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ALKALINE WATER AND HUMAN HEALTH: A COMPREHENSIVE REVIEW OF THERAPEUTIC POTENTIAL AND SCIENTIFIC EVIDENCE

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ABSTRACT

Alkaline water, characterized by its elevated pH and reduced oxidation-reduction potential (ORP), has gained popularity as a functional beverage marketed for its purported health benefits. Claims suggest that it can improve hydration, metabolic function, antioxidant status, and disease prevention. However, the scientific community remains divided regarding its clinical efficacy and physiological impact.

KEYWORDS: Alkaline water, metabolic syndrome, hydration, antioxidant, pH balance, oxidative stress, functional beverages.

INTRODUCTION

Water is fundamental to life and serves as a vital component of nearly every physiological process in the human body. Traditionally, the emphasis on hydration has been focused on water quantity; however, recent years have seen a surge in interest regarding water quality and composition, particularly with the growing market for alkaline water. Alkaline water is characterized by its elevated pH (typically between 8 and 10), reduced oxidation-reduction potential (ORP), and the presence of beneficial minerals. It is often promoted as a functional beverage with purported benefits ranging from enhanced hydration and metabolic balance to disease prevention.[1,17]

At the core of this interest is the theory that acid-base imbalance and oxidative stress are key contributors to the development of chronic diseases such as type 2 diabetes, hypertension, cardiovascular disease, gastrointestinal disorders, and even cancer. The modern diet-rich in processed foods, animal proteins, and low in alkaline-producing plant-based foods has been associated with low-grade metabolic acidosis, which may disrupt cellular function over time. Proponents of alkaline water suggest that by neutralizing excess acidity and reducing oxidative stress, it may support better metabolic functioning and improve overall health outcomes.[2,3]

A growing number of scientific studies-ranging from animal models and cross-sectional studies to randomized clinical trials-have begun to explore these claims with mixed but intriguing results. Some studies have shown that regular consumption of alkaline water may improve blood glucose control, lipid profiles, blood pressure, sleep quality, and even muscle strength-particularly in vulnerable populations such as postmenopausal women, whose hormonal changes often exacerbate metabolic dysfunction. Other experimental models in animals have demonstrated hypoglycemic, antioxidant, and immuno modulatory effects, while biochemical analyses of commercial alkaline water brands have exposed limitations in their actual alkalinity and mineral content, raising questions about standardization and efficacy.[4]

Moreover, systematic reviews have attempted to assess these claims more objectively. While some confirm slight benefits in hydration and metabolic outcomes, others conclude that alkaline water shows no significant superiority over regular mineral water in healthy populations. This divergence highlights the need for careful examination of study designs, participant populations, pH levels, and duration of intake when interpreting these findings.

Adding to the complexity, some studies suggest alkaline water may be ineffective or even misleading when marketed as a therapeutic option for specific conditions like kidney stone prevention, where actual alkali content is minimal compared to pharmaceutical agents such as potassium citrate. Conversely, in the domain of sports science, evidence suggests that alkaline water may enhance acid-base buffering and improve recovery post-exercise, particularly under conditions of high metabolic acidosis.

Thus, while the public perception of alkaline water has evolved rapidly due to commercial promotion and anecdotal testimonials, the scientific validation remains uneven. There is an

urgent need to assess whether the benefits are consistent, clinically meaningful, and applicable across different populations and health contexts.[5]

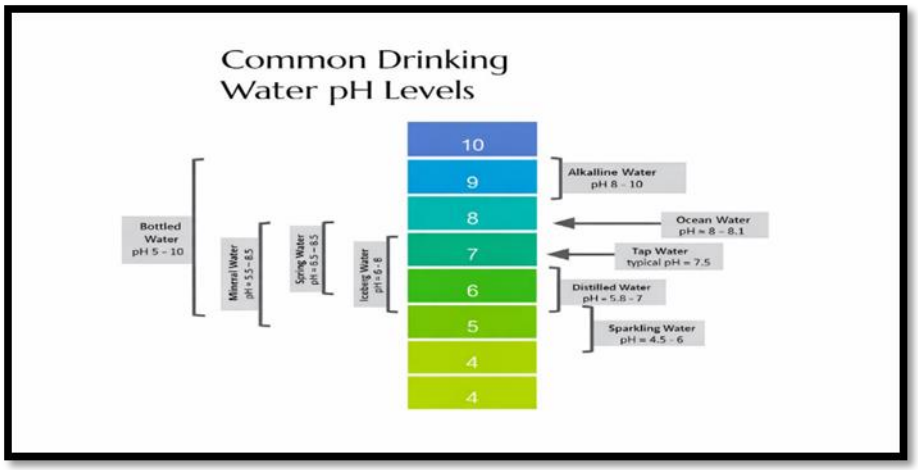

Figure 1: pH scale of common drinking water sources showing acidic, neutral, and alkaline ranges.[3]

METHODOLOGY

This review article employs a narrative synthesis approach to examine and integrate findings from experimental, observational, and review studies on the health effects of alkaline water consumption. The goal was to evaluate its clinical relevance across various health dimensions, including metabolic health, hydration, physical performance, and disease prevention.

1. Methods Used in the Included Studies

The ten selected articles for this review consist of a mix of human clinical trials, animal experiments, cross-sectional studies, laboratory analyses, and systematic literature reviews. The key research methods used across these studies include:

- Randomized Controlled Trials (RCTs): For instance, Chycki et al. used a double-blind, placebo-controlled RCT to measure anaerobic performance, hydration, and acid-base balance in combat athletes after consuming alkaline water.
- Cross-Sectional Studies: Chan et al. conducted a large-scale study comparing postmenopausal women who drank alkaline water with those who did not, measuring variables like blood pressure, glucose, and sleep.
- Animal Model Experiments: Mârza et al. studied the effects of alkaline water on weight, glucose levels, and blood biochemistry in rats over 40 days.
- Biochemical and Mineral Content Analyses: Patel et al. analyzed the alkali and mineral

content of commercial alkaline water and compared it with other beverages for stone prevention in urolithiasis patients.

- Mechanistic and Cellular Studies: Ignacio et al. and Delos Reyes et al. explored the mechanisms of alkaline water's antioxidant and anti-inflammatory actions in metabolic disease contexts.
- Systematic Reviews: Sunardi et al. conducted a review using PRISMA guidelines to evaluate and compare health effects of alkaline, oxygenated, and demineralized water versus mineral water among healthy individuals.

2. Data Collection and Analysis

For this review, relevant studies were identified from the provided PDF documents, which include full-length peer-reviewed articles published between 2012 and 2024. Each paper was read in full and data were extracted into a structured matrix to identify:

- Study design and population
- Duration and dosage of alkaline water exposure
- Outcome variables measured
- Statistical significance and effect sizes
- Conclusions and interpretations

The extracted information was then grouped thematically under major health-related domains:

1. Hydration and Physical Performance
2. Metabolic Health and Syndrome
3. Antioxidant and Anti-inflammatory Effects
4. Gastrointestinal and Renal Implications
5. Safety, Efficacy, and Biochemical Profile

A comparative qualitative analysis was performed to identify recurring trends, discrepancies, and research gaps.

3. Key Variables in the Review

Table 1: Across the analyzed studies, the following key variables were identified and categorized.

Category	Key Variables
Independent Variables	Type of water (alkaline vs. mineral vs. tap), pH level, dose, duration, method of ionization
Dependent	Hydration markers, blood glucose, triglycerides, HDL/LDL levels, blood

Variables	pressure, sleep quality, handgrip strength, urine pH, weight, oxidative stress biomarkers
Control Variables	Age, sex, physical activity level, baseline diet, underlying health conditions, environmental exposure
Confounding Variables	Socioeconomic status, medication use, body mass index, hydration habits, regional water quality

This structured methodological approach ensures a comprehensive and evidence-driven synthesis of the current knowledge on alkaline water and its potential health impacts.[5,14]

RESULT

This review analyzed evidence from clinical trials, animal studies, observational research, and systematic reviews to evaluate the therapeutic potential of alkaline water. The findings are grouped into five key thematic domains to highlight significant results, interpretive insights from the original authors, and how these outcomes relate to prior studies in the field.

1. Hydration, Acid-Base Balance, and Physical Performance[11,19]

Significant Findings

Chycki et al. (2022) demonstrated that athletes consuming alkaline water showed improved hydration status, reduced blood lactate concentration, and better acid-base balance post-exercise compared to controls. The intervention group recovered faster and demonstrated enhanced anaerobic performance under metabolic stress.

Interpretation

Authors attributed these benefits to the buffering effect of alkaline water, suggesting it helps mitigate exercise-induced acidosis. This effect is particularly useful for high-performance athletes engaging in repetitive, intense physical activity.

2. Metabolic Syndrome and Cardio metabolic Markers[10,13]

Significant Findings

Chan et al. (2022) found that regular consumption of alkaline water in postmenopausal women was associated with significantly lower fasting glucose, triglyceride/HDL ratios, diastolic blood pressure, and waist circumference.

Interpretation

The study suggests that alkaline water may confer protective metabolic effects, possibly by influencing systemic pH and reducing oxidative stress and inflammation, although causality

cannot be confirmed in a cross-sectional design.

3. Antioxidant and Anti-Inflammatory Properties[6,16]

Significant Findings

Multiple studies, including those by Ignacio et al. (2012) and Delos Reyes et al. (2021), emphasized alkaline water's role in reducing oxidative stress markers, neutralizing reactive oxygen species (ROS), and improving immune response.

Interpretation

Authors propose that alkaline reduced water (ARW) exhibits these properties due to its negative oxidation-reduction potential (ORP) and high dissolved hydrogen content-both of which contribute to cellular antioxidant defense mechanisms.

4. Gastrointestinal and Renal Health[7,8]

Significant Findings

Patel et al. (2024) found that commercially available alkaline waters contain minimal alkali content (<1 mEq/L) and therefore do not significantly aid in urinary alkalization compared to therapeutic agents like potassium citrate.

Interpretation

Alkaline water was shown to be ineffective for managing uric acid or cystine kidney stones, suggesting that consumer expectations regarding therapeutic use in nephrology should be tempered.

5. Safety and Comparative Health Effects[20]

Significant Findings

Sunardi et al. (2022) conducted a systematic review and found that no significant differences in gut microbiota, urine pH, blood biomarkers, or hydration status exist between people drinking alkaline water and those drinking standard mineral water. However, demineralized water was shown to lead to nutritional deficiencies over time.

Interpretation

While alkaline water is not harmful, its long-term superiority over mineral water for healthy individuals remains unproven. Its use may be more justified in specific clinical or athletic populations.

Table 2: Summary of Findings Across Domains.

Domain	Positive Effects	Limitations
Hydration & Performance	Improved lactate buffering, hydration status	Short-term data; mostly in athletes
Metabolic Syndrome	Lower glucose, TG/HDL, blood pressure	Mostly cross-sectional; no causality
Antioxidant Properties	Reduced ROS, anti-inflammatory action	Largely animal or in vitro studies
Renal Health	Limited benefit for urinary alkalinization	Commercial brands insufficient in alkali content
General Health Comparison	Comparable to mineral water in healthy populations	Not significantly better except in niche contexts

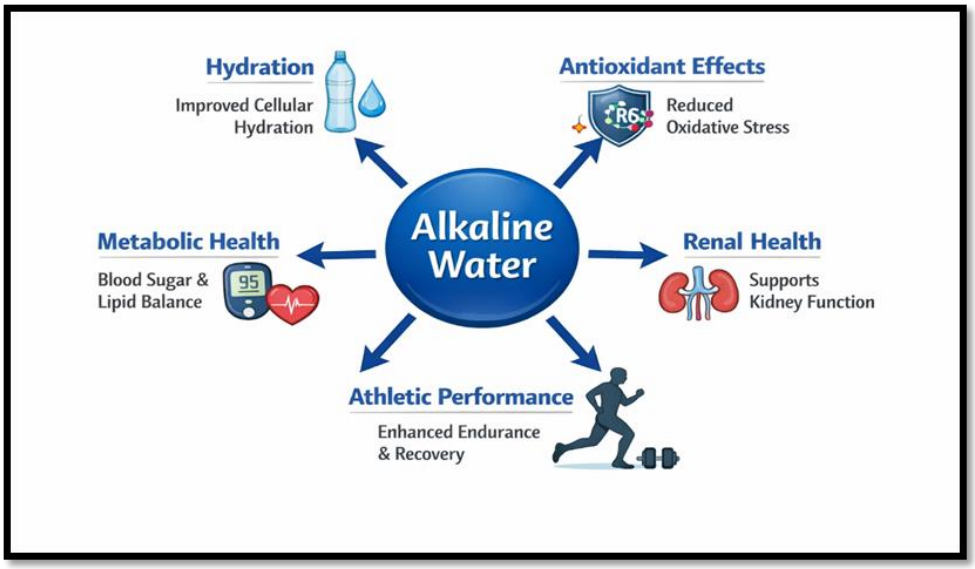

Figure 2: Benefecial effeccts of alkaline water.[17]

CONCLUSION

The findings of this review underscore the growing scientific interest in the potential health benefits of alkaline water, particularly in relation to hydration, metabolic health, oxidative stress, and chronic disease risk. While results from several preclinical and clinical studies suggest promising physiological effects, especially in specific populations such as athletes and postmenopausal women, the overall body of evidence remains heterogeneous and context-dependent.

Broader applications of the findings

The reviewed studies suggest that alkaline water may serve as a supportive intervention in the following broader health domains:

- Metabolic syndrome management: By potentially improving blood glucose, lipid profiles,

and abdominal obesity markers, alkaline water may complement dietary and pharmacological approaches for high-risk individuals.

- Athletic performance and recovery: Its buffering capacity against exercise-induced acidosis could benefit athletes by enhancing hydration status, muscular endurance, and post-exercise recovery.
- Oxidative stress and inflammation: The antioxidant properties of alkaline reduced water may contribute to cellular protection in oxidative-stress-related conditions, although further mechanistic studies are required.
- Functional beverages and wellness products: As consumers increasingly seek non-pharmaceutical wellness solutions, alkaline water presents a market-ready alternative with emerging but cautious scientific backing.

Real world applications

These findings can be translated into practical use in several ways:

1. Clinical Settings: Healthcare professionals may consider recommending alkaline water as a complementary hydration strategy for patients with mild metabolic dysregulation or those needing improved acid-base balance—while also ensuring patients understand it is not a replacement for medical therapy.
2. Sports Nutrition: Athletic trainers and sports dietitians might incorporate alkaline water in hydration regimens for endurance athletes, especially in high-intensity or high-heat training environments.
3. Public Health and Consumer Education: Awareness campaigns can promote informed consumption of alkaline water by clarifying that benefits depend on context, dosage, and individual health status—not merely the label or pH level.
4. Water Quality and Policy: The findings also support the importance of evaluating the mineral and alkali content of marketed alkaline waters to ensure transparency and regulatory oversight, especially where claims of therapeutic benefit are made.

In conclusion, alkaline water represents a potentially beneficial adjunct in wellness and disease prevention strategies, but it is not a panacea. More robust, long-term, and large-scale randomized controlled trials are necessary to establish causality, safety, and optimal usage guidelines. Until then, real-world application should remain personalized, evidence-informed, and guided by professional consultation.

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