Journal of Nutrition & Food Sciences
ISSN: 2155-9600
OPEN ACCESS Freely available online
Commentary

# Alkaline Water: An Overview of Acid Base Balance

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## ABSTRACT

Nearly all plain bottled and public drinking water in America is between pH 6.7 to 7.4, with alkaline water being unique in its pH range of 7.5 to 9.5. While research on the efficacy of alkaline water is limited, advocates believe it to deliver more optimal absorption to promote better hydration, enhance the body's ability to maintain fluid balance, and better manage acid in your bloodstream. But are these claims warranted? Let's look at the science.

**Keywords:** Alkaline water; Acid base balance; Net acid load; Electrolyte balance; Osmosis; Total body water; Ketogenic diet; Alkaline diet

## INTRODUCTION

Water is essential to life due to its vital role in hydration, metabolism, body temperature control, circulation and transportation [1,2]. Total body water accounts for about 60% of body weight in adults, with roughly 35% housed within cells as intracellular fluid, 25% outside cells as interstitial fluid and lymph, and about 5% in our bloodstream as plasma [1,2]. Cells can also make water as an end product of carbohydrate, protein and fat metabolism. Known as metabolic water, this contributes to less than 10% of our daily needs, with the food and drink we consume making greater than 90% [2]. As the primary component of all body fluids, water serves as the medium for an infinite amount of enzymatic reactions, which are activated or inhibited depending on the acidity of their environments [2]. As a result, acid base balance is tightly regulated from the point of oral consumption as food and drink, to excretion through our sweat, breath, saliva, urine and stools [1,2].

Nearly all plain bottled and public drinking water in America is between pH 6.7 to 7.4, with alkaline water being unique in its pH range of 7.5 to 9.5 [3-12]. Potential hydrogen, or pH, is a measure of how acidic or basic (alkaline) a solution is on a scale of 0 to 14, with 7 pH being neutral [2]. Alkaline water can be found naturally in aquifers, natural springs, glaciers and snowy mountain tops, depending on minerals present in neighboring rock and soil [5-12]. Commercial brands can also make alkaline water by adding protons to plain water to increase pH, through the process of electrolysis [2,13]. Manufacturers of all types of water will also commonly supplement with electrolytes claiming enhanced taste and hydration delivery to cells [5-12]. While research on the efficacy of alkaline water is limited, advocates believe it to deliver more optimal absorption to promote better hydration, enhance the body's ability to maintain fluid balance, and better manage acid in your bloodstream [3,5-7,10].

### But are these claims warranted? Let's look at the science

Water travels via passive diffusion, meaning it seeps through cell membranes without aid of transporters or pumps [2]. In the process of absorption, water permeates the gut lining to enter the cell, traveling through the cell to cross the basal membrane and enter the bloodstream [2,4]. This bidirectional movement is driven by electrolyte concentration and osmotic potential across membranes and is a normal function of water which is not enhanced by an alkaline pH [2].

During digestion, alkaline water travels down the upper gastrointestinal (GI) tract to meet the stomach. Triggered by the act of eating, the stomach releases hydrochloric acid along with acid loving digestive enzymes, to begin denaturing and breaking down the incoming contents [2,3]. This highly acidic environment is essential for protecting against harmful germs and promoting proper digestive enzyme function [2]. Currently, most commercial retail alkaline waters range from 7.5-9.5 pH which is defined as a weak base, while gastric hydrochloric acid with 0.8-1.35 pH, is deemed a strong acid [5-14]. In chemistry, when a weak base and strong acid are mixed, an acidic solution results [14]. This means that once alkaline water meets the stomach, it dissociates into an acidic mixture called chyme, to enter the small intestine for absorption [14]. While gastric acid production can be impacted by medication or suboptimal body secretions, the more alkaline gastric environment that results has shown to impair digestion, impede proper intestinal absorption, and promote bacterial GI overgrowth [2,15].

While alkaline water alone does not impact absorption, an overall alkaline diet may elicit a stronger response [8]. Looking at pH balance in terms of a net acid base load, evidence has shown fruits and vegetables to provide basic dietary precursors, while protein, meat, and fats provide acidic precursors [15-17]. However, the current body

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**Received:** 02-August-2022, Manuscript No. jnfs-22-18748; **Editor assigned:** 04-August-2022, PreQC No. jnfs-22-18748 (PQ); **Reviewed:** 18-August-2022, QC No. jnfs-22-18748; **Revised:** 23-August-2022, Manuscript No. jnfs-22-18748 (R); **Published:** 30-August-2022, **DOI:** 10.35248/2155-9600.22.12.1000868

**Citation:** Hauger O (2022) Alkaline Water: An Overview of Acid Base Balance. J Nutr Food Sci. 12:868.

of evidence is not yet supportive of the effectiveness of an overall alkaline diet as a therapy [3]. In a 2012 in vitro study, alkaline water with a 8.8 pH demonstrated an immediate and permanent inhibition of the digestive enzyme pepsin.8 While this may suggest a potential therapeutic target for those with acid reflux or chronic proton pump inhibitor users, it is important to note that this study was performed in a test tube rather than the human body, and more research is needed on the topic [2,8].

Compared to an alkaline diet, a very low carbohydrate, ketogenic diet has been shown to modify blood pH, although these changes remain within a tight physiological range [15-17]. Removing carbohydrates from the diet results in a higher blood acid load as the liver shifts to utilizing fatty acids for fuel and produces acidic ketones that are released into the bloodstream [2]. In circulation, a strict blood pH of 7.4 is maintained to support life, with fluctuations of even 0.05 pH leading to acidosis, impaired metabolism and organ dysfunction [2-4]. To maintain acid base balance, natural buffering systems in the lungs and kidneys work together to restore pH in the blood [16,17]. In extreme circumstances these systems are not enough and enteral administration of baking soda is needed to adequately buffer pH [16-18]. Chemically known as sodium bicarbonate, baking soda contains electrolyte sodium and bicarbonate as an alkaline base [2,14,16].

### But how does this work? Let's look at electrolytes

Occurring in soil and rock, electrolytes are naturally found in alkaline waters sourced from springs, glaciers, and melted snow caps [5-12]. These compounds are also added to most water varieties given their demonstrated ability to drive water shifts into cells [2,4,19]. While water can move freely across cell membranes, electrolytes require pumps and transporters to actively move in and out of cells, along with the help of glucose, amino acids, peptides and/or vitamins as cotransporters [2,19]. These pumps create electrolyte gradients, which drives water to move across the cell membrane to balance electrolytes across the cell membrane [2].

Electrolytes sodium ($Na^+$), potassium ($K^+$) and chloride ($Cl^-$) demonstrate the most activity across cell membranes and act as main drivers of fluid shifts [2]. In the intestines, sodium, chloride, and potassium are actively absorbed into the bloodstream, with water to follow as it moves down the concentration gradient [2]. During absorption, brush border pumps transfer glucose into cells using sodium as a cotransporter [2]. To enter the bloodstream, sodium ($Na^+$) is actively pumped across the basal membrane, with the potassium ($K^+$) moving into the cell as an exchange [2]. To balance these changing electrochemical gradients, membrane-bound pumps exchange protons ($H^+$) with sodium ($Na^+$), and chloride ($Cl^-$) with bicarbonate ($HCO_3^-$), to closely manage chemical properties of the cell [2,13]. Together these systems not only drive electrolyte movement that brings water into cells, but effectively maintain intra and extracellular pH gradients, to modify the pH of body fluids [13]. This has been demonstrated through studies showing increased body water content resulting from consumption of electrolyte enhanced water, compared to plain water [1,18,19].

While efficacy of alkaline water remains unclear, there is a large body of evidence supporting hydration enhancing effects of electrolytes [1,2,18,19]. Overall, claims connecting alkaline water to health benefits like enhanced absorption, optimized hydration, and better acid base regulation, are not supported by science. In summary, it has been shown that alkalinity does not enhance the functional properties of water including passive absorption, osmosis, or electrolyte management [2,3,14,15]. In fact, an acidic pH is essential for regular digestive function, with an alkaline pH leading to digestive dysfunction and subsequent malabsorption [2,15]. In regards to hydration, a large body of evidence supports intake of electrolyte enhanced water, rather than alkaline water, to increase total body water compared to plain water [1,18,19].

While evidence on efficacy of alkaline water is lacking, more research is needed on this topic. A systemic investigation of net acid load and buffering effects of an overall alkaline diet is warranted to evaluate this therapy as a potential target for digestive issues [4,15,17]. While evidence supporting electrolyte function is robust, specific dosing of electrolytes for enhanced hydration has not yet been identified [1,19]. A closer look at the supplemental addition of glucose, amino acids, peptides, and vitamin cotransporters is also needed, to identify maximum hydration capacity of electrolyte enhanced beverages [19].

## ACKNOWLEDGEMENT

None

## CONFLICTS OF INTEREST

The author has no relevant financial or non-financial interests to disclose.

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