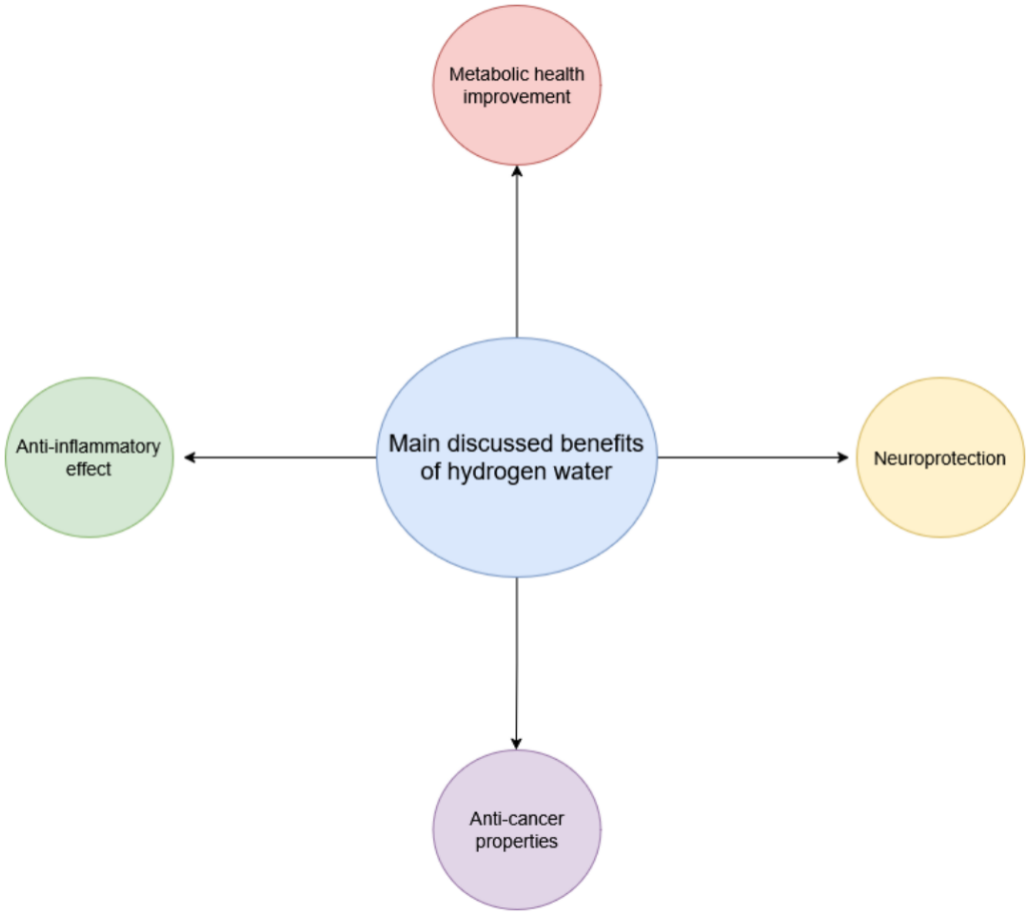

Fig. 2. *Summary of benefits of hydrogen-rich water.*

Anti-inflammatory effects

Oxidative stress arises from the strong cellular oxidizing potential of excess reactive oxygen species (ROS) (Wallace, 2005). Persistent oxidative stress is widely accepted as one of the causes of most lifestyle-related diseases, cancer, and the aging process. However, many antioxidant supplements have not prevented cancer, myocardial infarction, or atherosclerosis, and may even increase mortality. Research has shown that molecular hydrogen (H_2) acts as a novel antioxidant in both preventive and therapeutic applications. H_2 offers advantages as a potential antioxidant without adverse effects. It is mild enough not to disrupt metabolic redox reactions or affect ROS involved in cell signaling. It also has favorable distribution characteristics due to its ability to penetrate biomembranes and diffuse through barriers into cellular components. The mechanisms underlying the significant effects observed with very small quantities of H_2 remain elusive. (Ohta, 2011).

H_2 lowers oxidative stress indirectly through the modulation of gene expression and protein phosphorylation, however, the molecular mechanisms responsible for these pronounced effects remain unclear. Additionally, by influencing gene activity, H_2 acts as an anti-inflammatory, antiallergic, and anti-apoptotic agent, while also promoting energy metabolism ('Molecular Hydrogen as a Novel Antioxidant', 2015b).

Research has shown that hydrogen water consumption can reduce oxidative stress, cognitive impairment, brain edema, and inflammation (Hu et al., 2024). However, the effects of H_2-rich water on antioxidant systems have been tested largely within in vitro or animal models, with limited human data from a few patient studies allowing substantiation of the beneficial roles of the water (Guo et al., 2018; Nishimaki et al., 2018). The Korean study from 2020, which presents, to our knowledge, the first double-blind placebo-controlled comprehensive study investigating the effects of H_2-water in healthy adults, demonstrated that 1.5 L of H_2-water intake for 4 weeks reduced cell death and inflammatory responses by modulating transcriptional networks of TLR-NFκB signaling. In addition, it may promote biological antioxidant capacity for adults > 30 yrs more than younger individuals (Sim et al., 2020).

Another influential study from 2021 investigated the protective effect of drinking hydrogen-rich water on mice with nonalcoholic fatty liver disease to elucidate the mechanism underlying the therapeutic action of molecular hydrogen (Hydrogen-Rich Water Protects against Liver Injury in Nonalcoholic Steatohepatitis through HO-1 Enhancement via IL-10 and Sirt 1 Signaling, n.d.). While previous studies have reported that hydrogen water treatment for 6 or 10 weeks significantly attenuated oxidative stress and improved the liver function in patients with chronic hepatitis B (Xia et al., 2013) and metabolic syndrome (Song et al., 2013), respectively, the 2021 study findings indicated that molecular hydrogen is a novel therapeutic tool for treating NASH and liver fibrosis. Molecular hydrogen interacted with the cross-talk of the HO-1/IL-10 axis and suppressed the expression of phosphorylated STAT3 and the activation of downstream pMAPK signaling. Molecular hydrogen is therefore considered to be an effective treatment for the clinical management of NASH/liver fibrosis.

Metabolic health improvement

Recent advances in redox biology have led to widespread acceptance of the role of oxidative stress (OxS) in the complex pathophysiology of metabolic syndrome (MetS) (Spahis et al., 2017). As we established molecular hydrogen controls signal transduction and gene expression, suppressing pro-inflammatory cytokines and decreasing reactive oxygen species production. H_2 is sufficiently mild so as not to disrupt metabolic redox reactions or interfere with reactive oxygen species (ROS) involved in cell signaling. Evidence indicates that the mild hormetic-like effects of hydrogen may contribute to these benefits; however, further research is still required to confirm these findings (LeBaron et al., 2019).

A significant randomized, double-blind, placebo-controlled, crossover study conducted in 2008 investigated the effects of hydrogen-rich water intake on lipid and glucose metabolism in patients with either type 2 Diabetes mellitus or impaired glucose tolerance. Participants consumed either 900 mL per day of hydrogen-rich pure water or 900 mL of placebo pure water for eight weeks, followed by a 12-week washout period. Biomarkers of oxidative stress, insulin resistance, and glucose metabolism were measured at baseline and after eight weeks. Consumption of hydrogen-rich water resulted in significant reductions in modified low-density lipoprotein (LDL) cholesterol levels. Additionally, hydrogen-rich water intake was associated with a trend toward decreased serum concentrations of oxidized LDL and free fatty acids, as well as increased plasma levels of adiponectin and extracellular-superoxide dismutase. In four of six patients with impaired glucose tolerance (IGT), hydrogen-rich water intake normalized the oral glucose tolerance test (Kajiyama et al., 2008)

A study conducted in 2011 showed that long-term consumption of hydrogen water significantly reduced fat accumulation and body weight, despite no change in overall food and water intake. Moreover, hydrogen

water intake decreased plasma glucose, insulin, and triglyceride levels, an effect on hyperglycemia comparable to that of dietary restriction. A mechanistic study demonstrated that gene expression of the hepatic hormone fibroblast growth factor 21 (FGF21) was upregulated, which is expected to promote fatty acid and glucose expenditure. Furthermore, hydrogen water consumption stimulated energy metabolism, as indicated by increased oxygen consumption and carbon dioxide expiration. These findings suggest the potential benefit of molecular hydrogen (H_2) in ameliorating obesity, diabetes, and metabolic syndrome.

Two years later, researchers presented a paper with an objective to characterize the effects of H_2-rich water (0.9–1.0 l/day) on the content, composition, and biological activities of serum lipoproteins in 20 patients with potential metabolic syndrome. They found that supplementation with H_2-rich water seems to decrease serum LDL-C and apoB levels, improve dyslipidemia-injured HDL function, and reduce oxidative stress, and it may have a beneficial role in prevention of potential metabolic syndrome (Song et al., 2013).

In 2020, yet again, it was proven that high-concentration HRW might have promising effects as a therapeutic modality for attenuating risk factors of metabolic syndrome. There was a randomized, double-blinded, placebo-controlled study in 60 subjects (30 men and 30 women) with metabolic syndrome. An initial observation period of one week was used to acquire baseline clinical data, followed by randomization to either placebo or high-concentration HRW. Supplementation with high-concentration HRW significantly reduced blood cholesterol and glucose levels, attenuated serum hemoglobin A1c, and improved biomarkers of inflammation and redox homeostasis as compared to placebo. Furthermore, H_2 tended to promote a mild reduction in body mass index and waist-to-hip ratio (LeBaron et al., 2020).

Overall, hydrogen-rich water (HRW) likely influences cellular bioenergetics and lipid metabolism through multiple pathways and contributes to the regulation of cellular processes. Nevertheless, further research is required to directly evaluate the effects of molecular hydrogen on energy metabolism in order to clarify its role in maintaining homeostasis.

Neuroprotection

A 2007 study from Japan (Fukuda et al., 2007) was the first to report that hydrogen can selectively remove hydroxyl radicals (OH) and peroxynitrite, which are both major causes of oxidative stress and cell damage. Since then, numerous studies have demonstrated that H_2 exhibits significant therapeutic effects in various diseases, including those associated with brain oxidative stress.

It was shown that drinking H_2-containing water significantly reduces the loss of dopaminergic neurons in PD model mice (Fujita et al., 2009) and increases their stress resilience(Gao et al., 2017). The researchers stated that MPTP-induced accumulation of cellular 8-oxoguanine (8-oxoG), a marker of DNA damage, and 4-hydroxynonenal (4-HNE), a marker of lipid peroxidation, were significantly decreased in the nigro-striatal dopaminergic pathway in mice drinking H_2 -containing water. But the therapeutic potential of molecular hydrogen in PD and other neurodegenerative disorders has also been progressively elucidated through multidimensional studies (Wang et al., 2025).

Furthermore, hydrogen-rich water (HRW) has also been utilized in research on the treatment of depression. In 2017, a study conducted by Kei Mizuno and colleagues involved the administration of 600 mL of hydrogen-rich water (HRW) daily to patients over a four-week period. The investigators observed improvements in mood, reductions in anxiety, and regulation of autonomic nervous function, suggesting a potential benefit of HRW on central nervous system function and overall quality of life (Mizuno et al., 2018).

Anti-Cancer properties:

With cancer being the second leading cause of death in the world today (Roser, 2021), the pressure to find a substance with a healing effect is constantly growing. Hydrogen has been administered to cancer patients to control tumor progression, as part of combination therapies, and to mitigate side effects and adverse events associated with standard cancer treatments across various cancer types.

For a long time, people thought H_2 was an inert gas. This changed in 1975 when Malcolm Dole, F. Ray Wilson, and William P. Fife showed that high-pressure hydrogen could slow the growth of squamous cell carcinoma in mice. (Dole et al., 1975). It was one of the first studies on hydrogen in oncology. Since then, many papers on the subject have appeared-most of them on animals (Saitoh et al., 2008, 2009) (Kawai et al., 2012; Ye et al., 2008; Zhao et al., 2011)

Although randomized clinical trials investigating HRW remain limited in number, several notable studies have been conducted. Table 1 summarizes two impactful studies conducted on humans.

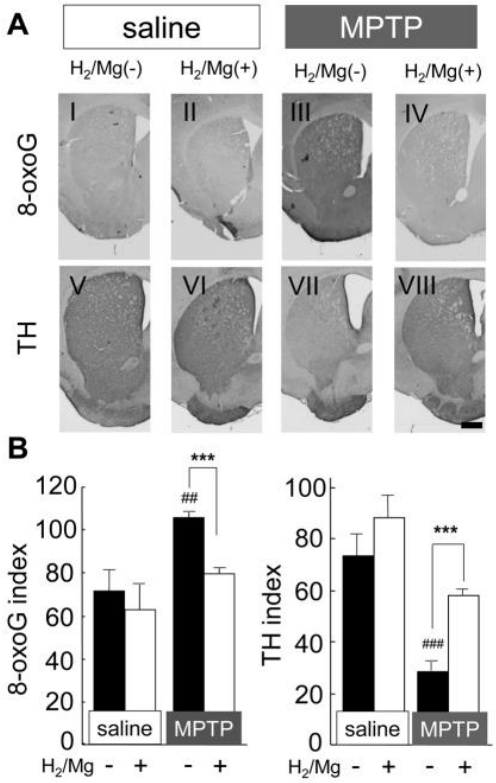

Fig. 3. *The image shows the loss of TH-positive neurons connected to administration of MPTP and no significant accumulation of 8-oxoG accumulation nor TH-positive staining in mice drinking H_2/Mg water. Adopted from (Fujita et al., 2009).*

Table 1. Comparison of HRW related studies.

Title	Effects of drinking hydrogen-rich water on the quality of life of patients treated with radiotherapy for liver tumors.	Protective effect of hydrogen-rich water on liver function of colorectal cancer patients treated with mFOLFOX6 chemotherapy.
Author	(Kang et al., 2011)	(Yang et al., 2017)
Objective	Does hydrogen treatment, in the form of hydrogen-supplemented water, improve QOL in patients receiving radiotherapy.	To investigate the protective effect of hydrogen-rich water on the liver function of colorectal cancer (CRC) patients treated with mFOLFOX6 chemotherapy.
Methods	Evaluation of global health status and QOL. The concentration of derivatives of reactive oxidative metabolites and biological antioxidant power in the peripheral blood were assessed.	Patients in the HRW group started drinking hydrogen water 1 day prior to chemotherapy until the end of the cycle. Liver function was assessed through lab tests.
Sample	49 patients receiving radiotherapy for malignant liver tumors.	144 randomized patients. 64- control groups 80- Hydrogen treatment group.
Key results	Reduced reactive oxygen metabolites in the blood. QOL scores significantly improved in patients treated with HRW.	No statistically significant differences in the levels of ALT, AST, ALP, DBIL and IBIL in the HRW group before and after chemotherapy. Difference in ALT, AST and DBIL levels before and after chemotherapy in the control group was statistically significant.

A randomized, placebo-controlled study was performed in 2011 to evaluate the effects of drinking hydrogen-rich water on 49 patients receiving radiotherapy for malignant liver tumors. The consumption of hydrogen-rich water for 6 weeks reduced reactive oxygen metabolites in the blood and maintained blood oxidation potential. Quality-of-life scores during radiotherapy were significantly higher in patients treated with hydrogen-rich water compared to patients receiving placebo water. There was no difference in tumor response to radiotherapy between the two groups(Kang et al., 2011)

In 2017, a study was conducted to investigate the protective effect of hydrogen-rich water on the liver function of colorectal cancer (CRC) patients treated with mFOLFOX6 chemotherapy. A controlled, randomized, single-blind clinical trial was designed. A total of 152 patients with CRC were recruited by the Department of Oncology of Taishan Hospital (Taian, China), among whom 146 met the inclusion criteria. The hydrogen-rich water group showed no significant changes in liver function before and after treatment, while the placebo group demonstrated significantly increased levels of ALT, AST, and IBIL. These findings suggest that hydrogen-rich water may mitigate mFOLFOX6-induced liver injury, but the HRW does not affect the anti-cancer effects of the treatment (Yang et al., 2017).

Conclusions

This review evaluates the potential health effects of hydrogen water, with particular attention to cardiovascular parameters, hepatic function, neuropsychiatric outcomes, and oxidative stress markers. While preliminary data suggest possible benefits, interpretation is constrained by notable methodological limitations. The majority of available studies have been conducted in animal models. Human studies are limited by small sample sizes(Mizuno et al., 2018; Sim et al., 2020), typically 10-50 participants, which restricts the generalizability of the findings. Furthermore, the lack of adequate placebo controls and blinding in several investigations may introduce bias.

Larger randomized controlled trials are required to more accurately delineate the potential benefits and risks of hydrogen water. As research in this area advances, rigorous study designs will be essential to clarify the effects of hydrogen water on both short- and long-term health outcomes.

In summary, although hydrogen water appears promising, its clinical application should be considered with caution pending more robust evidence.

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